Chapter XVI.—SHAPING AND PLANING MACHINES.

THE office of the shaping machine is to dress or cut to shape such surfaces as can be most conveniently cut by a tool moving across the work in a straight line.

The positions occupied among machine tools at the present time by shaping and planing machines are not as important as was the case a few years ago, because of the advent of the milling machine, which requires less skill to operate, and produces superior work.

All the cutting tools used upon shaping and planing machines have already been described with reference to outside tools for lathe work, and it may be remarked that a great deal of the chucking done on the shaping and planing machine corresponds to face plate chucking in the lathe. Both shaping machines and small planing machines, however, are provided with special chucks and work-holding appliances that are not used in lathe work, and these will be treated of presently. On large planing machines chucks

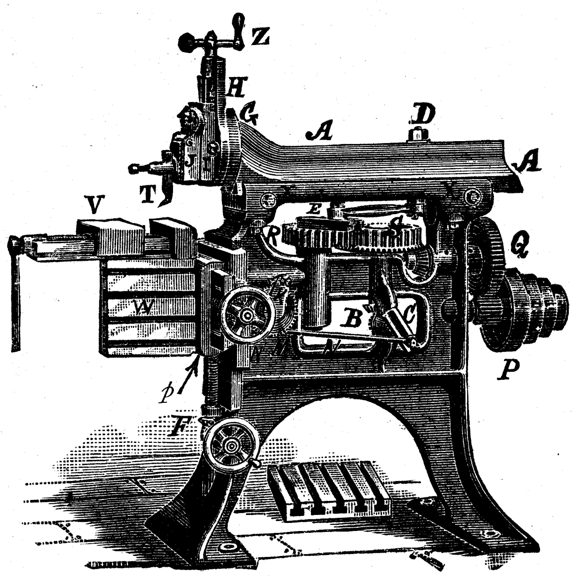

Fig. 1496.

are rarely used, on account of the work being too large to be held in a chuck. Shaping machines are also known as shapers and planing machines as planers.

The simplest form of shaping machine, or shaper as it is usually termed in the United States, is that in which a tool-carrying slide is reciprocated across the work, the latter moving at the end of each back stroke so that on the next stroke the tool may be fed to its cut on the work. Fig. 1496 represents a shaper of this kind constructed by Messrs. Hewes and Phillips, of Newark, New Jersey, in which P is a cone pulley receiving motion from a countershaft, and driving a pinion which revolves the gear-wheel Q, whose shaft has journal bearing in the frame of the machine. This shaft drives a bevel pinion gearing with a bevel-wheel in one piece with the eccentric spur-wheel S, which is upon a shaft having at its lower end the bevel-wheel B to operate the work-feeding mechanism. S drives an eccentric gear wheel R, fast upon the upper face of which is a projection E, in which is a T-shaped groove to receive and secure a wrist or crank pin which drives a connecting rod secured to the slide A by means of a bolt passing through A, and secured to the same by a nut D.

When the gear-wheel R revolves, the connecting rod causes slide A to traverse to and fro endways in a guideway, provided on the top of the frame at X. On the end of this slide is a head carrying a cutting tool T, which, therefore, moves across the work, the latter being held in the vise V, which is fast upon a table W upon a carriage saddle or slider *p*, which is upon a horizontal slide that in turn fits to a slide vertical upon the front of the machine, and may be raised or lowered thereon by means of an elevating screw driven by a pair of mitre-wheels at F. The slider and table W (and therefore the vise and the work) are moved along the horizontal slide to feed the work to the tool cut as follows. A short horizontal shaft (driven by the bevel pinions at B), drives at its outer end a piece C, having a slot to receive a crank pin driving the feed rod N, which operates a pawl K

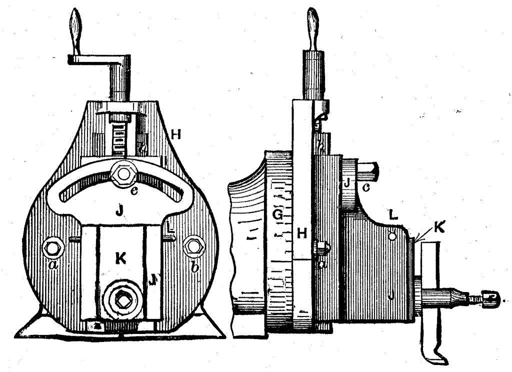

Fig. 1497.

engaging a ratchet wheel which is fast upon the horizontal screw that operates slider *p*.

The diameters of the eccentric gear-wheels E and S are equal; hence, C makes a revolution and the cross feed is actuated once for every cutting stroke. The swivel head H is bolted to the end of the slide or ram, as it is sometimes called, A, and is provided with a slide I upon which is a slider J, carrying an apron containing the tool post holding the cutting tool, the construction of this part of the mechanism being more fully shown in Fig. 1497. The eccentric gear-wheels R S are so geared that the motion of the slide A during the cutting stroke (which is in the direction of the arrow) is slower than the return stroke, which on account of being accelerated is termed a quick return. Various mechanisms for obtaining a quick return motion are employed, the object being to increase the number of cutting strokes in a given time, without accelerating the cutting speed of the tool, and some of these mechanisms will be given hereafter.

Referring again to the mechanism for carrying the cutting tool and actuating it to regulate the depth of cut in Fig. 1497, G is the end of the slide A to which the swivel head H is bolted by the bolts *a b*. The heads of these bolts pass into T-shaped annular grooves in G, so that H may be set to have its slides at any required angle. I is a slider actuated on the slide by means of the vertical feed screw which has journal bearing in the top of H,

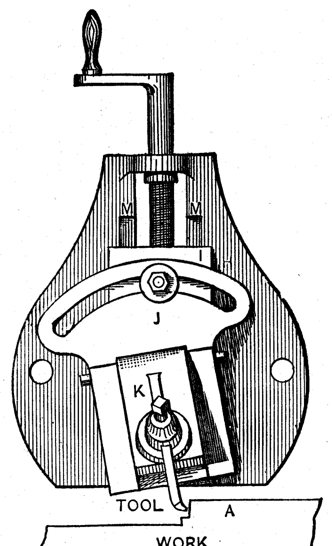

Fig. 1498.

and passes through a nut provided in I. To I is fastened the apron swivel J, being held by a central bolt not seen in the cut, and also by the bolt at *c*. In J is a slot, which when *c* is loosened permits J to be swung at an angle. The apron K is pivoted by a taper pin L, which fits into both J and K. During the cutting stroke the apron K beds down upon J, but during the back stroke the tool may lift the apron K swinging upon the pivot L. This prevents the cutting edge of the tool from rubbing against the work during the return stroke.

Thus in Fig. 1498 is a piece of work, and it is supposed that a cut is being carried down the vertical face or shoulder at A; by setting the apron swivel at an angle and lifting the tool during

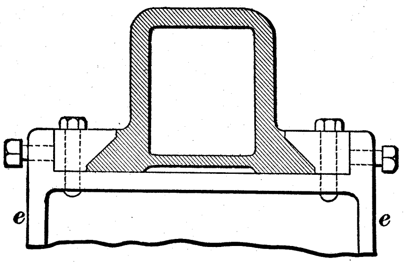

Fig. 1499.

the return stroke, its end will move away from the face of the shoulder. The slider I obviously moves in a vertical line upon slides M.

To take up the wear of the sliding bar A, various forms of guideways and guides are employed, a common form being shown in Fig. 1499. There are two gibs, one on each side of the bar, and these gibs are set up by screws to adjust the fit. In some cases only one gib is used, and in that event the wear causes the slide to move to one side, but as the wear proceeds exceedingly slowly in consequence of the long bearing surface of the bar in its guides, this is of but little practical moment. On the other hand, when two gibs are used great care must be taken to so adjust the screws that the slide bar is maintained in a line at a right angle to the jaws of the work-holding vice, so that the tool will cut the vertical surfaces or side faces of the work at a right angle to the work surface that is gripped by the vice.

To enable the length of stroke of slide A, Fig. 1496, to be varied to suit the length of the work, and thus not lose time by uselessly traversing that slide, E is provided with a T-slot as before stated, and the distance of the wrist pin (in this slot) from the centre of wheel E determines the amount of motion imparted to the connecting rod, and therefore to slide A. The wrist pin is set so as to give to A a rather longer stroke than the work requires, so that this tool may pass clear of the work on the forward stroke, and an inch or so past the work on the return stroke, the latter giving time to feed the tool down before it meets the work.

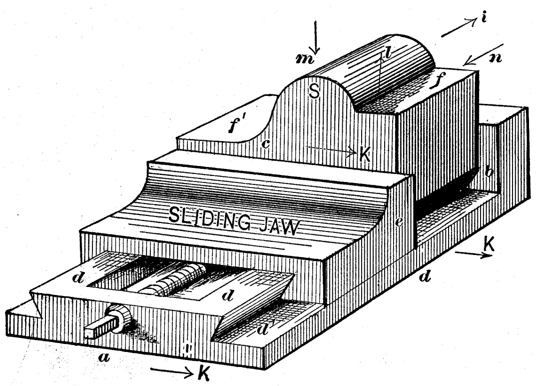

Fig. 1500.

The length of the stroke being set, the crank piece E (for its slot and wrist pin correspond to a crank) is, by pulling round the pulley P, brought to the end of a stroke, the connecting rod being in line with slide A. The nut D is then loosened and slide A may then be moved by hand in its slideway until the tool clears the work at the end corresponding to the connecting rod position when nut D is tightened and the stroke is set.

Now suppose it is required to shape or surface the faces *f* and *f'*, the round curve S and the hollow curve *c* of the piece of work shown held in a vice chuck in Fig. 1500, and during the cutting stroke the slide *a* will travel in the direction of *n* in the figure, while during its return stroke it will traverse back in the direction of *i*. The sliding table W in Fig. 1496 would continuously but gradually be fed or moved (so much per tool traverse, and by the feeding mechanism described with reference to Fig. 1501) carrying with it the vice chuck, and therefore the work When this feeding brought the surface of curve S, Fig. 1500, into contact with the tool, the feed screw handle in figure would be operated by hand so much per feed traverse, thus raising the slider, and therefore the tool, in the direction of *l*, and motion of the work to the right and the left of the tool (by means of the feed handle) would (if the amount of tool lift per tool stroke is properly proportioned to the amount of work feed to the right) cause the tool to cut the work to the required curvature. When the work had traversed until the tool had arrived at the top of curve S, the direction of motion of the feed-screw handle Z in Fig. 1496 must be reversed, the tool being fed down so much per tool traverse (in the direction of *m*) so as to cut out the curves from the top of S to the bottom of *c*, the face *f'* being shaped by the automatic feed motion only.

The feed obviously occurs once for each cutting stroke of the tool and for the vertical motion of the tool, or when the tool is operated by the hand feed-screw handle in Fig. 1496, the handle motion, and therefore the feed should occur at the end of the back stroke and before the tool again meets the work, so as to prevent the cutting edge of the tool from scraping against the work during its back traverse.

In this connection it may be remarked that by setting the apron swivel over, as in Fig. 1498, the tool is relieved from rubbing on the back stroke for two reasons, the first having been already explained, and the second being that to whatever amount the tool may spring, bend, or deflect during the cutting stroke (from the pressure of the cut), it will dip into the work surface and cut deeper; hence on the back stroke it will naturally clear the surface, providing that the next cut is not put on until the tool has passed back and is clear of the work.

Referring now to the automatic feed of the sliding table W, in Fig. 1496, the principle of its construction may be explained with reference to Fig. 1501, which may be taken to represent a class of such feeding mechanisms. A is a wheel corresponding to the wheel marked M in Fig. 1496, or, it may be an independent

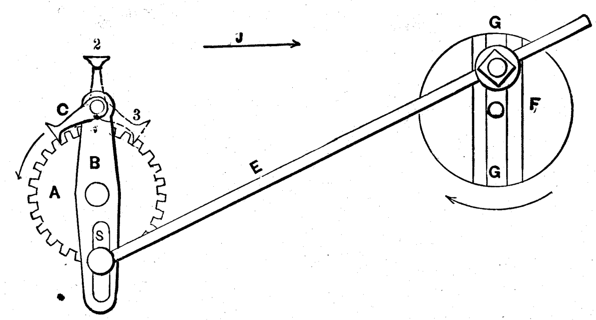

Fig. 1501.

wheel in gear with the feed wheel. On the same shaft as A is pivoted an arm B having a slot S at one end to receive a pin to which the feed rod E may connect. F is a disk rotated from the driving mechanism of the shaping machine, and having a T-shaped slot G G, in which is secured a pin to actuate the rod E. As F rotates E is vibrated to and fro and the catch C on one stroke falls into the notches or teeth in A and causes it to partly rotate, while on the return stroke of E it lifts over the teeth, leaving A stationary.

The amount of motion of B, and therefore the quantity of the feed, may be regulated at either end of E; as, for example, the farther the pin from the centre of G the longer the stroke of E, or the nearer the pin in S is to the centre of B the longer the stroke, but usually this provision is made at one end only of E.

To stop the feed motion from actuating, the catch C may be lifted to stand vertically, as shown in dotted lines in position 2, and to actuate the feed traverse in an opposite direction, C may be swung over so as to occupy the position marked 3, and to prevent it moving out of either position in which it may be set a small spring is usually employed.

Now suppose that the tool-carrying slide A, Fig. 1496, is traversing forward and the tool will be moving across the work on the cutting stroke, as denoted by the arrow *k* in Fig. 1502, the line of tool motion for that stroke being as denoted by the line *c a*. At *a* is the point where the tool will begin its return stroke, and if the work is moved by the feeding mechanism in the direction of arrow *e*, then the line of motion during the return stroke

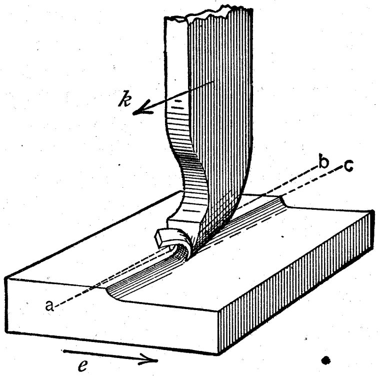

Fig. 1502.

will be in the direction of the dotted line *a b*, and as a result the tool will rub against the side of the cut.

It is to obviate the friction this would cause to the tool edge, and the dulling thereto that would ensue, that the pivot pin L for the apron is employed as shown in Fig. 1497, this pin permitting the apron to lift and causing the tool to bear against the cut with only such force as the weight of the apron and of the tool may cause. Now suppose that in Fig. 1503 we have a piece of work whose edge A A stands parallel to the line of forward tool motion, there being no feed either to the tool or the work, and if the tool be set to the corner *f* its line of motion during a stroke will be represented by the line *f g*. Suppose that on the next stroke the feed motion is put into action and that feeding takes place during the forward stroke, and the amount of the feed per stroke being the distance from *g* to *h*, then the dotted line from *f* to *h* repre-

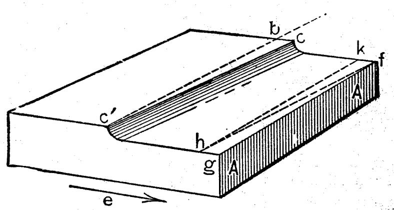

Fig. 1503.

sents the line of cut. On the return stroke the line of tool motion will be from *h* along the dotted line *h k*, and the tool will rest against the cut as before. Suppose again that the feed is put on during the return stroke, and that *c c′* represents the line of tool motion during a cutting stroke, and the return stroke will then be along the line from *c′* to *b*, from *c* to *b* representing the amount of feed per stroke; hence, it is made apparent that the tool will rub against the cut whether the feed is put on during the cutting or during the return stroke. Obviously then it would be preferable to feed the work between the period that occurs after the tool has left the work surface on the return stroke and before it meets it again on the next cutting stroke. It is to be observed, however, that by placing the pin actuating the rod E, Fig. 1501, on the other side of the centre of the slot G in F, the motion of E will be reversed with relation to the motion J of the slide; hence, with the work feeding in either direction, the feed may be made to occur during either the cutting or return stroke at will by locating the driving pin on the requisite side of the centre of G.

An arrangement by Professor Sweet, whereby the feed may be actuated during the cutting or return stroke (as may be determined in designing the machine), no matter in which direction the work table is being fed, is shown in Fig. 1504. Here there

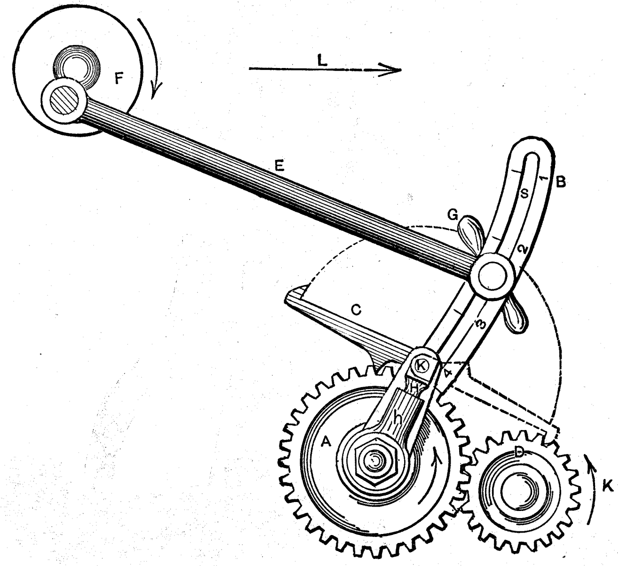

Fig. 1504.

are two gears A and D, and the pawl or catch C may be moved on its pivoted end so as to engage either with A or D to feed in the required direction.

Suppose the slide to be on its return stroke in the direction of L, and F be rotated as denoted by the arrow, then the pawl C will be actuating wheel A as denoted by its arrow, but if C be moved over so as to engage D as denoted by the dotted outline, then with the slide moving in the same direction, C will pull D in the direction of arrow K′, and wheel A will be actuated in the opposite direction, thus reversing the direction of the feed while still causing it to actuate on the return stroke.

Since the feed wheel A must be in a fixed position with relation to the work table feed screw, and since the height of this table varies to meet the work, it is obvious that as the work table is raised the distance between the centres of A and F in the figure is lessened, or conversely as that table is lowered the distance between those centres is increased; hence, where the work table has much capacity of adjustment for height, means must be provided to adjust the length of rod E to suit the conditions. This may be accomplished by so arranging the construction that the rod may pass through its connection with wheel F, in the figure, or to pass through its connection with B.

Fig. 1505 represents a shaper that may be driven either by hand or by belt power. The cone pulley shaft has a pinion that drives the gear-wheel shown, and at the other end of this gear-wheel shaft is a slotted crank carrying a pin that drives a connecting rod that actuates the sliding bar, or ram, as it is sometimes termed. The fly-wheel also affords ready means of moving the ram to any required position when setting the tool or the work.

Fig. 1506 represents a shaping machine by the Hewes and Phillips Iron Works, of Newark, N.J. The slide or ram is operated by the Whitworth quick return motion, whose construction will be shown hereafter. The vice sets upon a knee or angle plate fitting to vertical slideways on the cross slide, and may be raised or lowered thereon to suit the height of the work by means of the crank handle shown in front. The vice may be removed and replaced by the supplemental table shown at the foot of the machine. Both the vice and the supplemental table are capable of being swivelled when in position on the machine. The machine is provided with a device for planing circular work, such as sectors, cranks, &c., the cone mandrel shown at the foot of the machine bolting up in place of the angle plate.

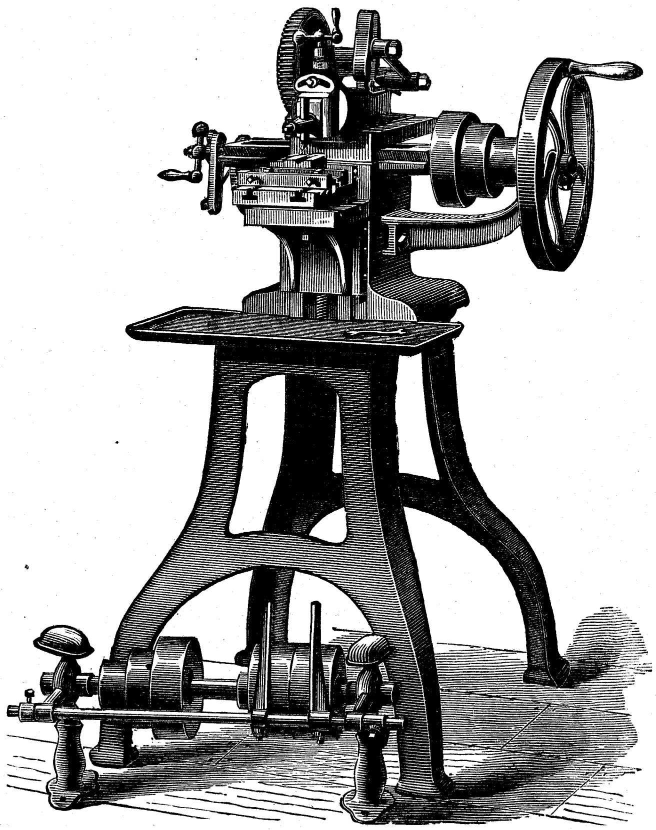

Fig. 1505.

shaper vice, which may be employed to hold almost any shape of work whose size is within the capacity of the chuck. Before describing, however, the various forms of shaper vices, it may be well to discuss points to be considered in its use.

The bottom surface *a a*, Fig. 1507, of a planer vice is parallel with the surfaces *d*, *d'* and as surface *a* is secured to the upper face of the slider table shown in figure, and this face is parallel to the line of motion of the slide A, and also parallel with the cross slide in that figure, it follows that the face *d* is also parallel both with the line of motion of slide A and with the surface of the slider table. Parallel work to be held in the vice may therefore be set down upon the surface *d* (between the jaws), which surface will then form a guide to set the work by. The work-gripping surfaces *b* and *e*, Fig. 1507, of the jaws are at a right angle to surface *a*, and therefore also to *d*, therefore the upper surface of work that beds fair upon *d*, or beds fair against *b*, will be held parallel to the line of motion X of the tool and the line Z of the feed traverse. Similarly the upper surfaces A, B of the gripping jaws are parallel to *a a*, hence they may be used to set the work true with the line of feed traverse. The sliding jaw, however, must be a sufficiently easy fit to the slideways that guide it to enable it to be moved by the screw that operates it, and as a result it has a tendency to lift upon its guideways so that its face *e* will not stand parallel to *b* or at a right angle to *d*. In Fig. 1508, for example, is a side view of a vice holding a piece of work W, the face *f* of the work being at an angle. As a consequence there is a tendency to lift in the direction of C. If the jaw does lift or spring in this direction it will move the work, so that instead of its lower face bedding down upon face *d*, Fig. 1507, it will lie in the direction of H, Fig. 1508, while its face parallel to *f*, instead of bedding fair against the face of jaw J, will lie as denoted by the line *g*, and as a result the work will not be held fair with either of those faces and the value of faces *b*, *d* and *e* in Fig. 1507 is impaired.

This lifting of the movable or sliding jaw is prevented in some

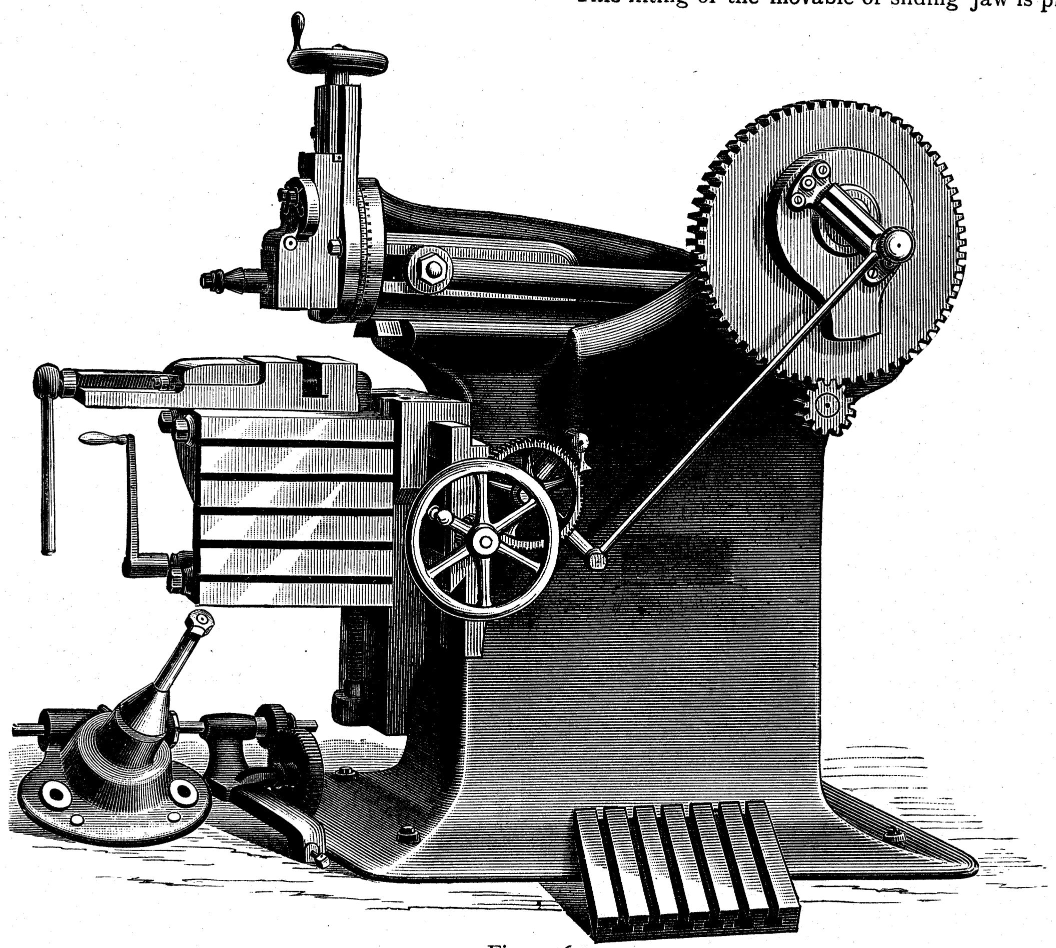

Fig. 1506.

Holding Work in the Shaper or Planer Vice.—The simplest method of holding work in a shaper is by means of a

forms of chuck, to be hereafter described, by bolts passing through which hold it down, but the tendency is nevertheless present, and it is necessary to recognise it in treating of chucking or holding work in such vices.

The work gripping face *b*, Fig. 1507, of the fixed jaw, however, is not subject to spring, hence it and the surface *d* are those by which the work may be set. The work, however, is held by the force of the screw operating the sliding jaw, hence the strain is in the direction of the arrow P in Fig. 1508, which forces it against the face of the fixed jaw. All the pressure that can be exerted to hold work down upon the surface *d*, Fig. 1507, is that due to the

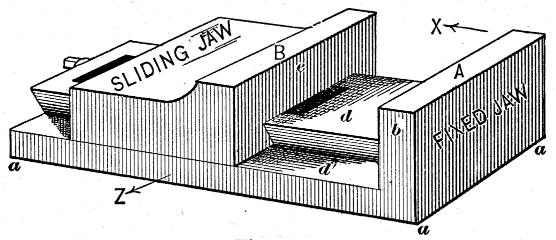

Fig. 1507.

weight of the work added to whatever effort in that direction there may be induced by driving the work down by blows upon surface *d* after the jaws are tightened upon the work. This, however, is not to be relied upon whenever there is any tendency for the work not to bed down fair. It follows, then, that surface *b* of the work-gripping jaw is that to be most depended upon in setting the work, and that the surface that is to act as a guide at each chucking should be placed against this surface unless there are other considerations that require to be taken into account.

For example, suppose we have a thin piece of work, as in Fig. 1509, and the amount of surface bearing against the fixed jaw is so small in comparison to its width between the jaws that *e* would form no practical guide in setting the work. If then the edges of such a piece of work were shaped first the face or faces may or may not be made at a right angle to them, or *square* as it is termed. But if the faces were shaped first, then when the work was held by them to have the edges shaped there would be so broad an area of work surface bedding against the jaw surface, that the edges would naturally be shaped square with the faces.

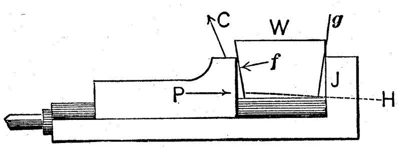

Fig. 1508.

In cases, therefore, where the area of bedding surface of the work against the faces of the jaws is too small to form an accurate guide and the work is not thick enough to rest upon the surface *d*, Fig. 1507, it is set true to that surface by a parallel piece.

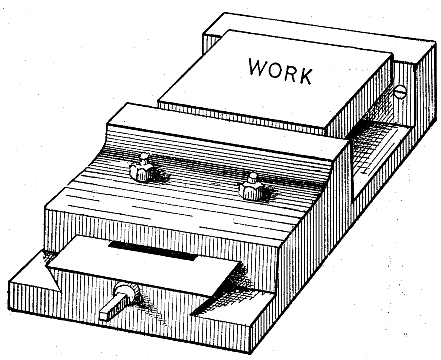

Fig. 1509.

If the work is wide or long enough to require it, two parallel pieces must be used, both being of the same thickness, so that they will keep the work true with the surface *d*.

Pieces such as P, Fig. 1510, are also used to set work not requiring to be parallel. Thus in figure are a number of keys placed side by side and set to have their edges shaped, and piece P is inserted not only to lift the narrow ends of the keys up, but also to maintain their lower edges fair one with the other, and thus insure that the keys shall all be made of equal width.

They are also serviceable to interpose between the work and the vice jaws when the work has a projection that would receive damage from the jaw pressure.

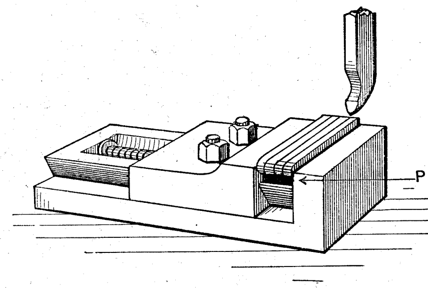

Fig. 1510.

Thus in Fig. 1511 the work W has such a projection and a parallel piece P is inserted to take the jaw pressure. By placing the broadest work surface *g* against the fixed jaw the work will be held true whether the movable jaw springs or not, because there will be surface *g* and surface H guiding it.

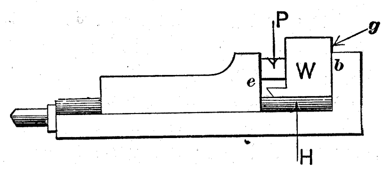

Fig. 1511.

But if the work were reversed, as in Fig. 1512, with the broadest surface against K, then if K sprung in the direction of C, the work would not be shaped true.

When the work is very narrow, however, the use of a parallel piece to regulate its height is dispensed with, and the top surface B of the jaw, in Fig. 1513, is used to set the work by. A line is marked on the work surface to set it by and a surface gauge is set upon the face B, its needle point being set to the line in a manner similar to that already explained with reference to chucking work in the lathe.

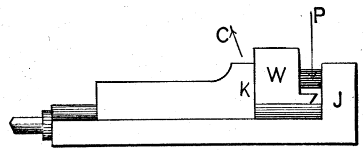

Fig. 1512.

All work should be so set that the tool will traverse across the longest length of the work, as denoted by the tool in Fig. 1502, and the arrow marking its direction of traverse.

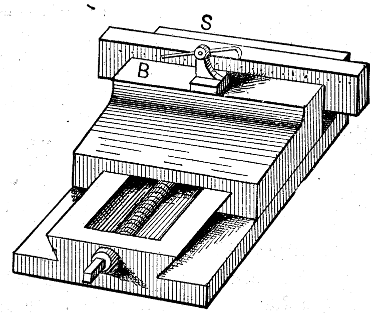

Fig. 1513.

The general principles governing the use of the shaper vice having been explained, we may now select some examples in its use.

Fig. 1514 represents a simple rectangular piece, and in order to have the tool marks run lengthwise of each surface (which is, as already stated the most expeditious) they must be in the direction of the respective arrows. In a piece of such relative proportions there would be little choice as to the order in which the surfaces should be shaped, but whatever surface be operated on first, that at a right angle to it should be shaped second; thus, if *a* be first, either *b* or *d* should be second, for the following reasons.

All the surfaces have sufficient area to enable them to serve as guides in setting the work, hence the object is to utilize them as much as possible for that purpose. Now, suppose that surface *a* has been trued first, and if *c* be the next one, then the bedding of surface *a* upon the vice surface or the parallel pieces must be depended upon to set *a* true while truing *c*. Now the surfaces *b*

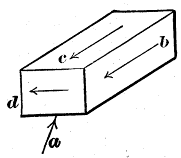

Fig. 1514.

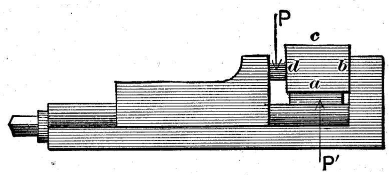

Fig. 1515.

and *d* may both, or at least one of them, may be untrue enough to cause the work to tilt or cant over, so that *a* will not bed fair, and *c* will then not be made parallel to *a*. It will be preferable then to shape *a* first and at the second chucking to set *a* against the stationary jaw of the vice, so that it may be held true.

The sliding jaw will in this case be against face *c*, and if that face is out of true enough to cant the work so that *a* will not bed fair, then a narrow parallel piece may be inserted between the sliding jaw and the work, which will cause *a* to bed fair. The third face should be face *c*, in which case face *a* will rest on one surface and face *b* will be against the fixed jaw, and there will be two surfaces to guide the work true while *c* is being trued. In this case also, however, it is better to use a parallel piece P, Fig. 1515, between the work and the sliding jaw, so as to insure that the work shall bed fair against the fixed jaw; and if necessary to bring up the top surface above the jaws, a second parallel piece P′ should be used.

Suppose now that we have a connecting rod key to shape, and it is to be considered whether the faces or the edges shall be shaped first. Now if the side faces are out of parallel it will take more filing to correct them than it will to correct the same degree of error in the edges; hence it is obviously desirable to proceed with a view to make all surfaces true, but more especially the side faces. As the set of the key while shaping these faces is most influenced by the manner in which the fixed jaw surface meets

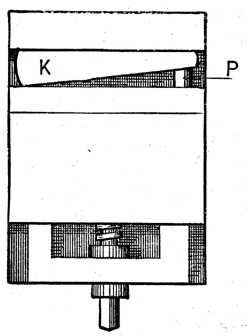

Fig. 1516.

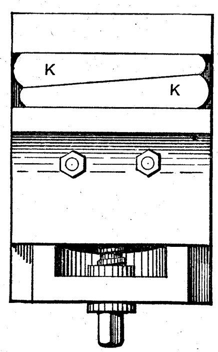

Fig. 1517.

the work, and as an edge will be the surface to meet the fixed jaw faces when the side faces are shaped, it will be best to dress one edge first, setting the key or keys, as the case may be, as was shown in Fig. 1510, so as to cut them with the tool operating lengthways of the key; one edge being finished, then one face of each key must be shaped, the key being set for this purpose with the surfaced edge against the fixed jaw. As the width of the key is taper, either a chuck with a taper attachment that will permit the sliding jaw to conform itself to the taper of the key must be used (vices having this construction being specially made for taper work as will be shown hereafter), or else the key must be held as in Fig. 1516, in which K represents the key with its trued edge against the fixed jaw, at P is a piece put in to compensate for the taper of the key, and to cause the other edge to bed firmly and fairly against the fixed jaw.

The first side face being trued, it should be placed against the fixed jaw while the other edge is shaped. For the remaining side face we shall then be able to set the key with a trued edge against the fixed jaw, and a true face resting upon a parallel piece, while the other edge will be true for the piece P, Fig. 1516, to press against, and all the elements will be in favor of setting the key

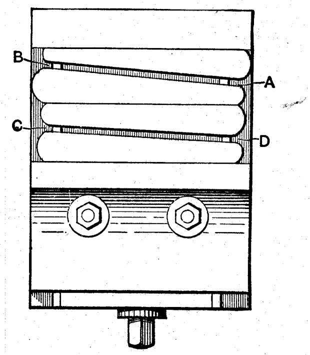

Fig. 1518.

so that the sides will be parallel one to the other, and the edges square with the faces.

In putting in the piece P, Fig. 1516, the key should be gripped so lightly that it will about bear its own weight; piece P may then be pushed firmly in with the fingers, and the vice tightened up.

If there are two keys the edges and one face may be trued up as just described, and both keys K, Fig. 1517, chucked at once by inverting their tapers as shown in figure. But in this case unless the edges are quite true they may cause the keys not to bed fair on the underneath face, and the faces therefore to be out of

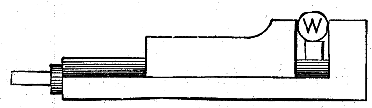

Fig. 1519.

parallel on either or both of the keys. If there are a number of keys to be cut to the same thickness it may be done as follows:—

Plane or shape first one edge of all the keys; then plane up one face, chucking them with one planed edge against each vice jaw, and put little blocks (A, B, C, D, Fig. 1518) between the rough edges; then turn them over, chuck them the same way and plane the other face, resting them on parallel pieces; then plane the other edges last.

In place of the small blocks A, B, C, D, a strip of lead, paste-

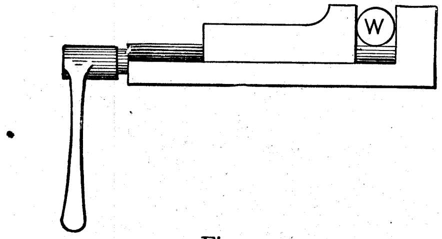

Fig. 1520.

board, or wood, or for very thin work a piece of lead wire, may be used.

Cylindrical work may be held in a vice chuck, providing that the top of the vice jaws is equal in height to the centre of the work, as in Fig. 1519, a parallel piece being used to set the work true. When, however, the work is to be shaped at one end only, it is preferable to hold it as in Fig. 1520, letting its end project out from the side of the chuck. In some vices the jaws are wider than the body of the chuck, so that cylindrical work may be held vertical, as in Fig. 1521, when the end is to be operated upon.

Fig. 1522 represents a simple form of shaper or planer chuck, such chucks being used upon small planing machines as well as upon shaping machines.

The base A is bolted to the work table, and is in one piece with the fixed jaw B. The movable jaw C is set up to meet the work by hand, and being free to move upon A may be used for either taper or parallel work. To fasten C upon the work, three screws threaded through F abut against the end of C; F being secured to the upper surface of A by a key or slip, which fits into

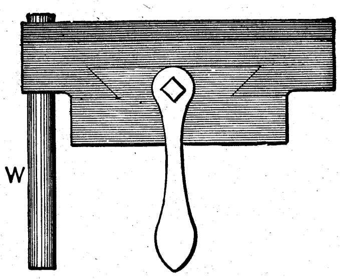

Fig. 1521.

a groove in F, and projects down into such of the grooves in the upper surface of A as may best suit the width of work to be held in the vice; C is held down by the bolts and nuts at G.

The operation of securing work in such a chuck is as follows:—The screws both at F and at G being loosened, and jaw C moved up to meet the work and hold it against the fixed jaw B, then nuts G should be set up lightly so that the sliding jaw will be set up under a slight pressure, screws F may then be set up and finally nuts G tightened.

This is necessary for the following reasons:—The work must,

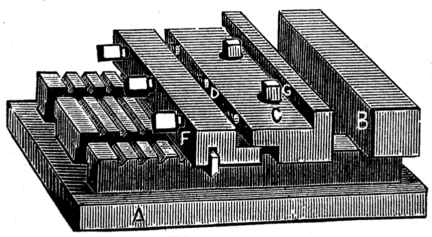

Fig. 1522.

in most cases, project above the level of the jaws so that the tool may travel clear across it; hence, the strain due to holding the work is above the level of the three screws, and the tendency, therefore, is to turn the jaw C upwards, and this tendency the screws G resist. A similar chuck mounted upon a circular base so that it may be swivelled without moving the base on the work table is shown in Fig. 1523. The capacity to swivel the upper part of the chuck without requiring the base of the chuck to be moved upon the table is a great convenience in many cases.

Fig. 1524 represents an English chuck in which the fixed jaw

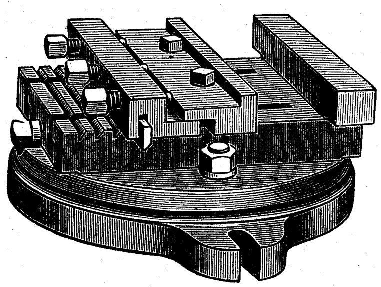

Fig. 1523.

is composed of two parts, A which is solid with the base G, and D which is pivoted to A at F. The movable jaw also consists of two parts, B which carries the nut for the screw that operates B, and C which is pivoted to B at E. The two pivots E, F being above the surface of the gripping jaws C, D, causes them to force down upon the surface of G as the screw is tightened, the work, if thin, being rested, as in the case of the chuck shown in Fig. 1523, upon parallel pieces.

Fig. 1525 represents a chuck made by W. A. Harris, of Providence. The jaws in this case carry two pivoted wings A, B, between the ends of which the work C is held, and the pivots

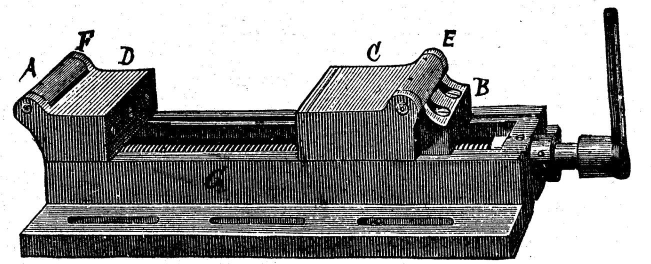

Fig. 1524.

being above the level of the work the tendency is here again to force the work down into the chuck, the strain being in the direction denoted by the arrows.

Here the work rests on four pins which are threaded in the

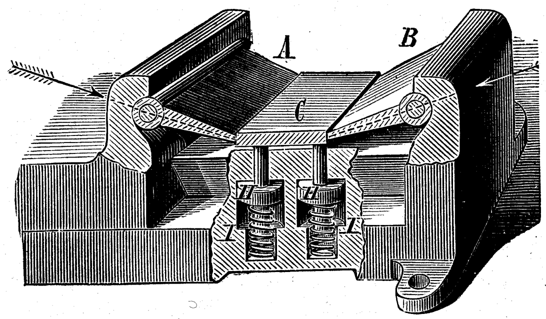

Fig. 1525.

collars H, so that by rotating the pins they will stand at different heights to suit different thicknesses of work, or they may be set to plane tapers by adjusting their height to suit the amount of taper required. The spiral springs simply support the pins, but

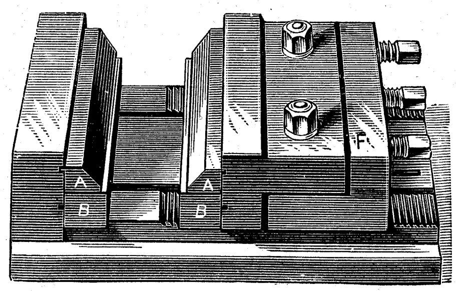

Fig. 1526.

as the jaws close the pins lower until the washer nuts H meet the surface of recess I.

Figs. 1526 and 1527 represent Thomas's patent vice, which possesses some excellent conveniences and features.

In Fig. 1526 it is shown without, and in Fig. 1527 with a swivel

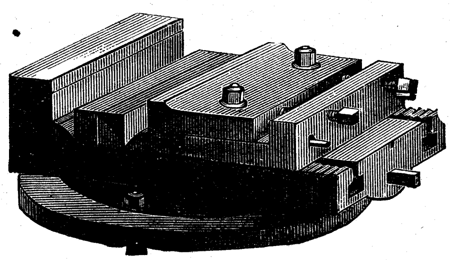

Fig. 1527.

motion. The arrangement of the jaws upon the base in Fig. 1526 is similar to that of the chuck shown in Fig. 1522, but instead of there being a key to secure the piece F to the base, there is provided on each side of the base a row of ratchet teeth, and there is within F a circular piece G (in Fig. 1528) which is serrated to engage the ratchet teeth. This piece may be lifted clear of the ratchet teeth by means of the pin at H, and then the piece F may be moved freely by hand backwards or forwards upon the base and swung at any required angle, as in Fig. 1528, or set parallel as in Fig 1527; F becoming locked, so far as its backward motion is concerned, so

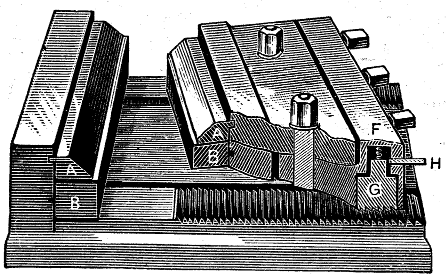

Fig. 1528.

soon as H is released and G engages with the ratchet teeth on the base. But F may be pushed forward toward the fixed jaw without lifting H, hence the adjustment of the sliding jaw to the work may be made instantaneously without requiring any moving or setting of locking keys or other devices.

It is obvious that it is the capability of G to rotate in their

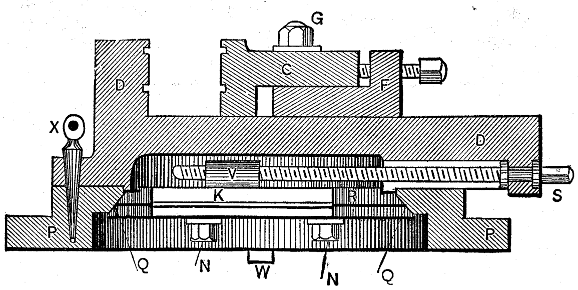

Fig. 1529.

sockets that enables F to be set at an angle and still have the teeth of G engage properly with those on the base plate.

The mechanism for swivelling the upper part or body upon the base and for locking it in its adjusted position is shown in Figs. 1529 and 1530. The body D is provided with an annular ring fitting into the bore of the base, which is coned at Q. The half-circular disks R fit this cone and are held to the body of the chuck

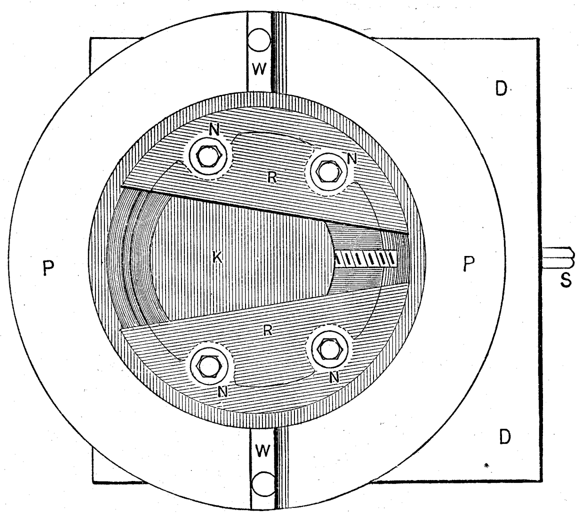

Fig. 1530.

by four bolts N, which are adjusted to admit disks R to move without undue friction. K is a key having on it the nut V, which receives a screw whose squared end is shown at S. By operating S in one direction key K expands disks R, causing them to firmly grip the base at the bevel Q, hence the base and the body are locked together. By operating S to unscrew in the nut V, K is moved in the opposite direction and R, R release their grip at Q and the body D may be swung round in any position, carrying with it all the mechanism except base P.

To enable the body to be readily moved a quarter revolution, or in other words, moved to a right angle, there is provided a taper pin, the base having holes so situated that the body will have been moved a quarter revolution when the pin having been removed from one hole in the base is seated firmly home in the other.

Referring again to Fig. 1526, there are shown one pair of

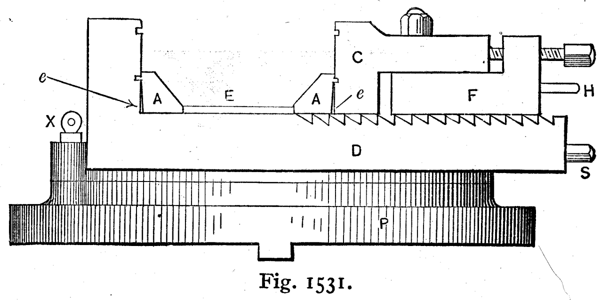

Fig. 1531.

parallel pieces marked respectively A, having bevelled edges, and another pair marked respectively B. Both pairs are provided with a small rib fitting into a groove in the jaws of the chuck, as shown in the figure.

These ribs and grooves are so arranged that the upper pair (A, A) may be used in the place of the lower ones, and the uses of these pieces are as follows:—

Suppose a very thin piece of work is to be planed, and in order to plane it parallel, which is ordinarily a difficult matter, it must

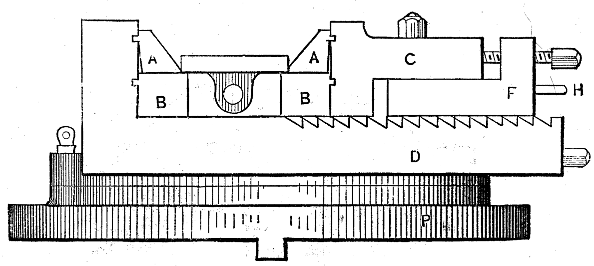

Fig. 1532.

bed fair down upon the face of the vice, which it is caused to do when chucked as in Fig. 1531, in which the work is shown laid flat upon the face of the vice, and gripped at its edges by the pieces A A.

These pieces, it may be noted, do not bed fair against the gripping faces of the jaws, but are a trifle open at the bottom as at *e*, *e*, hence when they are pressed against the work they cant over slightly and press the work down upon the chuck face causing

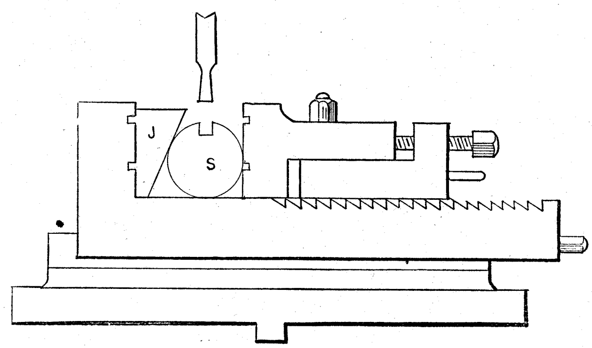

Fig. 1533.

it to bed fair. Furthermore, the work is supported beneath its whole surface, and has, therefore, less tendency to spring or bend from the holding pressure; and as a result of these two elements much thinner work can be planed true and parallel than is possible when the work is lifted up and supported upon separate parallel pieces, because in the latter case the work, being unsupported between the parallel pieces, has more liberty to bend from the pressure due to the tool cut, as well as from the holding pressure.

Fig. 1532 shows the chuck holding a bracket, having a projection or eye. The work rests on pieces B, B, and is gripped by pieces A,A. It will be observed that A, A being beveled enables the cut to be carried clear across the work.

Fig. 1533 represents the chuck in use for holding a piece of

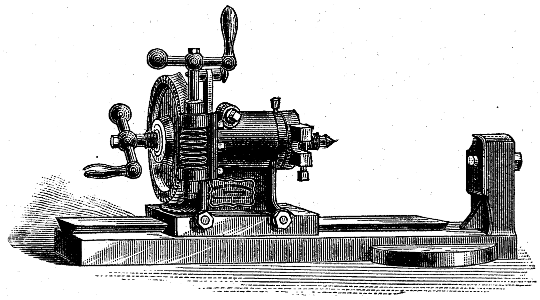

Fig. 1534.

shafting S to cut a keyway or spline in it. In this case a bevelled piece J is employed, its bevelled face holding the work down upon the chuck face.

Fig. 1534 represents a chuck termed shaper centres, because the work is held between centres as in the case of lathe work. or bed. To frames D are bolted the work-holding tables E, E, the bolts securing them passing into vertical T-grooves in D, so that E may be adjusted at such height upon D as may be found necessary to bring the work within proper range of the cutting tool. The work tables E, E are raised or lowered upon D by means of a vertical screw, which is operated by the handle H, this part of the mechanism accomplishing the same end as the elevating mechanism shown in Fig. 1496. The swivel head J is here provided at its top with a segment of a worm-wheel which may be actuated to swivel that head by the worm G.

The swivel head may thus be operated upon its pivot, causing the tool point to describe an arc of a circle of which the pivot is the centre. To steady the swivel head when thus actuated, there is behind the worm segment a V-slide that is an arc, whose centre is also the centre of the pivot.

The tool-carrying slide A is operated as follows: The driving pulley P rotates a shaft lying horizontal at the back of the machine. Along this shaft there is cut a featherway or spline driving a pinion which operates a link mechanism such as described with reference to Fig. 1550.

The means of adjusting the distance the head of A shall stand out from B, are similar to that described for Fig. 1496, a bolt passing through A, and in both cases attaching to a connecting rod or bar.

At K is a cone mandrel such as has been described with refer-

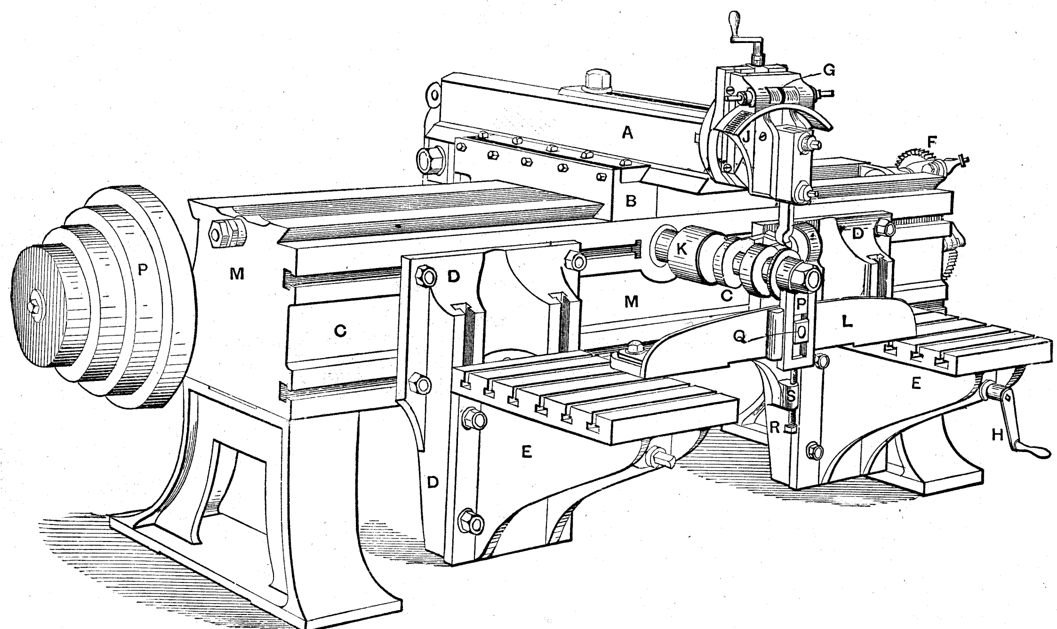

Fig. 1535.

The live spindle is carried in and is capable of motion in a sleeve, the latter having upon it a worm-wheel, operated by a worm, so that it can be moved through any given part of a circle, and has index holes upon its face to determine when the wheel has been moved to the required amount.

For work that is too large to be operated upon in the class of shaping machine shown in Fig. 1506, and yet can be more conveniently shaped than planed, a class of machine is employed in which the tool-carrying slide is fed to the work, which is chucked to a fixed table or to two tables.

Fig. 1535 represents a machine of this class. The tool-carrying slide A, in this case, operates in guideways provided in B, the latter being fitted to a slideway running the full length of the top of the frame M. The base slider B is fed along the bed by means of a screw operating in a nut on the under side of B, this screw being operated once during each stroke of the tool-carrying slide A, by means of a pawl feeding arrangement at F, which corresponds to the feeding device shown in Fig. 1501.

Two vertical frame pieces D, D are bolted against the front face of the machine, being adjustable along any part of the bed or frame length, because their holding bolts have heads capable of being moved (with the frame pieces D) along the two T-shaped grooves shown, their T-shape being visible at the end of the frame ence to lathe work upon which is chucked a cross-head C. By means of suitable mechanism, this mandrel is rotated to feed the circular circumference of the cross-head jaws to the cut, the slider B remaining in a fixed position upon the bed M.

To support the outer end of the cone mandrel a beam L is bolted to the two tables E, E. On L is a slideway for the piece P. At S is a lug upon E through which threads a screw R, which adjusts the height of the piece P, while Q is a bolt for securing P in its adjusted position. This cone mandrel and support is merely an attachment to be put on the machine as occasion may require.

Fig. 1536 represents a shaping machine by the Pratt and Whitney Company. In this machine a single sliding head is used and the work remains stationary as in the case of the machine shown in Fig. 1535. The vice is here mounted on a slide which enables the work to be finely adjusted beneath the sliding bar independently of that bar, which is provided with a Whitworth quick-return motion.

As the tool-carrying slide of a shaping machine leaves its guideways during each stroke, the tool is less rigidly guided as the length of slide stroke is increased, and on this account its use is limited to work that does not require a greater tool stroke than about 18 inches, and in small machines not to exceed 12 inches. The capacity of the machine, however, is obviously greatest when the length of the work is parallel to the line of motion of the feed traverse. Work whose dimension is within the limit of capacity

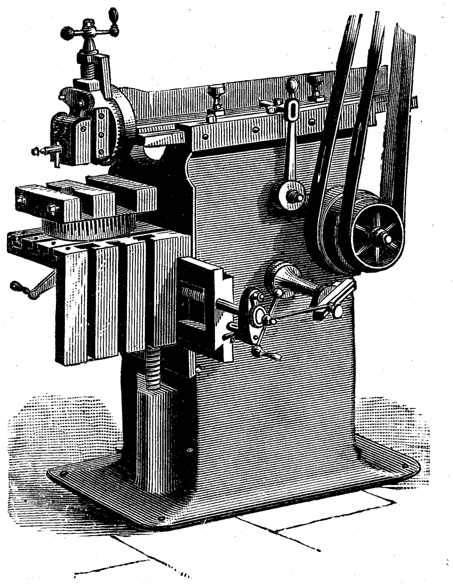

Fig. 1540.

of the shaper can, however, be more expeditiously shaped than planed because the speed of the cutting tool can be varied to suit

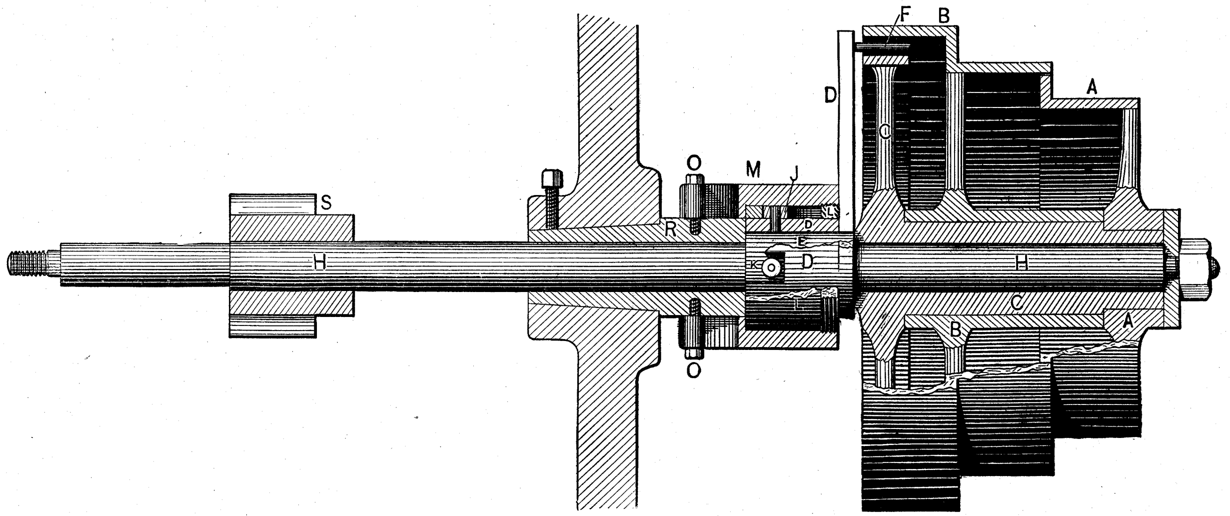

Fig. 1541.

the nature of the work, by reason of the machine having a cone pulley, whereas in a planing machine the cutting speed of the tool is the same for all sizes of work, and all kinds of metal.

In shaping machines such as shown in Fig. 1537, or in similar machines in which the work table is capable of being traversed instead of the head, the efficiency of the work-holding table and of the chucking devices may be greatly increased by constructing the table so that it will swivel, as in Fig. 1538, which may be done by means of the employment of Thomas's swivelling device in Fig. 1530. By this means the ends of the work may be operated upon without removing it from the chuck. Or the work may be shaped taper at one part and parallel at another without unchucking it.

Fig. 1539 shows a circular table swivelled by the same device, sitting upon a work table also swivelled.

Fig. 1540 represents a general view of a shaping machine having the motion corresponding in effect to a planing machine, the object being to give a uniform rate of speed to the tool throughout, both on its cutting and return stroke. The feed always takes place at the end of the return stroke, so as to preserve the edge of the tool, and the length of the stroke may be varied, without stopping the machine, by simply adjusting the tappets or dogs, the range of stroke being variable from ¼ inch to 20 inches, while the return stroke is 40 per cent. quicker than the cutting one. There are two different rates of cutting speed, one for steel and the other for the softer metals.

The ram or bar is provided with a rack (Z, Fig. 1545) which engages with a pinion S, Fig. 1541, H being the driving shaft driven by the belt cones A and B. These two cones are driven by separate belts, but from the same counter-shaft, one being an open and the other a crossed belt. The open belt drives either the largest step of pulley B, giving a cutting speed suitable for steel, or the smaller step, giving a cutting speed for softer metals, as cast iron, &c. The crossed belt drives, in either case, the pulley A for the quick-return stroke, and this pulley revolves upon a sleeve or hub C, which revolves upon the shaft H. The sleeve or hub C is in one piece with a pulley C, whose diameter is such as to leave an annular opening between its face and the bore of the largest step of cone pulley B, and pulley A is fast to the hub or sleeve C. It will be seen that as the driving belts from the counter-shaft are one open and one crossed, therefore pulley A runs constantly in one direction, while pulley B runs constantly in the other, so that the direction of motion of the driving shaft H depends upon whether it is locked to pulley A or to pulley B.

In the annular space left between the face of pulley C and the cone B is a steel band G, Fig. 1542, forming within a fraction a complete circle, and lined inside and out with leather, and this band is brought, by alternately expanding and contracting it, into contact with either the bore of the largest cone step of B or with the outside face of pulley C. The ends of this band are pivoted upon two pins F, which are fast in two arms E and D, in Fig. 1542. Arm E is fastened to the driving shaft H, and its hub has

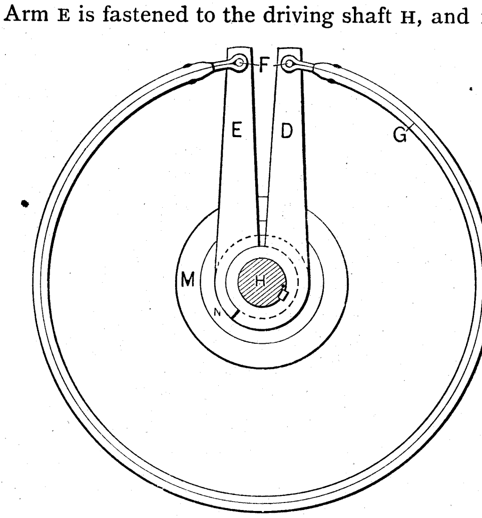

Fig. 1542.

two roller studs K, Fig. 1541, these being diametrically opposite on the said hub. The hub of arm D is a working fit upon the hub

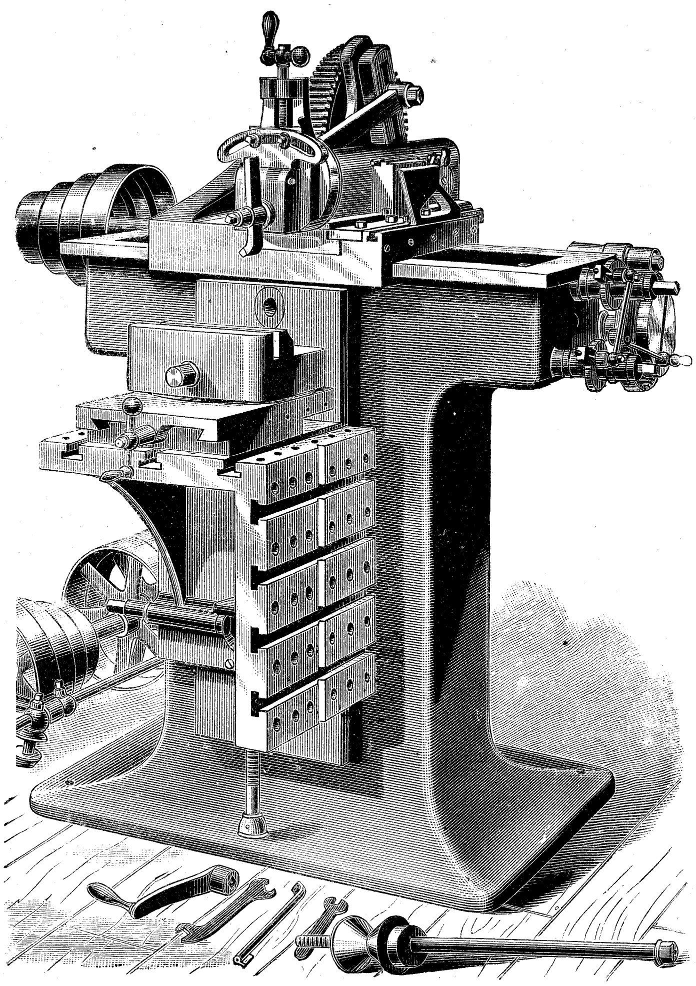

Fig. 1536.

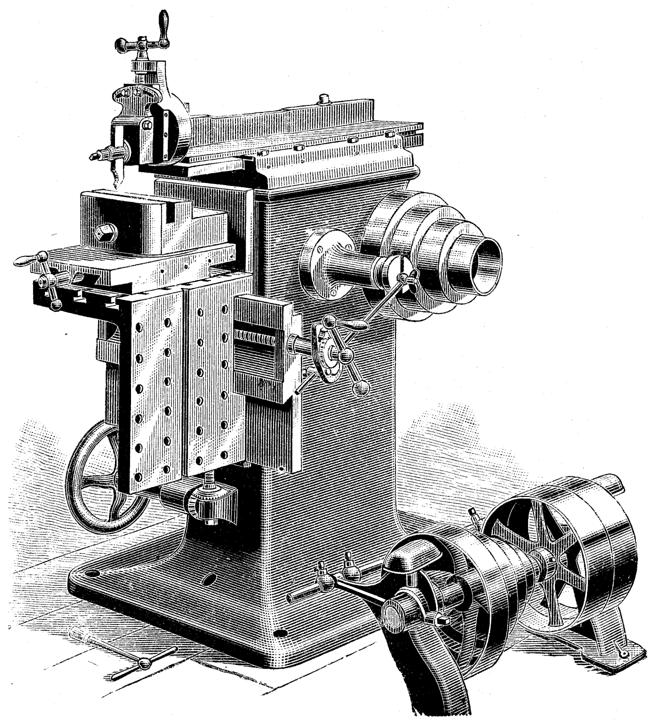

Fig. 1537.

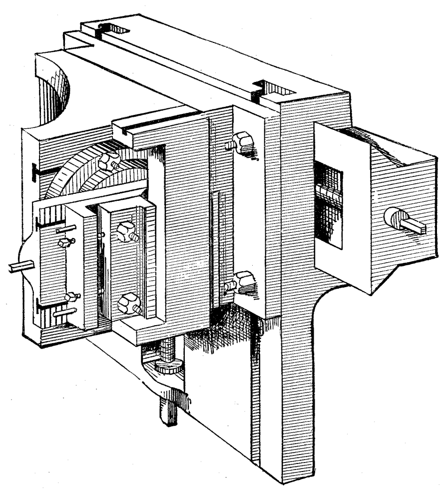

Fig. 1538.

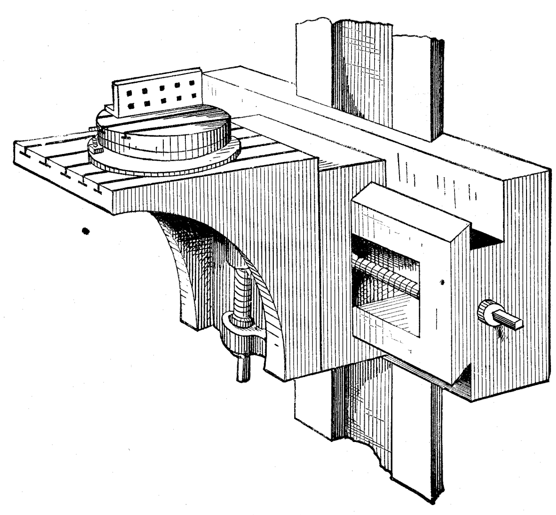

Fig. 1539.

of E, and has two slots to admit the above rollers. Hub D is also provided with two studs and rollers placed midway between the studs K. These latter rollers project into the spiral slots K′ of the ring in Fig. 1543, this ring enveloping the hub of D and being enveloped by the sleeve M, which contains two spiral grooves diametrically opposite, and lying in an opposite direction to grooves K′, Fig. 1543. Sleeve M is prevented from revolving by rollers on the studs O, which are screwed into the bearing bush R, and carry rollers projecting into the slots in M.

It is evident that if the ring L, Fig. 1543, is moved endways

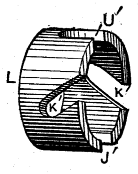

Fig. 1543.

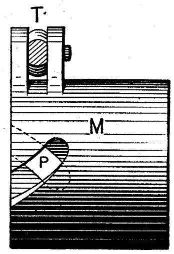

Fig. 1544.

with M, then the arms E, D, together with the band G, will be expanded or contracted according to the direction of motion of the ring, because the motion of M, by means of its spiral grooves, gives a certain amount of rotary motion to the ring L, and the spiral grooves in the ring give a certain amount of rotary motion to the arms D and E, Fig. 1542. When this rotary motion is in one direction the band is expanded; while when it is reversed it is contracted, and the direction of motion of shaft H is reversed.

The outer sleeve M carries the rod T, Figs. 1544 and 1545, which is connected to the lever U, the upper arm of which is

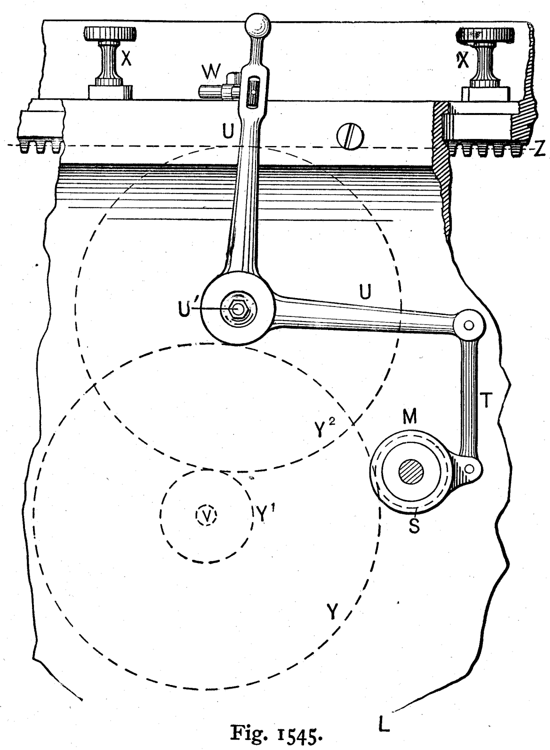

Fig. 1545.

operated by the tappets or dogs X on the ram or sliding bar, and it is obvious that when U is vibrated sleeve M is operated in a corresponding direction, and the ring L also is moved endwise in a corresponding direction, actuating the band as before described, the direction of motion being governed, therefore, by the direction in which U is moved by the tappets or dogs. A certain degree of friction is opposed to the motion of lever U in order to keep it steady, the construction being shown in Fig. 1546, where it is seen that there is on each side of its nut a leather washer, giving a certain amount of elasticity to the pressure of the nut holding it in place on the shaft U.

The mechanism for actuating the feed at the end of the return stroke only, is shown in Fig. 1547. The shaft V (which is also seen in a dotted circle in Fig. 1545) carries a flange *c*, on each side of which is a leather disk, so that the pressure of the bolts which secure *b* to the sleeve *a* causes *c* to revolve under friction, unless sleeve *a*, slotted bar *b*, and flange *c* all revolve together, or,

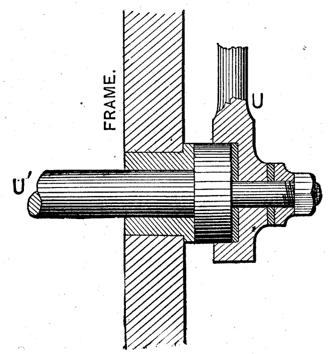

Fig. 1546.

in other words, *c* revolves under friction when it revolves within *a b*.

Fig. 1548 is an end view of Fig. 1547.

Fig. 1549 gives a cross-sectional view of the shaft sleeve, &c. The sleeve *a* is provided with two pins *i*, *i*, and a pin *k* is fast in the frame of the machine, and it is seen that *a* and V may revolve together in either direction until such time as one of the pins *i* meets the stationary pin *k*, whereupon the further revolving of *a*

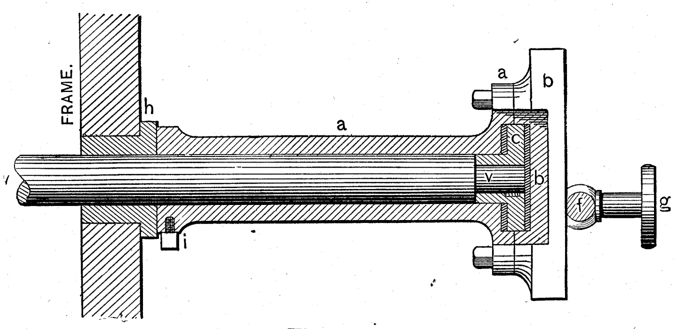

Fig. 1547.

will be arrested and V will revolve within *a*, and as flange *c*, Fig. 1547, revolves with V, it will do so under the friction of the leather washers. The pins *i* and the pin *k* are so located that *a* can have motion only when the ram or sliding-bar is at the end of the return stroke, and the feed-rod *f*, being connected to *b*, is therefore actuated at the same time.

Among the various mechanisms employed to give a quick return to the tool-carrying slide of shaping machines, those most

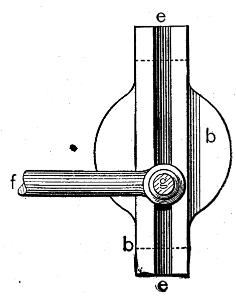

Fig. 1548.

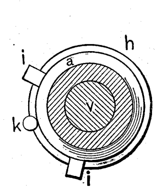

Fig. 1549.

frequently employed are a simple crank, a vibrating link, and the Whitworth quick-return motion, the latter being the most general one.

The principle of action when a vibrating link is employed may be understood from Fig. 1550, in which P is a pinion driven by the cone pulley and imparting motion to D. At L is a link pivoted at C. At A is a link block or die capable of sliding in the slot or opening in the link and a working fit upon a pin which is fast in the wheel D. As D rotates the link block slides in the slot and the link is caused to travel as denoted by the dotted lines. R is a rod connecting the tool-carrying slide S to the upper end of link

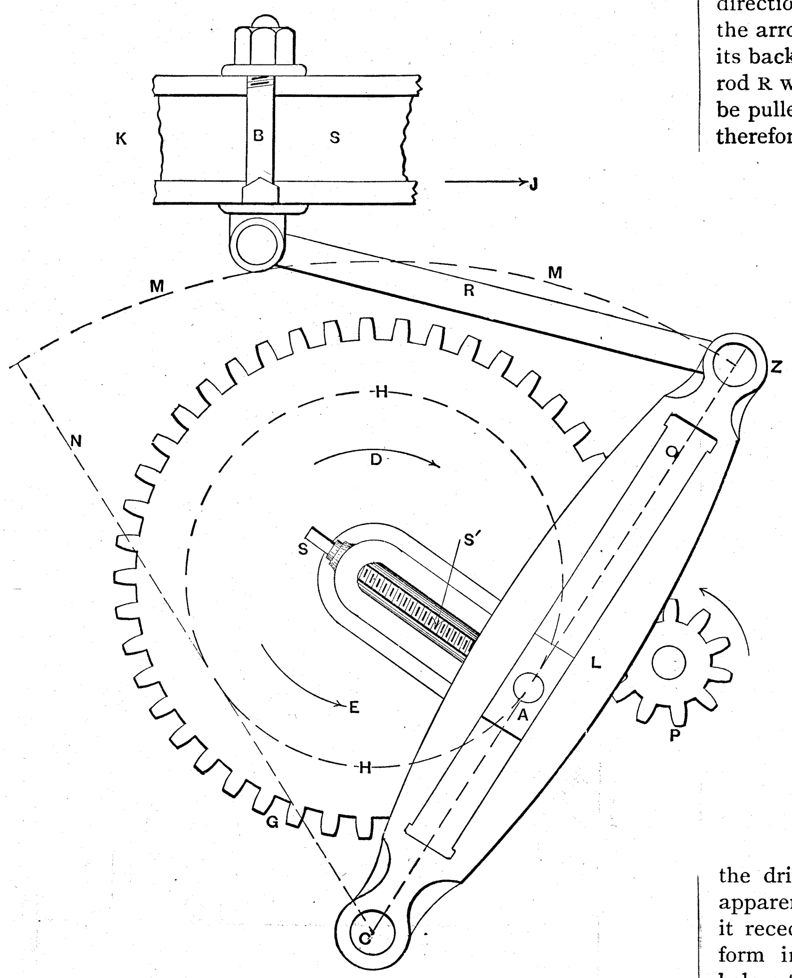

Fig. 1550.

L, and therefore causing it to reciprocate with L. But S being guided by its slide in the guideway traverses in a straight line.

Since the rotation of P and D is uniform, the vibrations of the link L will vary in velocity, because while the link block is working in the lower half of the link slot it will be nearer to the centre of motion C of the link, and the upper end of C will move proportionately faster. The arrangement is such that during this time the tool-carrying slide is moved on its return stroke, the cutting stroke being made while the link block is traversing the upper half of the slot, or in other words, during the period in which the crank pin in A is above the horizontal centre of wheel D.

Now suppose the arrangement of the parts is such that the front of the machine or the cutting tool end of the slide is at the end K of S, then S will be pushed to its cut by the rod R at an angle which will tend to lift S in the slideways. But suppose the direction of rotation of wheel D instead of being as denoted by the arrow at D be as denoted by the arrow at E, then S will be on its back stroke, the front of the machine being at J. In this case rod R will pull S to the cut, and S will, from the angularity of R, be pulled down upon the bed of the slideway guiding it, and will therefore be more rigidly held and less subject to spring, because the tendency to lift is resisted on one side by the adjustable gib only, and on the other by the projecting V, whereas the tendency to be pulled downwards is resisted by the strength of the frame of the machine.

Furthermore, as the pressure on the cutting tool is below the level of the tool-carrying slide it tends to force that slide down upon the slideway, and it will therefore be more rigidly and steadily guided when the force moving the slide and the tool pressure both act in the same direction.

To vary the length of stroke of S pin A is so attached to wheel D that it may be adjusted in its distance from the centre of D.

The Whitworth quick-return motion is represented in Fig. 1551. At P is the pinion receiving motion from the cone pulley or driving pulley of the machine and imparting motion to the gear-wheel G, whose bearing is denoted by the dotted circle B. Through B passes a shaft C, which is eccentric to B and carries at its end a piece A in which is a slot to receive the pin X, which drives rod R whose end Z is attached to the ram of the machine. At D is a pin fast in gear-wheel G and passing into a slot in A.

Taking the position the parts occupy in the figures, and it is seen that the axis of B is the centre of motion of G and is the fulcrum from which the pin D is driven, the power being delivered at X. The path of motion of the driving pin D is denoted by the dotted circle H′, and it is apparent that as it moves from the position shown in the figure it recedes from the axis of C, and as the motion of G is uniform in velocity therefore D will move A faster while moving below the line M than it will while moving above it, thus giving a quick return, because the cutting stroke of the ram occurs while D is above the line M and the return stroke occurs while D is below M.

In some constructions the pin X and pin D work in opposite ends of the piece A, as shown in Fig. 1552. This, however, is an undesirable construction because the shaft C becomes the fulcrum, and as the power and resistance are on opposite ends of the lever A, the wheel G is therefore forced against its bearing, and this induces unnecessary friction and wear.

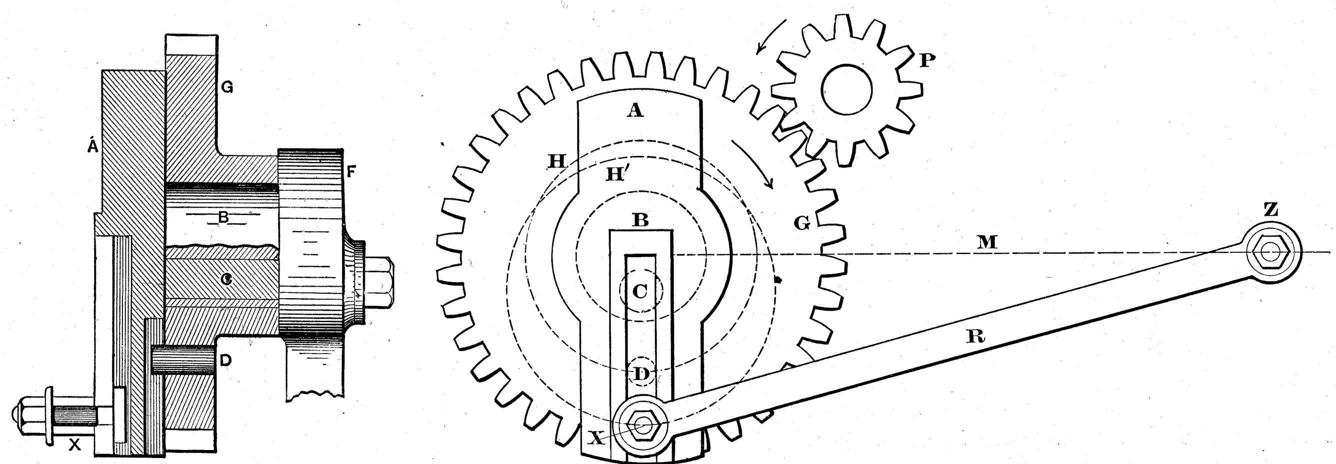

Fig. 1551.

We may now consider the tool motion given by other kinds of slide operating mechanism.

In Fig. 1553 is a diagram of the tool motion given when the slide is operated by a simple crank C, the thickened line R representing the rod actuating the slide and line on the line of motion of the cutting tool. The circle H denotes the path of revolution of the crank pin, and the black dots 1, 2, 3, 4, &c., equidistant positions of the crank pin.

Line *m* represents the path of motion of the cutting tool.

If a pair of compasses be set to the full length of the thick line

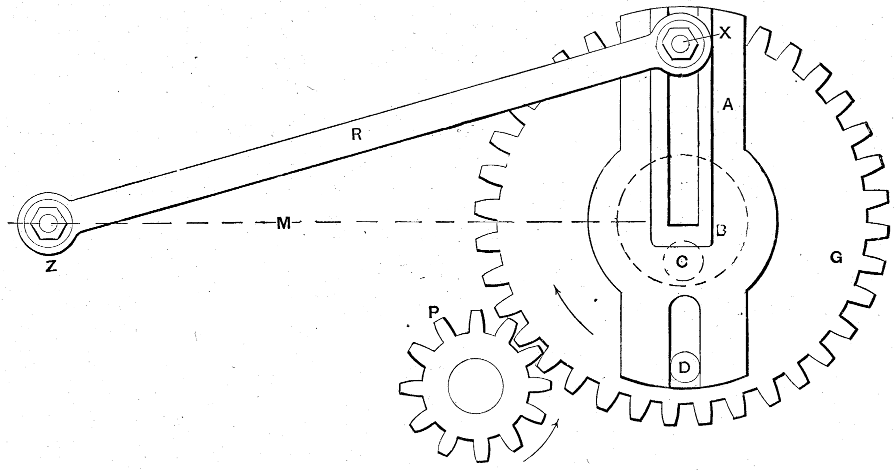

Fig. 1552.

R, that is from the centre of the crank pin to end B of line R, and these compasses be then applied to the centre of crank pin position 1, and to the line *m*, they will meet *m* at a point denoted by line *a*, which will, therefore, represent the position of the tool point when the crank pin was in position 1. To find how far the tool point is moved while the crank pin moves from position 1 to position 2, we place the compass point on the centre of crank pin position 2 and mark line *b*. For crank position 3 we have by the same process line *c*, and so on, the twelve lines from *a* to *l* representing crank positions from 1 to 12.

Now let it be noted that since the path of the crank pin is a circle, the tool point will on the backward stroke occupy the same position when the crank pin is at corresponding positions on the forward and backward strokes. For example, when the crank pin is in position 7 the tool point will be at point *g* on the forward stroke, and when the crank pin is in position 17 the tool will be at point *g* on the backward stroke, as will be found by trial with the compasses; and it follows that the lines *a*, *b*, *c*, &c., for the forward stroke will also serve for the backward one, which enables us to keep the engraving clear, by marking the first seven positions on one side of line *m*, and the remaining five on the other side of *m*, as has been done in the figure.

Obviously the distances apart of the lines *a*, *b*, *c*, *d*, &c., repre-

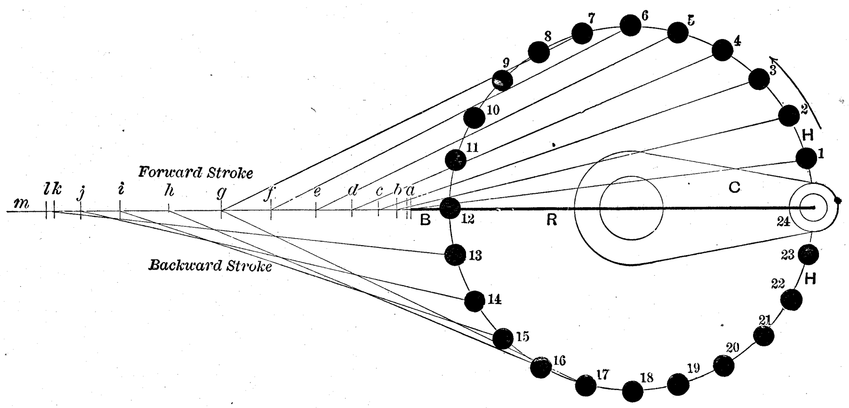

Fig. 1553.

sent the amount of tool motion during equal periods of time, because the motion of the crank pin being uniform it will move from position 1 to position 2 in the same time as it moves from position 2 to position 3, and it follows that the cutting speed of the tool varies at every instant in its path across the work, and also that since the crank pin operates during a full one-half of its revolution to push the tool forward, and during a full one-half to pull it backward, therefore the speed of the two strokes are equal.

We may now plot out the motion of the link quick return that was shown in Fig. 1550, the dotted circle H′, in Fig. 1554, representing the path of the pin A, and the arc H representing the line of motion of the upper end of link L, and lines N, O, its centre line at the extreme ends of its vibrating motion. In Fig. 1554 the letters of reference refer to the same parts as those in Fig. 1550. We divide the circle H′ of pin motion into twenty-four equidistant parts marked by dots, and through these we draw lines radiating from centre C and cutting arc H, obtaining on the arc H the various positions for end Z of rod R, these positions being marked respectively 1, 2, 3, 4, &c., up to 24. With a pair of compasses set to the length of rod R from 1 on H, as a centre, we mark on the line of motion of the slide line *a*, which shows where the other end of the rod R will be (or, in other words, it shows the position of bolt B in Fig. 1550), when the centre of A, Fig. 1550, is in position 1, Fig. 1554.

From 2 on arc H, we mark with the compasses line *b* on line M, showing that while the pin moved from 1 to 2, the rod R would move slide S, Fig. 1550, from *a* to *b*, in Fig. 1554. From 3 we mark *c*, and so on, all these marks being above the horizontal

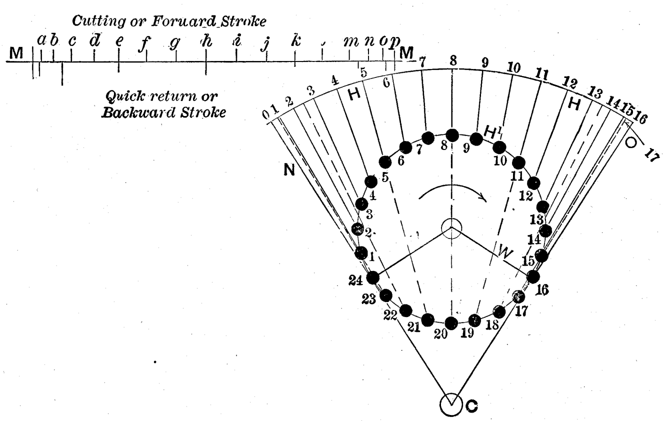

Fig. 1554.

line M, representing the line of motion, and being for the forward stroke. For the backward stroke we draw the dotted line from position 17 up to arc H, and with the compasses at 17 mark a line beneath the line M of motion, pursuing the same course for all the other pin positions, as 18, 19, &c., until the pin arrives again at position 24, and the link at O, and has made a full revolution, and we shall have the motion of the forward stroke above and that of the backward one below the line of motion of the slide.

On comparing this with the crank and with the Whitworth motion hereafter described, we find that the cutting speed is much more uniform than either of them, the irregularity of motion occurring mainly at the two ends of the stroke.

In Fig. 1555 we have the motion of the Whitworth quick return described in Fig. 1551, H′ representing the path of motion of the driving-pin D about the centre of B, and H the path of motion of X about the centre C, these two centres corresponding to the centres of B and C respectively in Fig. 1551. Let the line M correspond to the line of motion M in Fig. 1551. Now, since pin D, Fig. 1551, drives, and since its speed of revolution is uniform, we divide its circle of motion H′ into twenty-four equal divisions, and by drawing lines radiating from centre B, and passing through the lines of division on H′, we get on circle H twenty-four positions for the pin X in Fig. 1551. Then setting the compasses to the length of the rod (R, Fig. 1551), we mark from position 1 on circle H as a centre, line *a*; from position 2 on H we mark line *b*, and so on for the whole twenty-four positions on circle H, obtaining from *a* to *n* for the forward, and from *n* to *y* for the motion during the backward stroke. Suppose, now, that the mechanism remaining precisely the same as before, the line M of motion be in a line with the centres C, B, instead of at a right angle to it, as it is in Fig. 1551, and the motion under this new condition will be as in Fig. 1556, the process for finding the amount of motion along M from the motion around H being precisely as before.

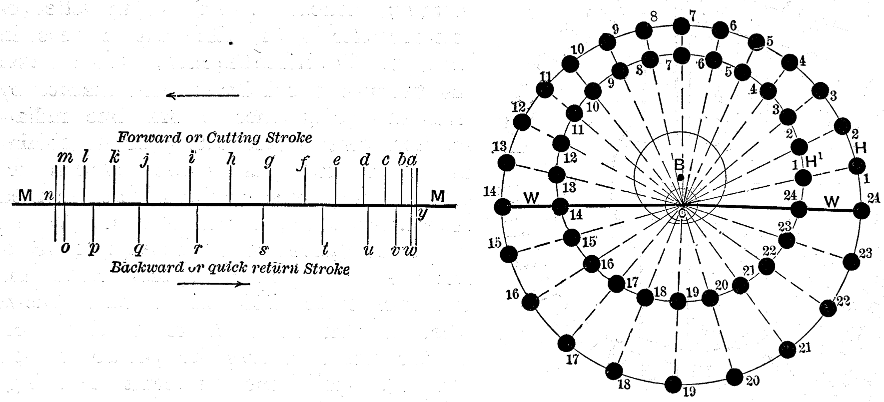

Fig. 1555.

The iron planing machine, or iron planer as it is termed in the United States, is employed to plane such surfaces as may be operated upon by traversing a work table back and forth in a straight line beneath the cutting tool. It consists essentially of a frame or bed A, Fig. 1557, provided on its upper surface with guideways, on which a work carrying table T may be moved by suitable mechanism back and forth in a straight line.

This frame or bed carries two upright frames or stanchions B, which support a cross-bar or slide C, to which is fitted a head which carries the cutting tool.

To enable the setting of the tool at such a height from the table as the height of the work may require, the cross slide C may be raised higher upon the uprights B by means of the bevel gears F, G, H, and T, the latter being on a shaft at the top of the machine, and operating the former, which are on vertical screws N, which pass down through nuts that are fast upon the cross slide C.

To secure C at its adjusted height, the uprights are provided with T-shaped slots H H, and bolts pass through C, their heads being in the T-grooves, and their nuts exposed so that a wrench may be applied to them.

The faces of the cross slide C are parallel one to the other, and stand at a right angle to the V-guideways on which the work table (or platen as it is sometimes termed) slides; hence the cross slide will, if the table is planed true or parallel with this cross slide, be parallel with the table at whatever height above the table it is set, providing that the elevating screws, when operated, lift each end of C equally.

The construction of the head D corresponds to that of the head shown in Figs. 1497 and 1498 for a shaper, except that in this case the swivel head is secured to a saddle that slides along C, being provided with a nut operated by a feed screw J, which moves D along C.

The mechanism for operating the work table or platen T is as follows:—P P′ are two loose pulleys and P″ is a driving pulley fast on the same shaft. This shaft drives, within the casing at Q, a worm operating a worm-wheel, which actuates inside the frame A and beneath the work table a train of gears, the last of which gears with a rack, provided on the underneath side of the table.

The revolutions of this last wheel obviously cause the work table to slide back and forth while resting on the V-guideways provided on top of the frame A, the direction of table motion being governed by the direction in which the wheel revolves.

This direction is periodically reversed as follows:—The pulley P is driven by a crossed belt, while pulley P′ is driven by an open or uncrossed one, hence the direction of revolution of the driving pulley P″ will be in one direction if the belt is moved from P to P″, and in the other if the belt is moved from P′ to P″. Mechanism is provided whereby first one and then the other of these belts is moved so as to pass over upon P″ and drive it, the construction being as follows:—

To the edge of the work table there is fixed a stop R, which as the table traverses to the right meets and moves a lever arm S, which through the medium of a second lever operates the rod X, which operates a lever *u*, which has a slot through which one of the driving belts passes. The lever *u* operates a second lever *w* on the other side of the pulleys, and this lever also has a slot through which the other driving belt passes.

When the stop R moves the lever arm S levers *u* and *w* therefore move their respective belts, one moving from the tight pulley P″ to a loose one as P, and the other moving its belt from the loose pulley as P′ to the tight one P″, and as the directions of belt motions are opposite the direction of revolution of P″ is reversed by the change of belt operating it. There are two of the stops R, one on each side of the lever S, hence one of these stops moves the lever S from left to right and the other from right to left.

Suppose, then, that the table is moving from right to left, which is its cutting stroke, and the driving belt will be on the pulley P″ while the other belt will be on pulley P. Then as the stop R moves S and operates X the arm *u* will move its belt from P″ to P′, and arm *w* will move its belt from P to P″, reversing the direction of motion of P″, and therefore causing the table T to move from left to right, which it will continue to do until the other stop corresponding to R meets S and moves it from right to left, when the belts will be shifted back again. The stroke of the table, therefore, is determined by the distance apart of the stops R, and these may be adjusted as follows:—

They are carried by bolts whose heads fit in a dovetail groove Z provided along the edge of the table, and by loosening a set screw may therefore be moved to any required location along the bed.

To give the table a quick return so that less time may be occupied for the non-cutting stroke, all that is necessary is to make the countershaft pulley that operates during the back traverse of larger diameter than that which drives during the cutting traverse of the table.

In order that one belt may have passed completely off the driving pulley P″ before the other moves on it the lever motions of *u* and *w* are so arranged that when the belt is moving from P″ to P lever *u* moves in advance of lever *w*, while when the other belt is being moved from P″ to P′ lever *w* moves in advance of lever *u*.

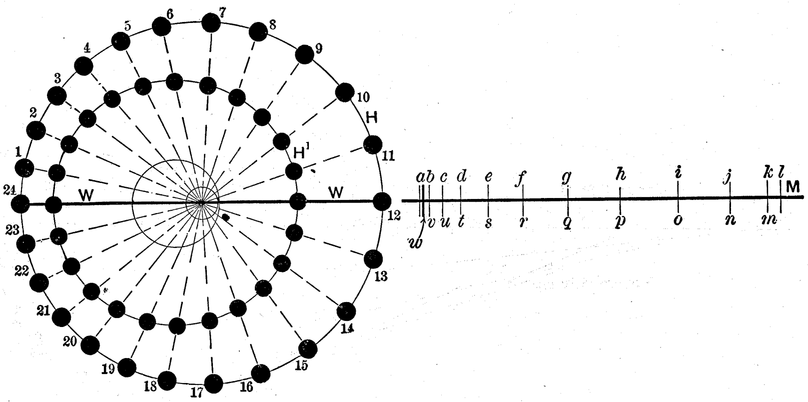

Fig. 1556.

To enable the work table to remain at rest, one driving belt must be upon P and the other upon P′, which is the case when the lever arm S is in mid position, and to enable it to be moved to this position it is provided with a handle K forming part of lever S.

To cause the tool to be fed to its cut before it meets the cut and thus prevent it from rubbing against the side of the cut, as was described with reference to Fig. 1503, the feed takes place when

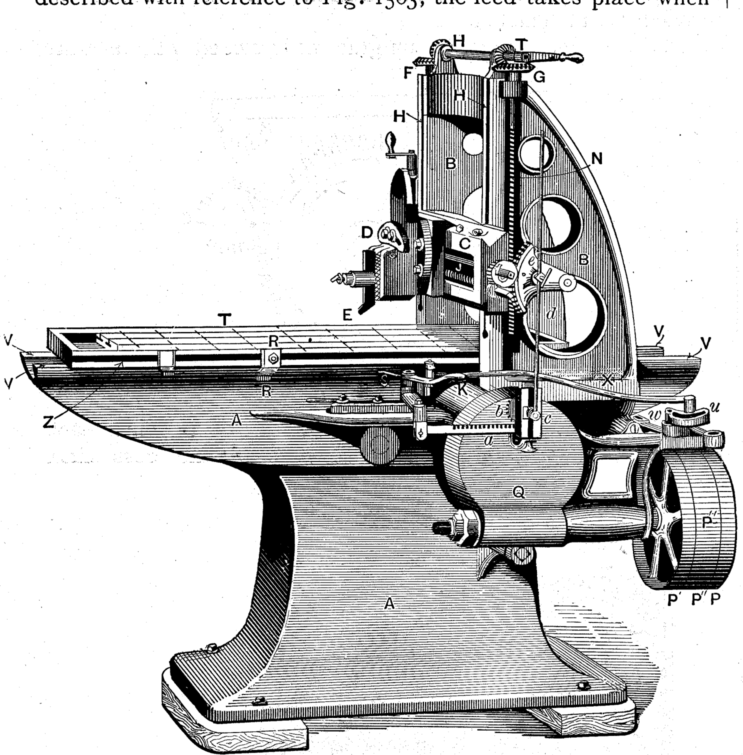

Fig. 1557.

the table motion is reversed from the back or return stroke to the cutting or forward stroke by the following mechanism :—

At a is a rack that is operated simultaneously with S and by the same stop R. This rack operates a pinion b, which rotates the

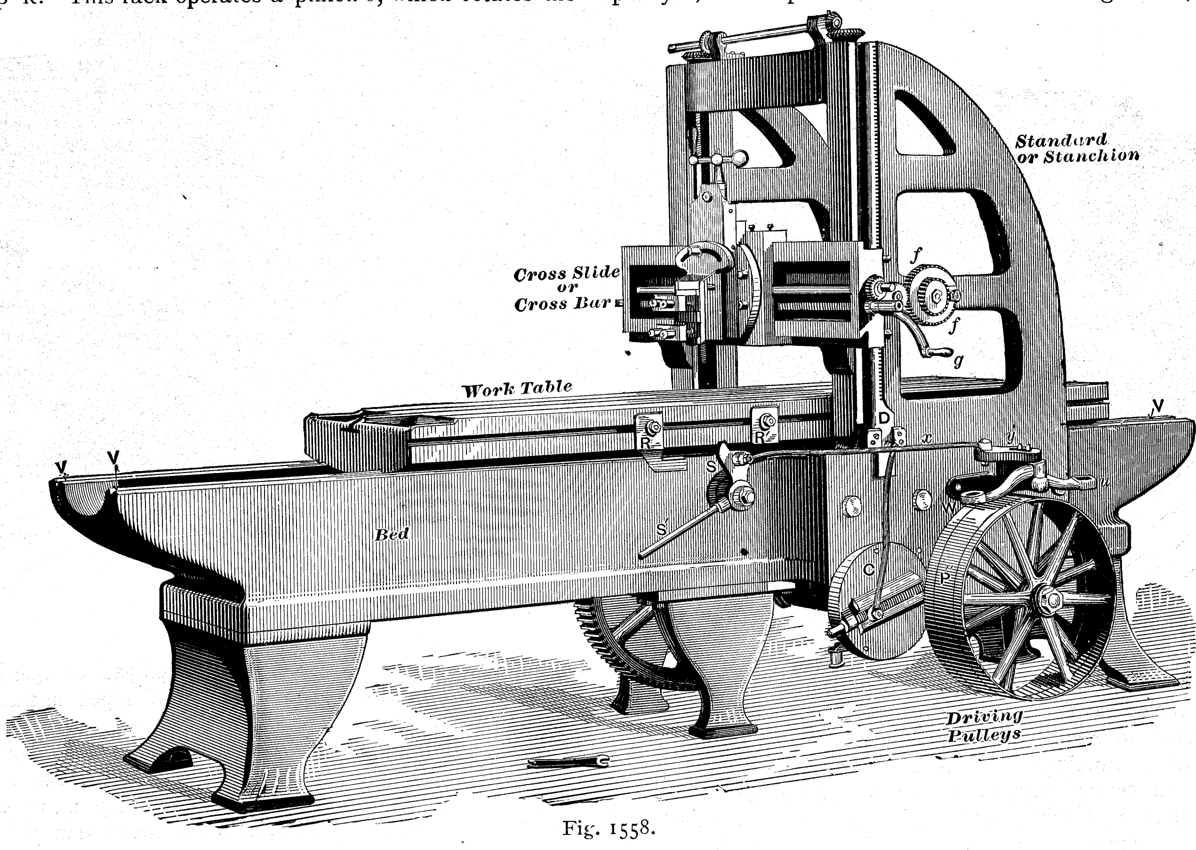

Fig. 1558.

slotted piece c, in which is a block that operates the vertical rod d, which is attached to a segmental rack e, which in turn operates a pinion which may be placed either upon the cross-feed screw J, or upon the rod above it ; the latter operates the vertical feed of the tool through mechanism within the head D and not therefore shown in the engraving. Thus the self-acting tool feed may take place vertically or across the work table at will by simply placing the pinion upon the cross-feed screw or upon the feed rod, as the case may be.

Fig. 1558 represents a planer by David W. Pond, of Worcester, Massachusetts, in which the rod x is connected direct from S to a pivoted piece y in which is a cam-shaped slot through which pass pins from the belt-moving arms u and W. The shape of the slot in y is such as to move the belt-moving arms one in advance of the other, as described with reference to Fig. 1566.

The feed motions are here operated by a disk C, which is actuated one-half a revolution when the work table is reversed. This disk is provided on its face with a slideway in which is a sliding block that may be moved to or from the centre of C by the screw shown, thus varying at will the amount of stroke imparted to the rod which moves the rack by means of which the feed is actuated through the medium of the gear-wheels at f. The handle g is for operating the feed screw when the self-acting feed is thrown out of operation, which is done by means of a catch corresponding in its action to the catch shown in Fig. 1501. S and S′ are in one piece, S′ being to move the two driving belts on to the loose pulleys so as to stop the work table from traversing.

The size of a planer is designated from the size of work it will plane, and this is determined by the greatest height the tool can be raised above the planer table, the width between the stanchions, and the length of table motion that can be utilized while the tool is cutting ; which length is less than the full length of table stroke, because in the first place it is undesirable that the rack should pass so far over the driving wheel or pinion that any of the teeth disengage, and, furthermore, a certain amount of table motion is necessary to reverse after the work has passed the tool at the end of each stroke.

Fig. 1559 represents a method employed in some English planing machines to drive the work table and to give it a quick return motion. In this design but one belt is used, being shifted from pulley A, which operates the table for the cutting stroke, to pulley J, which actuates the table for the return stroke. The middle pulley K is loose upon shaft B, as is also pulley J, which is in one piece with pinion J′. Motion from A is conveyed through shaft B and through gear C, D, E to F, and is reduced by reason of the difference in diameter between D and E and between F and G. Motion for the quick return passes from J direct to F without being reduced by gears D, E, hence the difference between the cutting

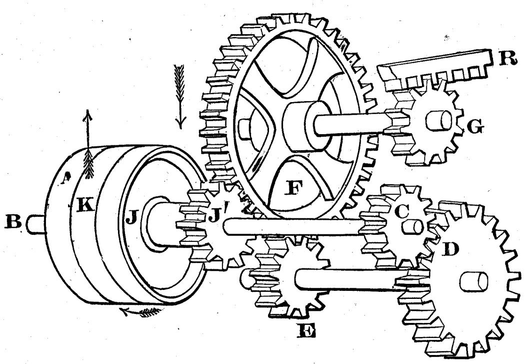

Fig. 1559.

speed and the speed of the return stroke is proportionate to the relative diameters or numbers of teeth in D and E, and as E contains 12 and D 20 teeth, it follows that the return is $\frac{8}{12}$ quicker than the cutting stroke.

In this design the belt is for each reversal of table motion moved across the loose pulley K from one driving pulley to the other, and therefore across two pulleys instead of across the width of one pulley only as in American machines.

In American practice the rack R, Fig. 1559, is driven by a large gear instead of by a pinion, so that the strain on the last driving shaft S, in Fig. 1560, shall be less, and also the wheel less liable to vibration than a pinion would be, because in the one case, as in Fig. 1559, the power is transmitted through the shaft, while in the other, as in Fig. 1560, it is transmitted through the wheel from the pinion P to the rack R.

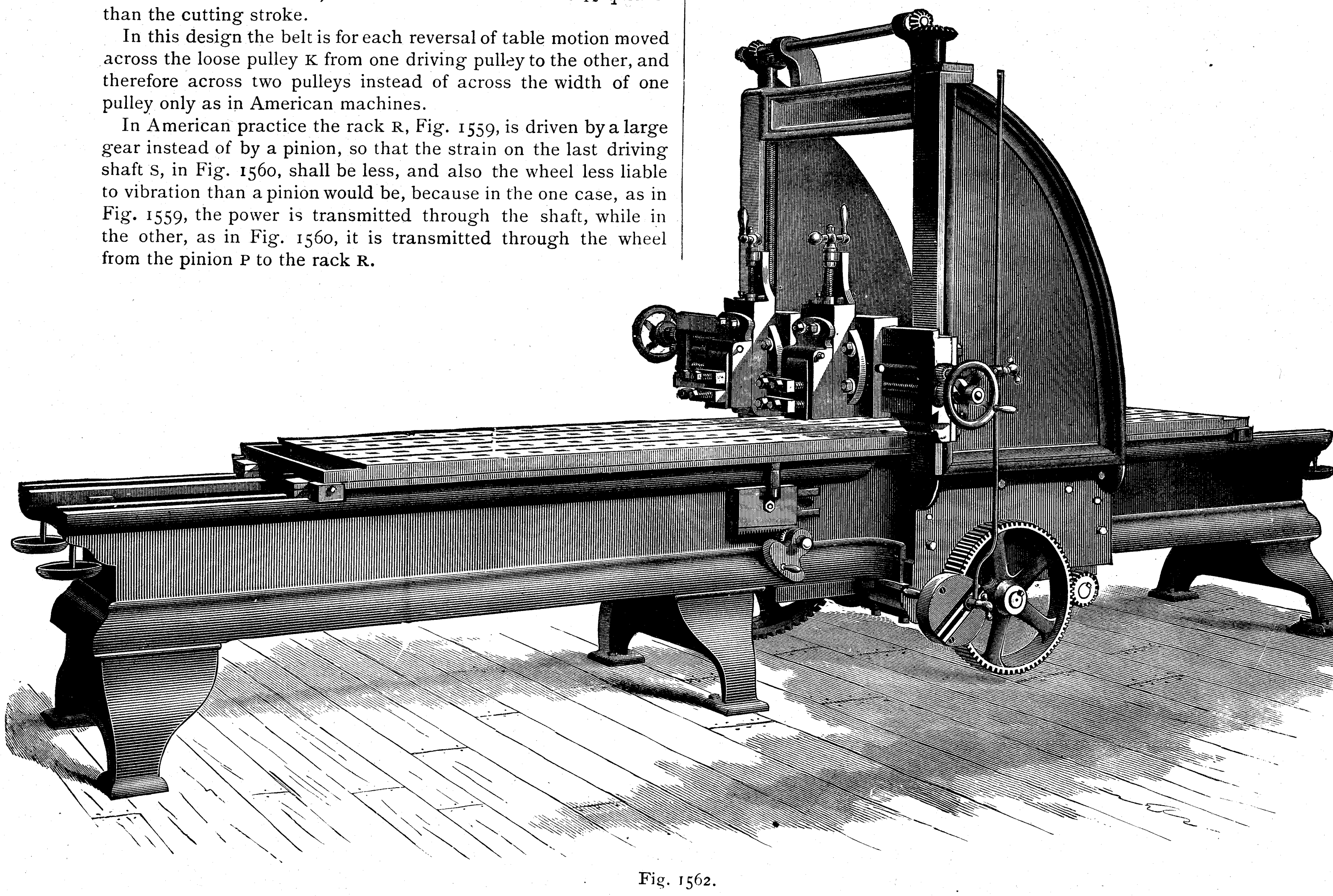

Fig. 1562.

Fig. 1561 represents a planer, designed for use in situations where a solid foundation cannot be obtained, hence the bed is made of unusual depth to give sufficient strength and make it firm and solid on unstable foundations, such as the floors in the upper stories of buildings. In all other respects the machine answers to the general features of improved planing machines.

As the sizes of planing machines increase, they are given increased tool-carrying heads; thus, Fig. 1562 represents a class in which two sliding heads are used, so that two cutting tools may operate simultaneously. Each head, however, is capable of independent operation; hence, one tool may be actuated automatically along the cross slide to plane the surfaces of the work, while the other may be used to carry a cut down the sides of the work, or one tool may take the roughing and the other follow with the finishing cut, thus doubling the capacity of the machine.

In other large planers the uprights are provided with separate

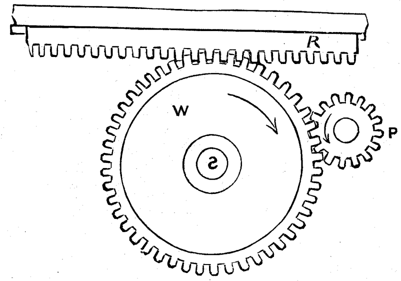

Fig. 1560.

heads as shown in the planer in Fig. 1563, in which each upright is provided with a head shown below the cross slide. Either or both these heads may be employed to operate upon the vertical side faces of work, while the upper surface of the work is being planed.

The automatic feed motion for these side heads is obtained in the Sellers machine from a rod actuated from the disk or plate in figure, this rod passing through the bed and operating each feed by a pawl and feed wheel, the latter being clearly seen in the figure.

To enable the amount of feed to be varied the feed rod is driven by a stud capable of adjustment in a slot in the disk.

Fig. 1563 represents a planing machine designed by Francis Berry & Sons, of Lowerby Bridge, England. The bed of the machine is, it will be seen, L-shaped, the extension being to

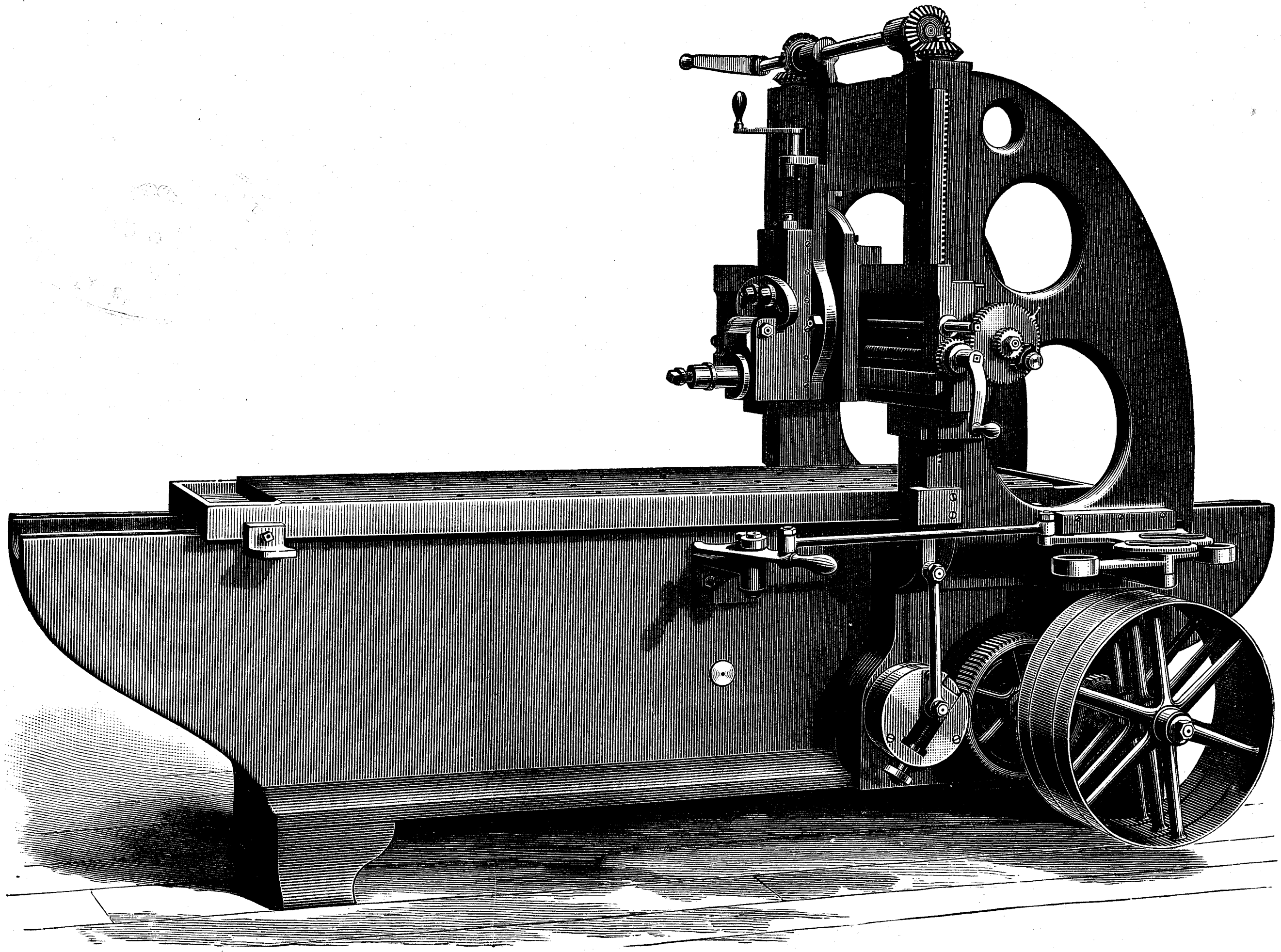

Fig. 1561.

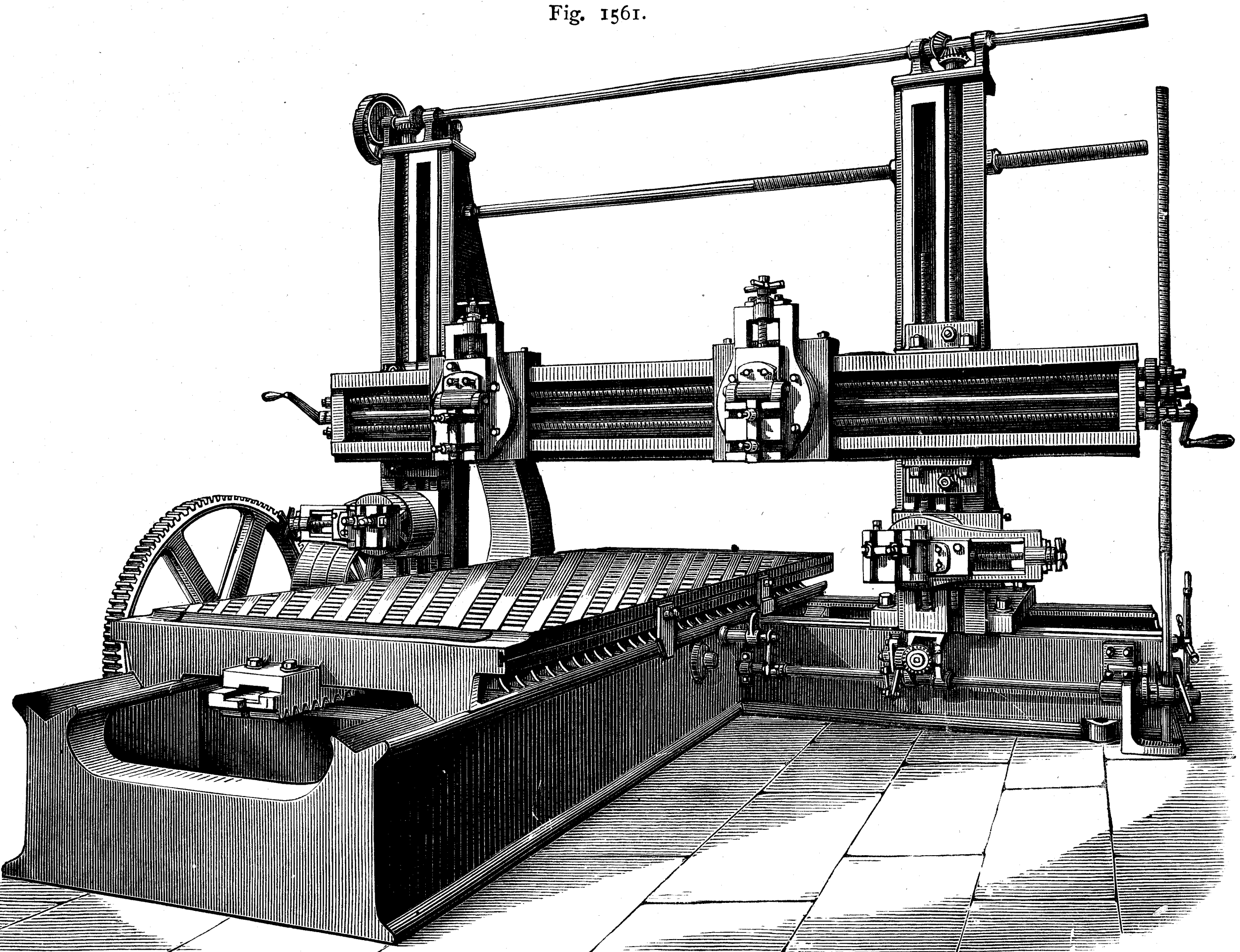

Fig. 1563.

provide a slide to carry the right-hand standard, and permit of its adjustment at distances varying from the left-hand standard to suit the width of the work. This obviously increases the capacity of the machine, and is a desirable feature in the large planers used upon the large parts of marine engines.

ROTARY PLANING MACHINE.—Fig. 1564 is a rotary planing machine. The tools are here carried on a revolving disk or cutter head, whose spindle bearing is in an upper slide with 2 inches of motion to move the bearing endways, and thereby adjust the depth of cut by means of a screw. The carriage on which the spindle bearing is mounted is traversed back and forth (by a worm and worm-wheel at the back of the machine) along a horizontal slide, which, having a circular base, may be set either parallel to the fixed work table or at any required angle thereto.

By traversing the cutter head instead of the work, less floor space is occupied, because the head requires to travel the length of the work only, whereas when the work moves to the cut it is all on one side of the cutter at the beginning of the cut, and all on the other at the end, hence the amount of floor space required is equal to twice the length of the work.

The disk or cutter head is in one piece with the spindle, and carries twenty-four cutters arranged in a circle of 36 inches in diameter. These cutters are made from the square bar, and each cutting point should have the same form and position as referred to one face, side, or square of the bar, so that each cutter may take its proper share of the cutting duty; and it is obvious that all the cutting edges must project an equal distance from the face of the disk, in which case smooth work will be produced with a feed suitable for the whole twenty-four cutters, whereas if a tool cuts deeper than the others it will leave a groove at each passage across the work, unless the feed were sufficiently fine for that one tool, in which case the advantage of the number of tools is lost.

The cutters may be ground while in their places in the head by a suitable emery-wheel attachment, or if ground separately they must be very carefully set by a gauge applied to the face of the disk.

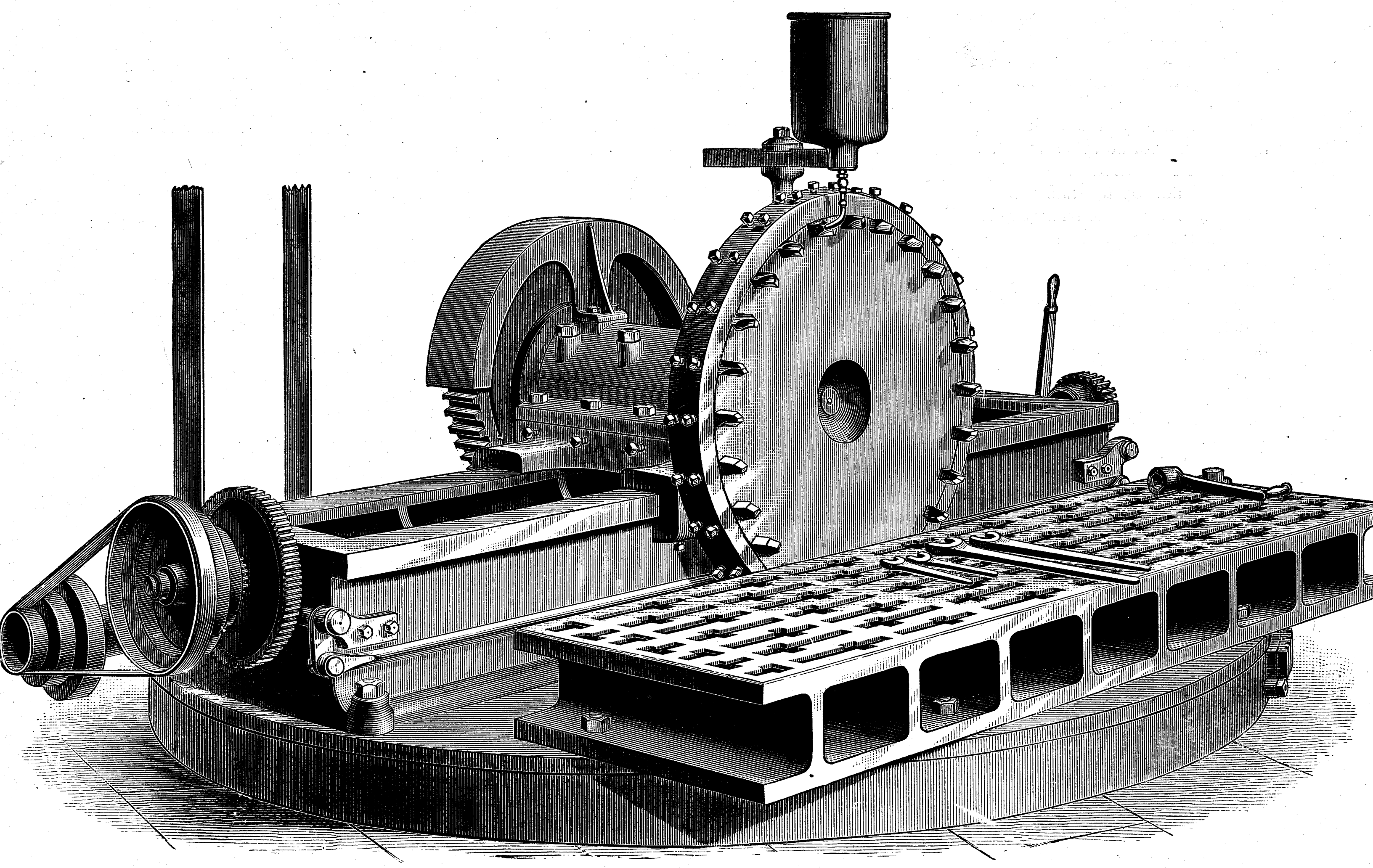

Fig. 1564.