CHAPTER XVIII.—.DRILLING MACHINES.

POWER DRILLING MACHINES.—The drilling machine consists essentially of a rotating spindle to drive the drill, a work-holding table, and means of feeding the drill to its cut. The spindle speed and the force with which it is driven are varied to suit the work. The feeding is sometimes given to the spindle, and at others to the work table. In either case, however, the feeding mechanism should be capable of varying the rate of feed and of permitting a quick withdrawal of the drill. The spindle should be supported as near to its drill-holding end as possible. When the table feeds to the work the spindles may be held rigidly, because of their not requiring to pass so far out or down from the bearing supporting them; but when the spindle feeds, it must either pass through its bearings, or the bearing, or one of them, must either be capable of travel with the spindle or adjustable with relation to the machine framing.

In using small drills in a machine it is of the first importance that the amount of pressure necessary to feed the drill be plainly perceptible at the hand lever or other device for feeding the drill or the work, as the case may be, as any undue pressure causes the drills to break. To attain sensitiveness in this respect the parts must be light and easy both to move and to operate.

Fig. 1671 represents the American Tool Company's delicate drilling machine for holes of $\frac{1}{4}$ inch and less in diameter. It consists of a head fixed upon a cylindrical column and affording journal bearing to the drill-driving spindle, which is driven by belt. The table on which the work is placed is carried by a knee that may be fixed at any required height upon the same round column. The knee and table may be swung out of the way, the column serving as a pivot. The table has journal bearing in the knee, and is fed upwards by the small lever shown.

Fig. 1672 represents Elliott's drilling machine for drills from $\frac{1}{32}$ inch to $\frac{3}{4}$ inch in diameter. The work table may be revolved in the arm that carries it, and this arm may be swung round the column or post. It is operated upwards for the feed by the hand lever shown. The conical chuck shown lying on the work table fits into the hole that is central in the table, and is used to receive the end of cylindrical work and hold it true while the upper end is operated upon.

The construction of the live spindle and its cone are shown in Fig. 1673. The drill chuck Q is attached to and driven by a one-inch steel spindle 19 inches long, which is accurately fitted through the sleeve bearings, within which it is free to move up and down, but is made to revolve with the cone by means of the connection O, one end of which slides upon the rods L. The drill is held up by means of the spiral spring M acting from the bottom of cone to the collar O. The weight of cone and spindle is carried upon a raw-hide washer, beneath which is the cupped brass P which retains the oil. The thrust of the feed lever G is also taken by a raw-hide washer R.

The machine is provided with a hand and a foot feed by means of the compound lever W Z, Fig. 1674, actuating the feed rod J, which passes up within the column and connects to the lever K, the latter being suspended by a link H.

Fig. 1675 represents Slate's sensitive drilling machine, in which the lower bearing for the live spindle is carried in a head H that fits to a slide on the vertical face of the frame, so that it may be adjusted for height from the work table W to suit the height of the work. L is a lever operating a pinion engaging a rack on the sleeve S to feed the spindle. The table W swings out of the way and a conically recessed cup chuck C is carried in a bracket fitting into a guideway in the vertical bed G. The cone of the cup chuck is central to or axially in line with the live spindle, hence cylindrical work may have its end rested in the cone of the cup chuck, and thus be held axially true with the live spindle.

Fig. 1676 represents a drilling machine in which the spindle has four changes of feed, and is fed by a lever handle operating a pinion that engages a rack placed at the back of a sleeve forming the lower journal bearing for the spindle. This lever is provided with a ratchet so that it may be maintained in a handy position for operating. The work table is raised or lowered by a pinion operating in a rack fast upon the face of the column, a pawl and ratchet wheel holding it in position when its height has been set. A lever is used to operate the pinion, being inserted in a hub fast upon the same spindle that carries the pinion and the ratchet wheel.

Fig. 1677 represents a drilling machine by Prentice Brothers, of Worcester, Massachusetts. Motion for the cone pulley A is received by pulleys B and is conveyed by belt to cone pulley C,

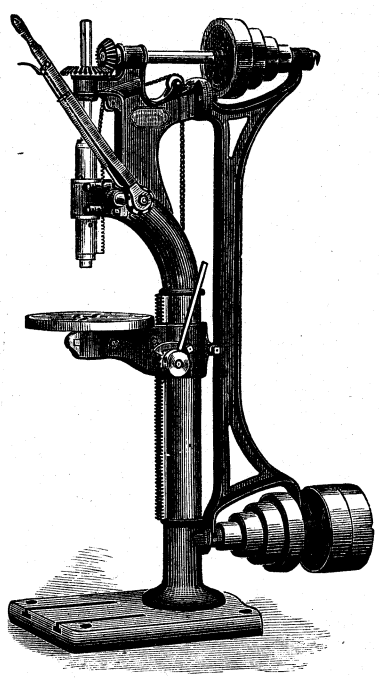

Fig. 1676.

which is provided with back gear, as shown; the driving spindle D drives the bevel pinion E, which gears with the bevel-wheel F, which drives the drill spindle G by means of a feather fitting in a keyway or spline that runs along that spindle. Journal bearing is provided to the upper end of the spindle at H and to the lower end by bearings in the head J, which may be adjusted to stand at, and be secured upon any part of the length of the slideway K. By this arrangement the spindle is guided as near as possible to the end L to which the drill is fixed and upon which the strain of the drilling primarily falls. This tends to steady the spindle and prevent the undue wear that occurs when the drill spindle feeds below or through the lower bearing.

The feed motions are obtained as follows:—

On the drill spindle is a feed cone M which is connected by belt to cone N, which drives a pinion O, that engages a gear P upon the feed spindle Q, which has at its lower end a bevel pinion, which drives a bevel gear upon the worm shaft R. The worm shown on R drives the worm-wheel S, whose spindle has a pinion in gear with the rack T, which is on a sleeve U on the drill spindle

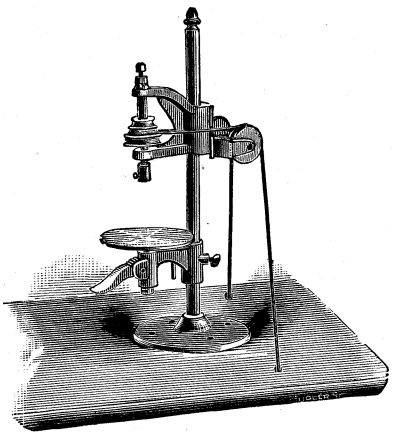

Fig. 1671.

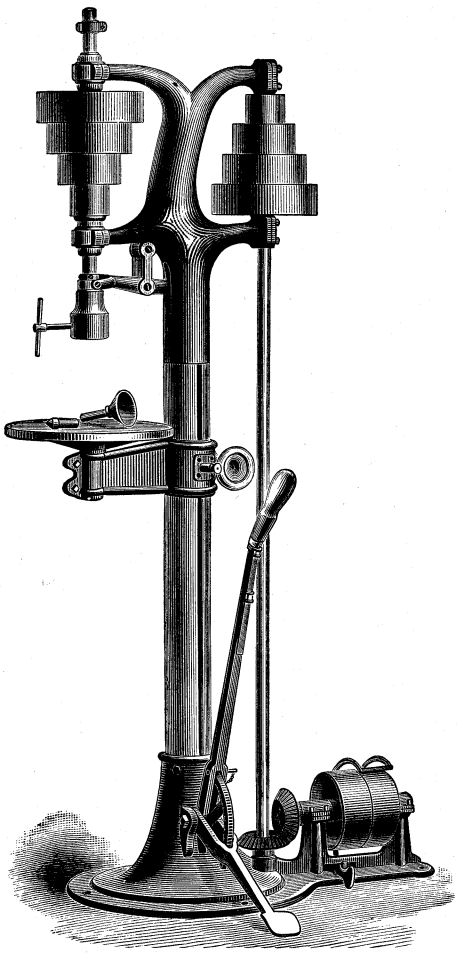

Fig. 1672.

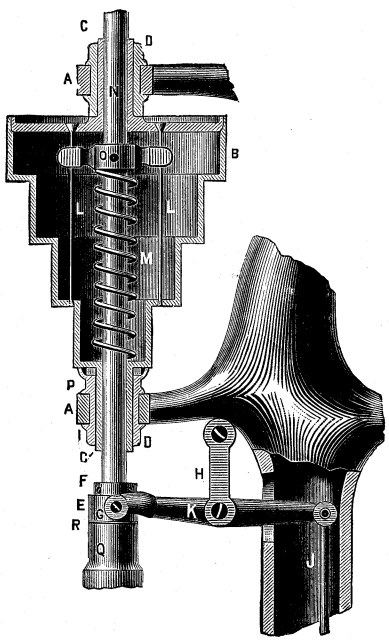

Fig. 1673.

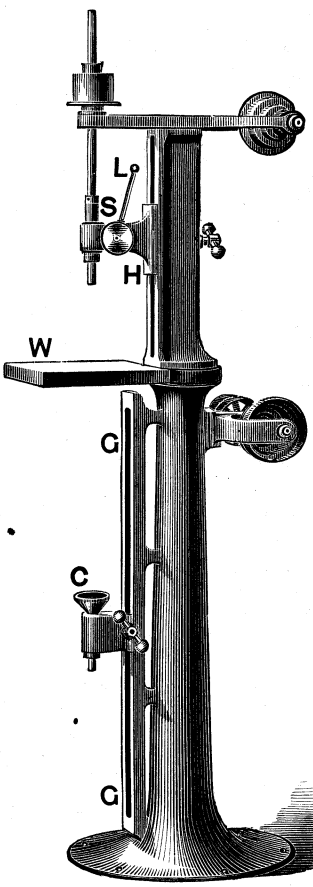

Fig. 1675.

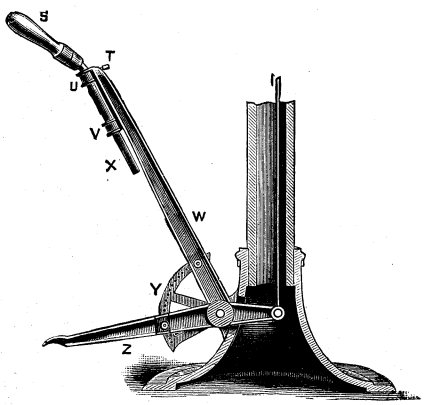

Fig. 1674.

G. It is obvious that when the rack T is operated by its pinion the sleeve U is moved endways, carrying the feed spindle with it and therefore feeding the drill to its cut, and that as the feed cone M has three steps there are three different rates of automatic feed.

To throw the self-feed into or out of action the following construction is employed :—

The worm-wheel S has on its hub face teeth after the manner of a clutch, and when these teeth are disengaged from the clutch sleeve W the worm-wheel S rides or revolves idly upon its shaft or spindle, which therefore remains at rest. Now the clutch sleeve S has a feather fitting to its spindle or shaft, so that the two must, if motion takes place, revolve together, hence when W is pushed in so as to engage with S, then S drives W and the latter drives the spindle, whose pinion operates the rack T.

A powerful hand feed to the drill spindle is provided as follows :—

The worm shaft R is hollow, and through it passes a rod having at one end the hand nut V and at the other a friction disk fitting to the bevel gear shown at the right-hand end of the worm-shaft. This friction disk is fast upon the worm-shaft and serves to lock

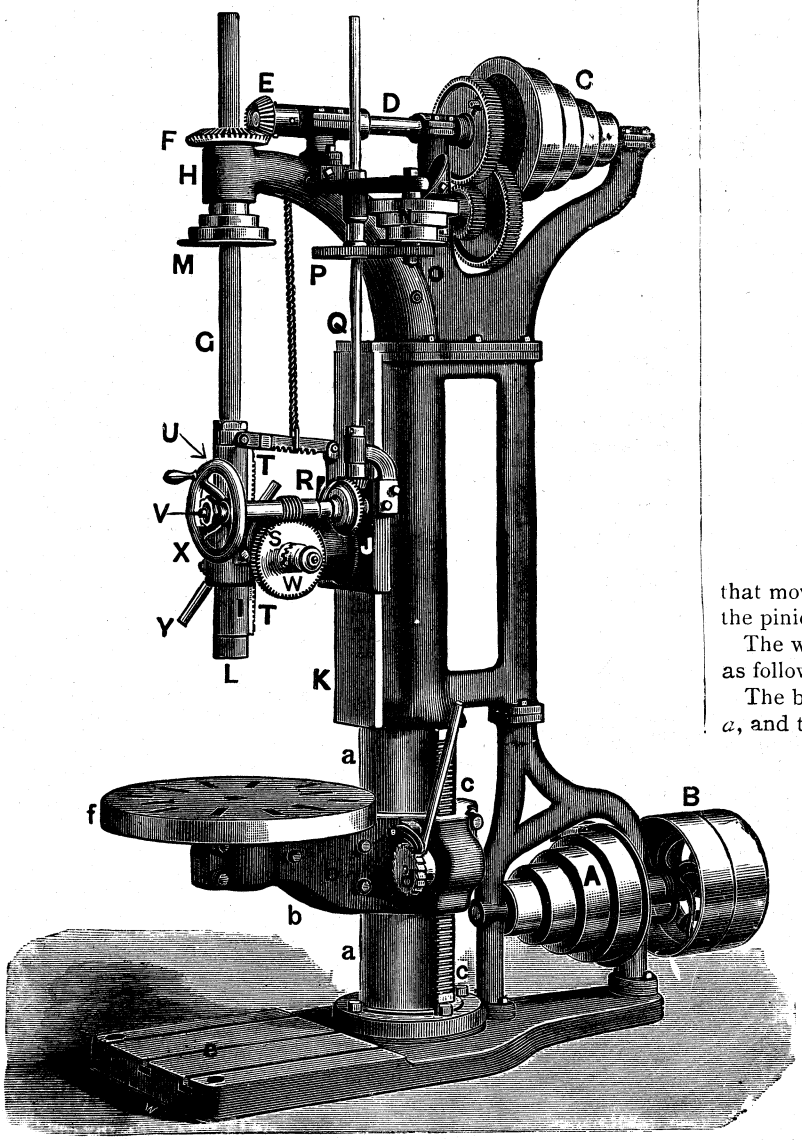

Fig. 1677.

the bevel gear to the worm-shaft when the nut V is screwed up, or to release it from that shaft when V is unscrewed.

Suppose, then, that V is unscrewed and shaft R will be unlocked from the bevel-wheel and may be operated by the hand wheel X, which is fast upon the worm-shaft, and therefore operates it and worm-wheel S, so that W being in gear with S the hand feed occurs when X is operated and V is released. But as the motion of S is, when operated by its worm, a very slow one, a second and quick hand feed or motion is given to the spindle G as follows, this being termed the quick return, as it is mainly useful in quickly removing the drill from a deep hole or bore.

The spindle carrying S and W projects through on the other side of the head J and has at its end the lever Y, hence W being released from S, lever Y may be operated, thus operating the pinion

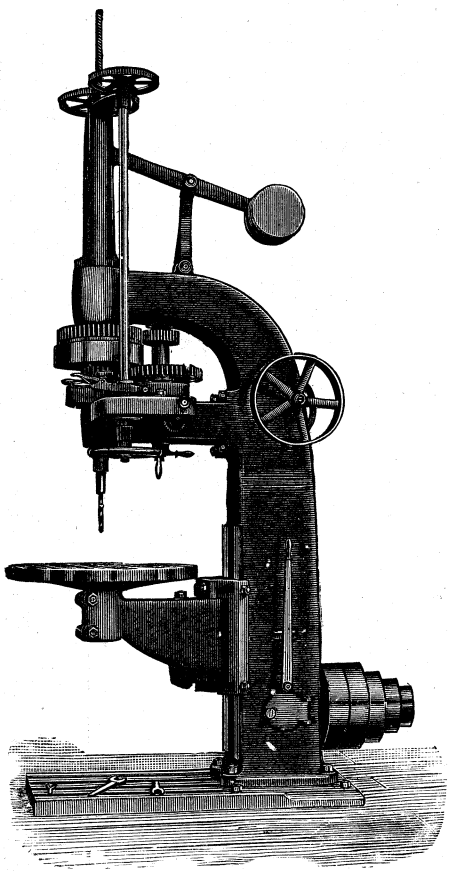

Fig. 1678.

that moves rack T, one revolution of Y giving one revolution to the pinion, both being on the same shaft or spindle.

The work is carried and adjusted in position beneath the drill as follows :—

The base of the column or frame is turned cylindrically true at *a*, and to it is fitted a knee *b* which carries a rack *c*. The knee *b* affords journal bearing to a spindle which has a pinion gearing with the rack *c*, and at the end of this spindle is a ratchet-wheel *d* operated by the lever shown. A catch may be engaged with or disengaged from ratchet *d*. When it is disengaged the lever may be operated, causing the pinion to operate on rack *c* and the knee *b* to raise or lower on *a* according to the direction in which the lever is operated. As the knee *b* carries the rack the knee may be swung entirely from beneath the drill spindle and the work be set upon the base plate *e* if necessary, or it may be set upon the work table *f* which has journal bearing in the knee *b*, so that it may be revolved to bring the work in position beneath the drill.

In the Sellers drilling machine, Fig. 1678, the drill spindle when in single gear is driven by belt direct, producing a uniform and smooth motion that is found of great advantage in drilling the smaller sizes of holes. The back gear is arranged to drive the spindle direct without the power requiring to be transmitted through a shaft, which induces vibration. The drill spindle is provided with variable rates of self-acting feed, but may also be moved rapidly by hand, and is counterbalanced. The work table is capable of revolving upon its axis, and the arm on which it is carried is pivoted in a slide upon a vertical slideway on the front of the main frame. so that

the table and the arm may be swung out of the way for work that can be more advantageously rested on the base plate of the machine. A central hole is bored in the table, being true to the drill spindle when the arm is in its mid position, and clamps are provided to secure the circular table against rotation when it is set to place, and also to secure the swinging bracket to any required position. This form of table, like the compound table, has the advantage of permitting all parts of the table being brought in turn under the drill, but the motion is not in right lines. Holes are provided in the circular table to admit holding-down bolts.

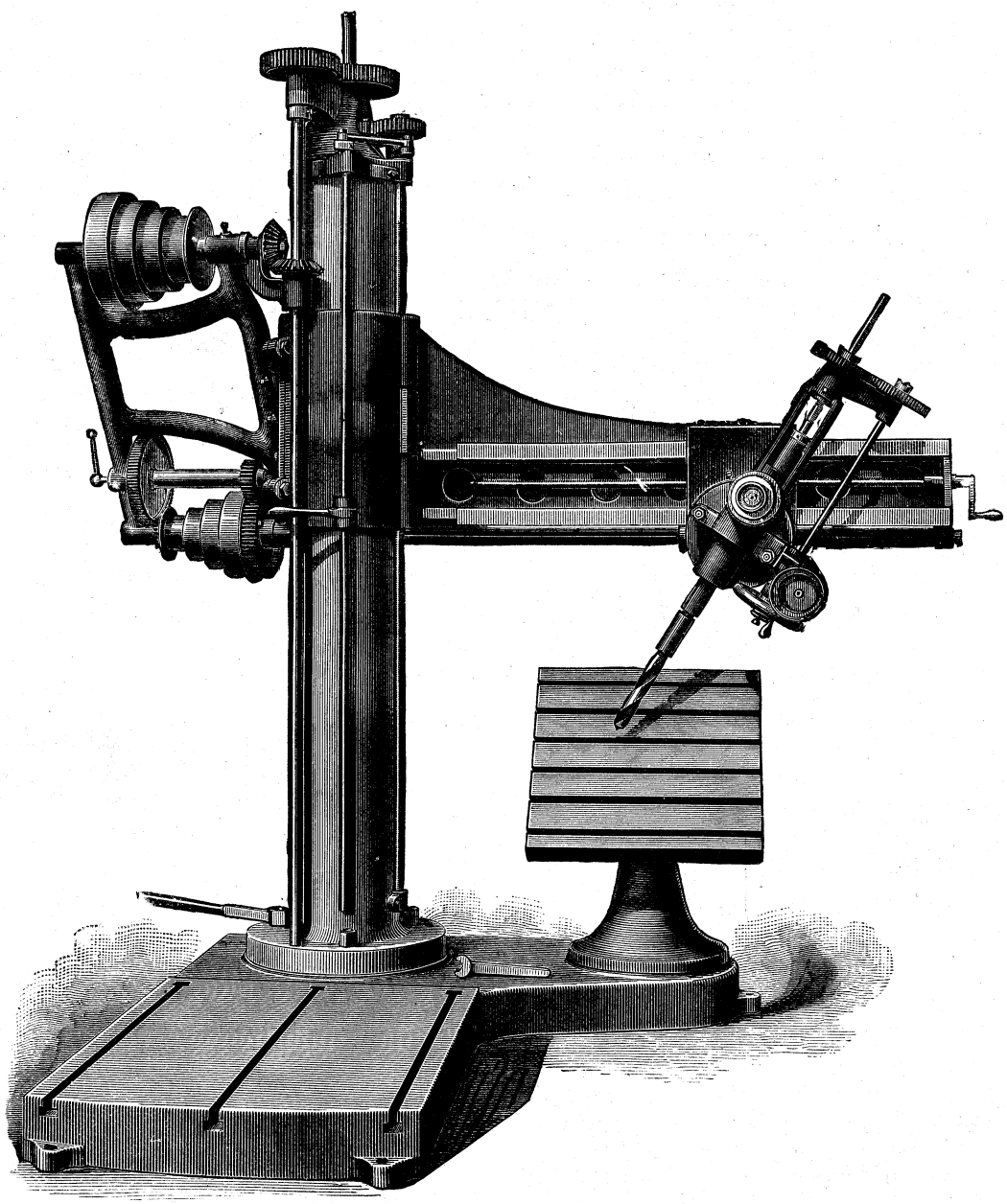

Fig. 1680.

The rates of feed are proportioned to the kind of drilling to be done. When the back gear is not in use and small drills are to be driven, the range of feeds is through a finer series than when the back gear is being used, and large drills or boring bars are to be driven.

Fig. 1679 represents a drilling machine of English design. The cone pulley A is provided with back gear B placed beneath it, the live spindle driving the drill spindle through the bevel gears C, one of which is fast upon a sleeve D through which the drill spindle E passes. The feed motions are obtained as follows:—I is the feed cone driving cone J, which drives a worm and worm-wheel at K. In one piece with the worm-wheel is a ratchet wheel L, and at M is a handle with a pawl that may be engaged with or disengaged from ratchet-wheel L. When it is engaged the handle, which is fast upon the vertical feed spindle N, is revolved by the worm-wheel and the automatic feed is put in operation; but when the pawl is disengaged the worm and worm-wheel revolve in the bearing while the spindle N remains at rest, unless it be operated by the handle M, which obviously revolves the spindle N more quickly than the worm and gives to a corresponding extent a quick motion to the drill spindle. Spindle N is provided with the gear-wheel O, which drives gear P, which is threaded upon the feed screw F and has journal bearing at Q. The sleeve D has journal bearing at G and at H. At R is a hand wheel upon a horizontal shaft at whose other end is a bevel gear engaging with a bevel gear on the vertical screw for the knee T which fits to the vertical slides V. The work table W is fitted to a horizontal slide upon the arm X, which is pivoted to the knee T at Y, the handle for operating the screw of the table being at Z.

RADIAL DRILLING MACHINE.—Fig. 1680 represents a radial drilling machine, the column of which envelops a sleeve round which it may be swung or revolved, the sleeve extending some distance up from the base plate. The arm fits to the column and may be raised or lowered to any desired height to suit the work, the construction being as follows:—

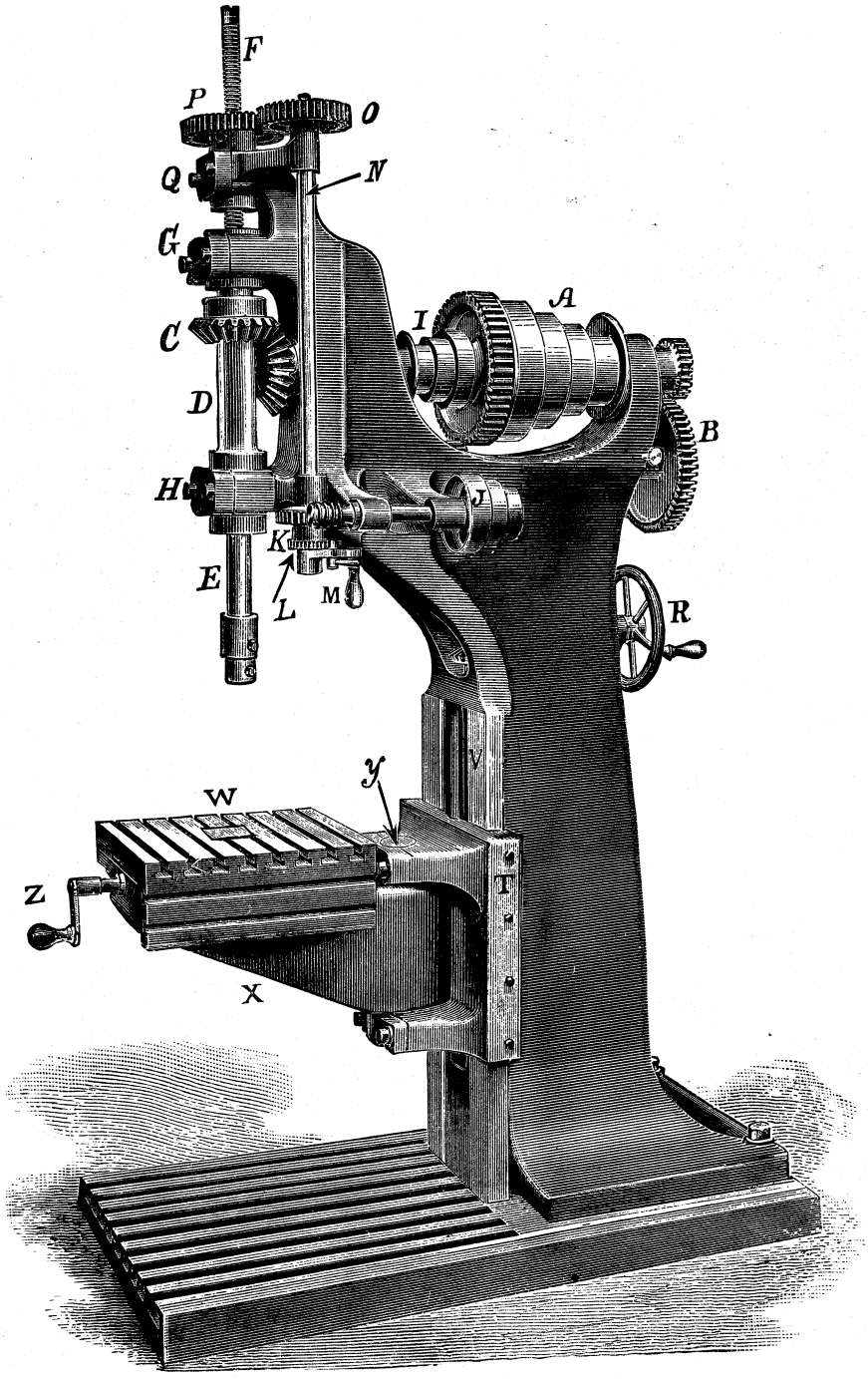

Fig. 1679.

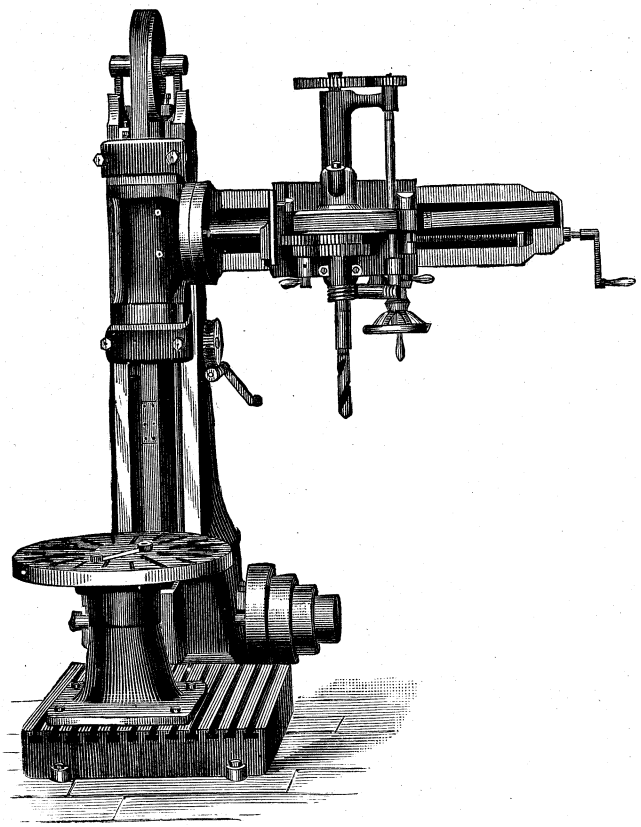

Fig. 1681.—Front View.

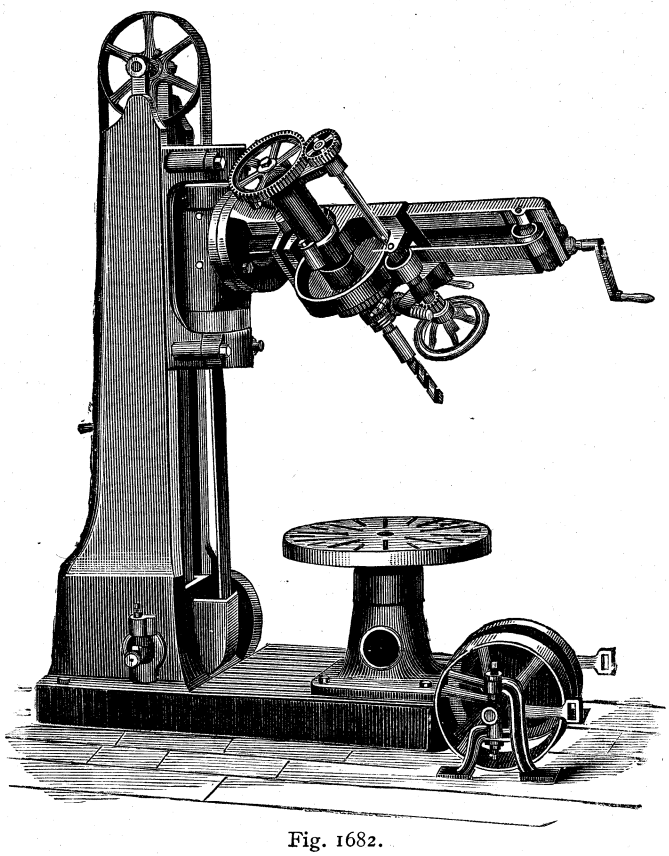

Fig. 1682.

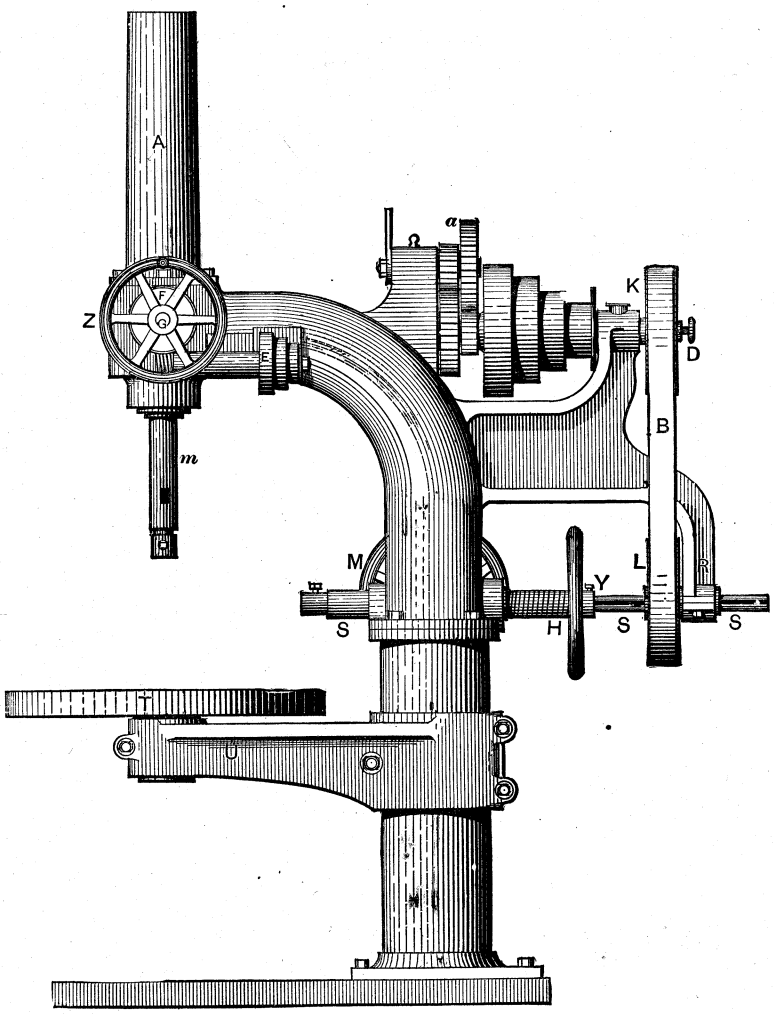

Fig. 1683.—Side Elevation.

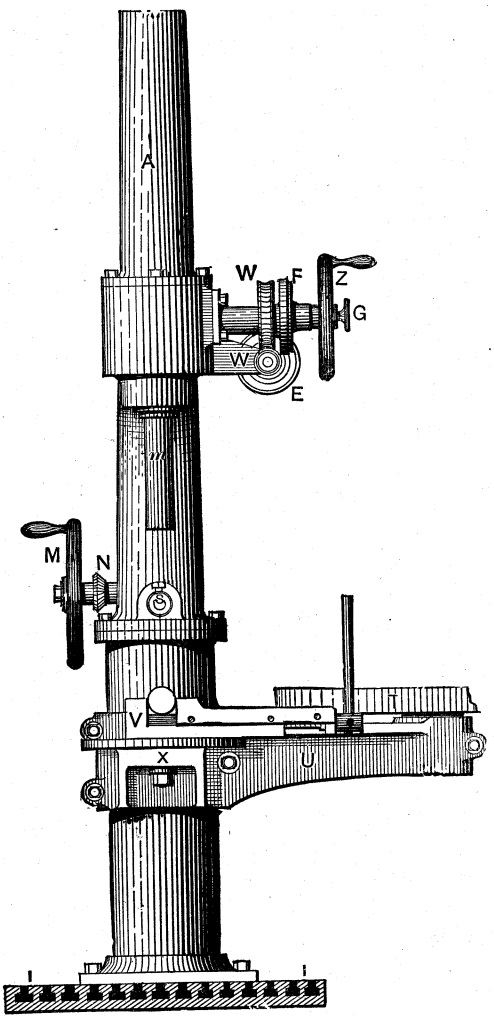

Fig. 1684.—Front Elevation.

Motion by belt is given to the spindle shown extending above the top of the column, and the pair of gears beneath it convey motion to the pair of bevels which drive the upper cone pulley which connects by belt to the lower one, which is provided with back gears to give the necessary changes of speed and power for the wide range of work the machine is intended for; the live spindle of the lower cone pulley extends past the collar and runs beneath the horizontal arm, giving motion to the drill spindle, which is carried in a sliding head. The spindle may be set at any required angle to the arm.

The vertical screw on the right hand of the column passes through a nut in the column, so that by throwing the gearing at the upper end of the screw into action, the arm may be raised or lowered by power.

The vertical rod appearing in the front of the column and having an arm at its top, is for putting this gearing in or out of action, the arm being raised or lowered according to the direction in which the rod is operated by the lever handle shown upon it, and in front of the column. The gearing at the top of the raising and lowering screw is constructed on the principle that was shown in Fig. 566, for reversing the direction of a lathe feed.

The capacity to swing the drill spindle at an angle enables the drilling of long work such as the flanges of pipes, by setting the pipe at an angle and swinging the spindle so as to stand parallel to it, while the facility with which the arm may be moved to any required position makes it easier to move the arm to the work, so that the latter will require but one chucking or setting.

Radial drilling machines are of various constructions. In some the drilling head is carried by an arm standing at a right angle to the main column or frame, and is capable of being moved to any required position upon the length of this arm. The arm itself is sometimes made capable of swinging upon its own axis, as shown in Fig. 1682.

It is also capable of being adjusted at any height from the bed or base plate upon which the upright or main frame sits, or above the work table when one is used as in the figure.

The advantage given by these facilities is that a heavy piece of work may be set upon the base plate or work table, and be drilled in various places without requiring to be moved.

Figs. 1681 and 1682 represent a radial drilling machine, in which the radial arm is carried on a head, which fits a vertical slideway provided on the face of the upright column, and may be moved to any required height on this slideway by means of a rack and worm gear, the latter being shown in the front view.

The seat of the arm on this head is cylindrical, the head being pivoted upon it in order that it may permit of its being rotated to hold the drill at an angle. The drill spindle is carried in a head sliding on the radial arm as already stated, and is driven as follows :—

Motion from the shop driving shaft is communicated by belt to the cone pulley shown at the base of the upright column.

The spindle of this cone pulley drives a belt which passes up the column over an idle pulley on the sliding head that carries the radial arm ; hence it passes along the front of the radial arm and partly round a pulley on the drill spindle, two idle pulleys holding it in contact with the drill spindle pulley. Hence it passes over a small pulley at the outer end of the radial arm, and returns along that arm through the sliding head, over an idle pulley to the pulley seen at the head of the vertical column, and from this pulley it passes to the pulley that is on the cone spindle shaft at the base of the column. The drill is provided with an automatic feed actuated by the worm shown on the drill spindle.

In Figs. 1683, 1684, and 1685 is represented a combined drilling and boring machine.

It is provided with an horizontal as well as with a vertical spindle, either of which may be used for boring as well as for drilling. In the case of the vertical spindle the boring bar may extend down and have journal bearing in a block, or bearing secured to the base plate I.

Each spindle has eight changes of speed, four in single, and four in double gear, that is when the back gears at *a* are in operation.

Motion from the pulley K on the cone spindle is conveyed by belt B to pulley L, whose hub extends through the frame at R and affords journal bearing to that end of spindle S which has a feed motion at H. Motion is conveyed from the cone spindle to vertical spindle *m* as follows :—

Referring to Fig. 1685, bevel-wheel *f* is on the end of the cone spindle and drives bevel-wheel *g*, which drives spindle *m*. This spindle is provided with an automatic as well as a hand-feed motion, the construction being as follows :—

Referring first to the automatic feed, the cone pulley E′, Fig. 1685, which is upon the main cone spindle of the machine, drives cone E, Fig. 1683, and the latter operates a worm W, Fig 1684, engaging a worm-wheel W, which drives the bevel gear *a*, shown by dotted circles in Fig. 1685 ; *a* drives the bevel gear *c* upon the sleeve *o*, which has journal bearing (in the frame A of the machine) both at its upper end and immediately above C. The upper end of the sleeve *o* is threaded to receive an inner sleeve *n*, within which

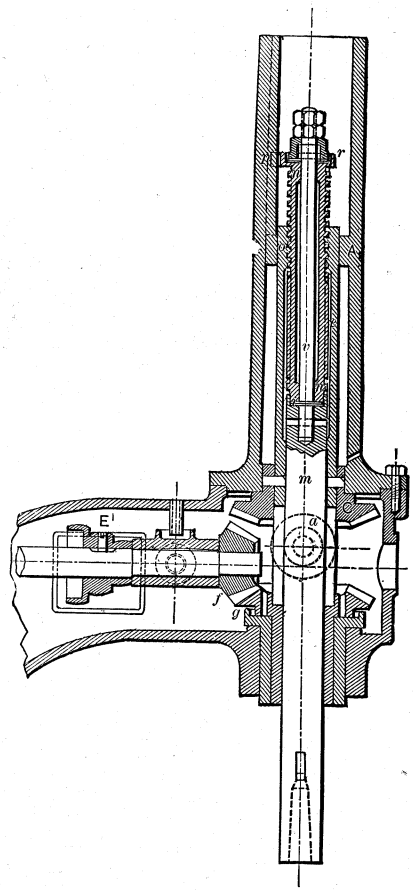

Fig. 1685.

is a spindle *v*, having journal bearing at each end of *n* and being fast to *m*, so as to revolve with it. End motion to *n* is prevented by a collar at its upper end *r* and by three steel washers at *i*, the latter taking the thread when the drill spindle *m* is in operation. The inner sleeve *n* is prevented from revolving by means of a lug or projection which passes into a slot or groove running vertically in the bore of the outer casing A ; hence when *o* is revolved by *a* it acts as a nut to *n*, causing the latter to move endways and feed the drill spindle *m*.

To enable the engagement or disengagement of the automatic feed, there is at F, Fig. 1684, a friction disk, the female half of which is fast upon the spindle that drives bevel gear *a* in Fig. 1685, while the male half is in one piece with the hand wheel Z, Fig. 1684, which has journal bearing upon the spindle of *a*. G is a hand nut for engaging or disengaging the friction disks. In addition to the ordinary work table T, the knee U carries on a projection X a work-holding vice V, which is a great convenience, especially for cylindrical work. The base of the machine is provided with a plate upon which work may be secured independent of the work table T, or the lower end of a boring bar may be steadied by a step bolted to the base plate.

The construction of the machine, as will be seen, is very substantial throughout, since all the strains are central, the spindles are well supported, and there is a commendable absence of springs, pull-pins, and other light parts that are liable to get out of order from the wear and tear of the ordinary machine-shop tool. It may also be remarked that the combination of the two spindles is effected without impairing either the usefulness or handiness of the vertical spindle.

In Fig. 1686, which is taken from *Mechanics*, is illustrated a combined drilling and turning machine. In this machine the motion for both drilling and turning is received by belt on the cone pulley shown on the right, which is provided with back gear similar to that of a lathe. The live spindle thus driven has a face plate at the left-hand end, whereon work may be chucked to be operated upon by a tool in the compound slide rest shown on the cylindrical column. Motion to the drill spindle is conveyed by belt from a pulley on this same live spindle, hence the same cone pulley and back gear are utilized for either drilling or turning. The self-acting feed for the drill spindle is actuated by an eccentric on that spindle operating an arm, having a pawl engaging with the ratchet wheel on the lower end of the vertical feed spindle. Obviously when the pawl is thrown out of engagement with the ratchet wheel, the horizontal hand wheel may be used to feed the drill spindle by hand or to withdraw it, as the case may be.

The work table for drilling operations has motion laterally in two directions (one at a right angle to the other) by means of being carried on slides, and is fitted to a vertical slide on the face of the column so that it may be raised and lowered to suit the height of the work by means of the worm and worm-wheel shown, the latter being on the same shaft as a pinion engaging with a vertical rack on the face of the upright frame or column.

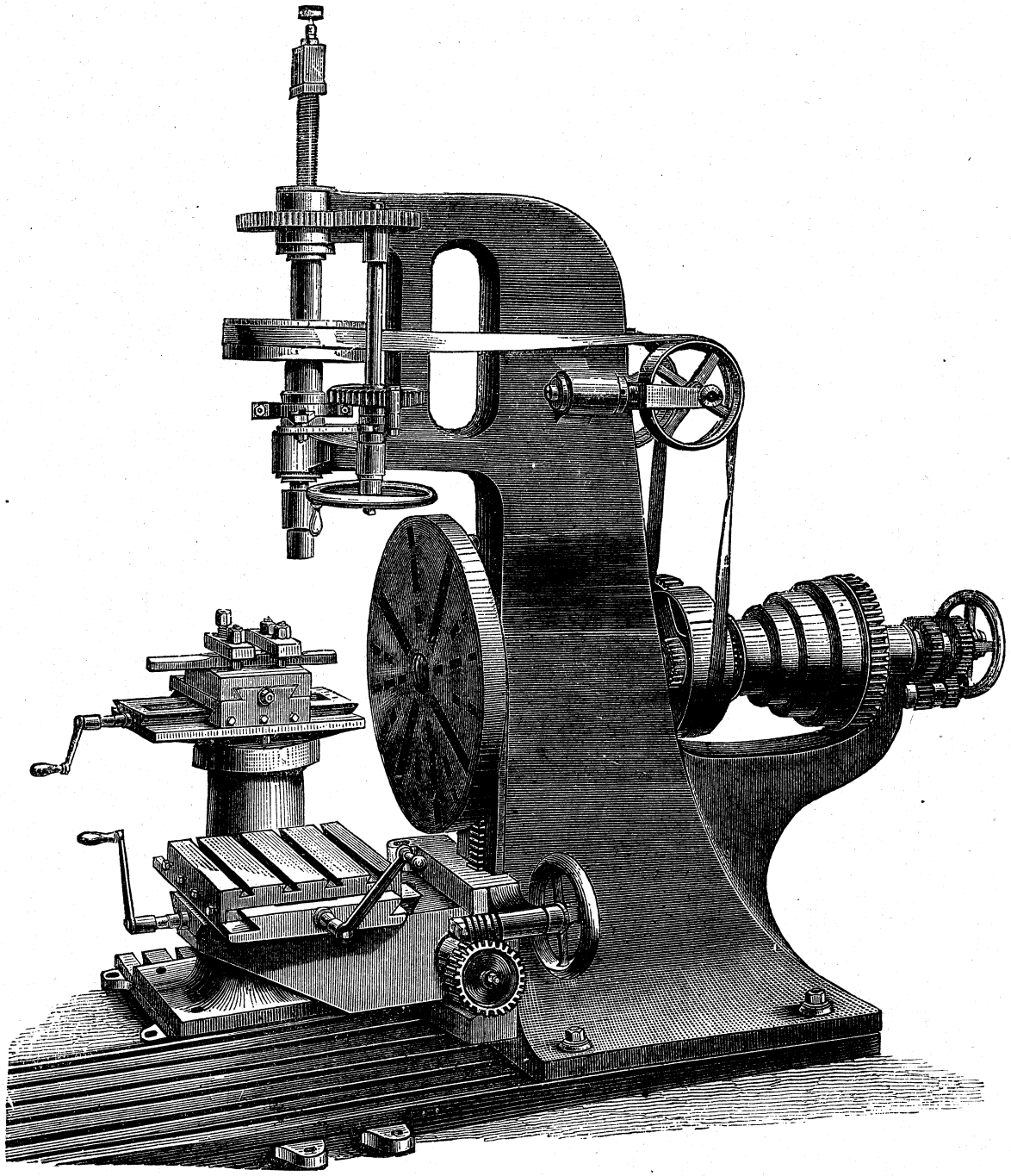

Fig. 1686.

In Fig. 1687 is represented a horizontal drilling and boring machine. In this machine the work-holding table is provided with a hand feed, and the drilling or boring spindle with hand and self-acting feed, the latter being variable to suit different kinds of work. The table has a compound motion upon suitable

slideways and rests upon a frame or knee that is elevated by two vertical screws that are operated by hand wheel. This knee fits to a vertical slideway on the main frame, so that its upper face, and therefore the face also of the work table, is maintained parallel with the drill spindle at whatever height it may be set from it.

The arbor that carries the drill spindle is arranged with a face plate so that the machine can be used as a facing lathe. The feeds are arranged in two separate series, a fine and a coarse, and both of these series are applicable to any speed or any size of drill. The value of the coarse feed will be felt in all kinds of boring with bars and cutters, inasmuch as it is possible to rough out with a fine feed and finish with a light cut and a very coarse feed.

For work that is too large to be conveniently lifted to the table of a machine the floor boring machine is employed.

Fig. 1688 represents a machine of this class, which consists of two heads that may be moved about upon, and secured to, any part of its base or bed plate to which the work is secured. The boring bar it will be seen stands horizontal, and may be set at any height from the base plate between the limits of 14 inches and 6 feet 4 inches, the driving head being raised on its slideway on the face of its standard or column by automatic mechanism. The feed is automatic and variable in amount to suit the nature of the duty.

The bar has eight speeds, four in single and four in double gear.

In order to insure that the crank pins of locomotive driving wheels shall stand with their axes parallel to that of the wheel shaft, and that they shall also stand 90° apart when measured on the wheel circle, it is necessary that the holes for these pins be

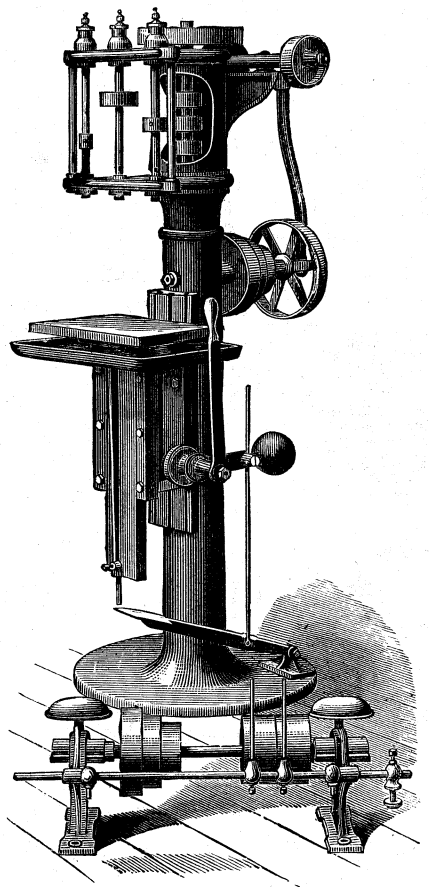

Fig. 1690.

bored after the wheels are upon their shaft, it being found that if the crank pin holes are bored before the wheels are upon the shaft they are liable to be out of parallel and out of quarter.

To avoid these errors a quartering machine is employed, such as shown in Fig. 1689. This machine consists of two heads carrying stationary or dead centres to hold the wheel axle, as in a lathe. Each of these heads is provided with a boring bar having an automatic and adjustable feed, the axes of these bars being 90°, or one quarter of a circle, apart.

As both crank pin holes are bored simultaneously and with the wheel rigidly fixed and held upon centres the work will obviously be true. This machine may also be used as an ordinary horizontal boring machine.

Multiple drilling machines are employed for two general purposes: first, those in which a number of holes may be advan-

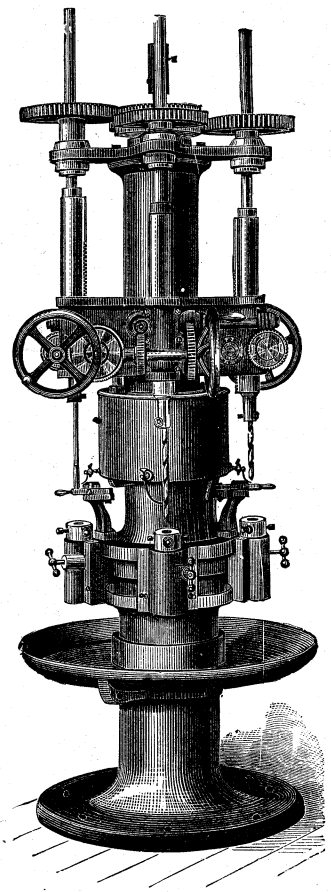

Fig. 1691.

tageously drilled simultaneously; and second, where a number of operations require to be performed upon one and the same hole. When the object is to drill a number of holes spaced a certain distance apart in one piece of work, the spindles may be so constructed that their distances one from the other may be adjustable, so that they may be set to drill the holes equally or unequally spaced as may be required.

In such machines it will be more convenient to feed the work to the drill, so as to have but one feed motion, instead of having a separate feed motion to each drill spindle. When, however, a number of separate operations are to be performed upon the same hole, it is preferable to rotate the table so that the work may be carried from one spindle to the other, the spindles feeding automatically and simultaneously.

Fig. 1690 represents a three-spindle drilling machine. The main driving spindle is vertical and within the top of the column, having three pulleys to connect by belt to the vertical drill driving spindles, whose driving pulleys are of different diameters to vary the speed to suit different diameters of drilling tools. A foot feed is provided by means of the treadle, and a hand feed by means of the lever, the weight of the work table being balanced by means of the ball weight shown. The work table is adjustable for height in a main table, that is adjustable for height on the face of the column. Similar machines are made with four or more spindles.

Fig. 1691 represents a four-spindle machine, in which each spindle has a separate and independent feed, which may be operated in unison or separately as may be required.

The four spindles are driven by means of a gear-wheel engaging

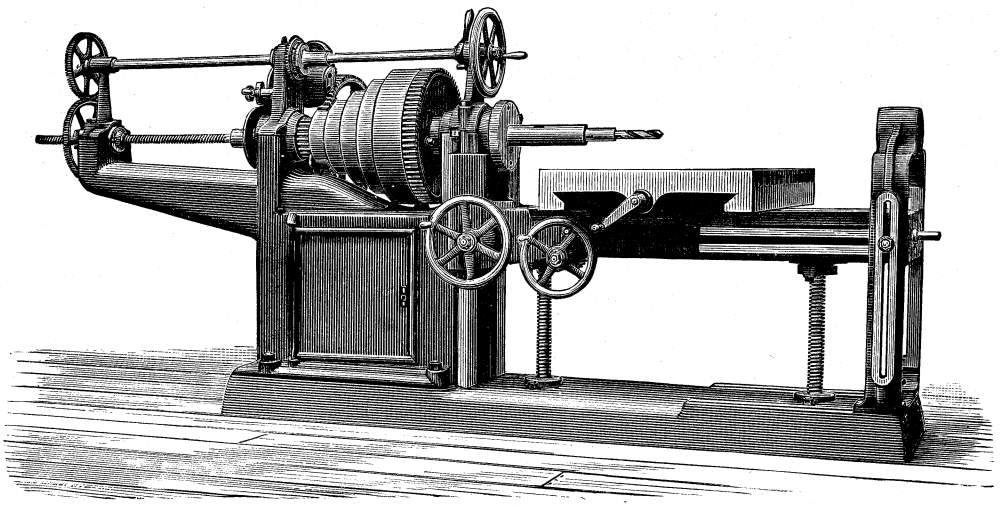

Fig. 1687.

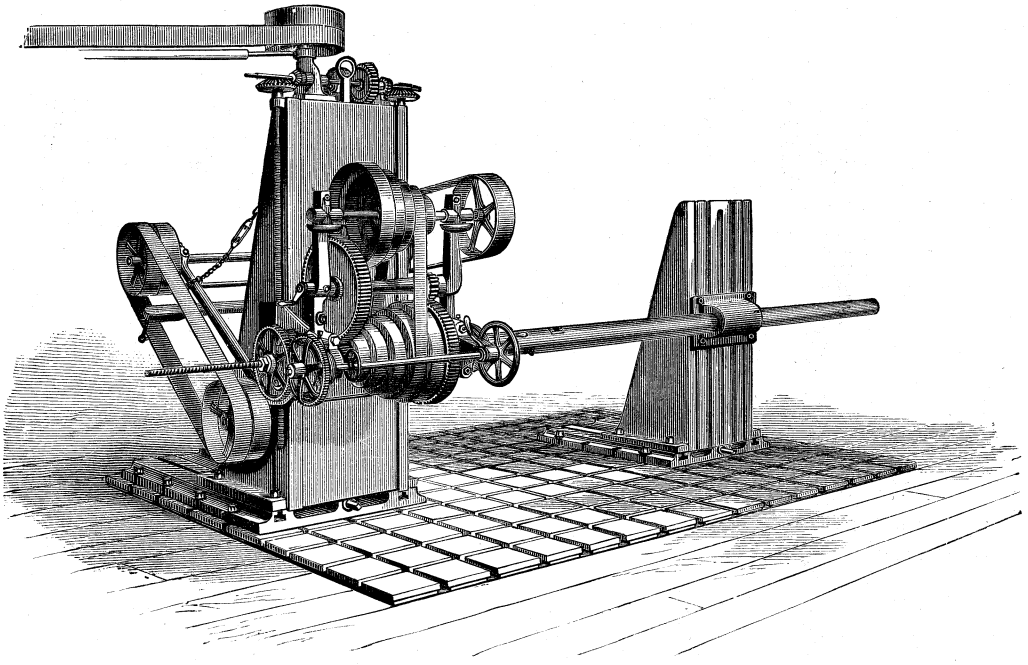

Fig. 1688.

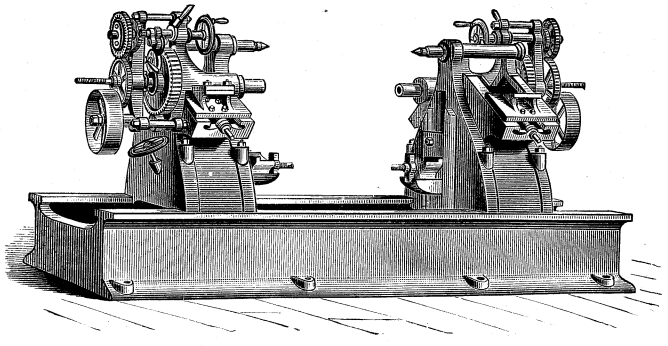

Fig. 1689.

with a gear on the central or main driving spindle. The work-holding table rotates about the column of the machine, and is arranged with a stop motion that locks the table in position when the work-holding chucks are exactly in line with the drill spindles. Suppose, then, one spindle to drive a drill, the second driving an enlarging drill, a third driving a countersink, and a fourth a reamer. A piece of work may then be fastened beneath the first spindle and be drilled. The table may then be rotated one-fourth of a revolution, bringing it beneath the enlarging drill, while a second piece of work is placed beneath the first or piercing drill. The table may then be given another quarter rotation, bringing the piece of work first put in beneath the countersink, the second beneath the enlarging drill, while a third piece may be placed beneath the first or piercing drill. The table being again given one-quarter rotation the first piece will be brought beneath the reamer, the second beneath the countersink, the third beneath the enlarging drill, and a fourth may be placed beneath the piercing drill; all that will then be necessary is to remove the first piece when it arrives at the piercing drill and insert a new piece; the four spindles operating simultaneously, and the process continuing, the four operations proceed together.

Thus the piece of work is finished without being released from the holding devices, which insures truth while requiring a minimum of attendance. The amount of feed being equal for all four spindles the depth to which each tool will operate is gauged by the distance it stands down from the feeding head, each spindle being capable of independent adjustment in this respect, so that the tool requiring to move the farthest through the work will meet it the first, and so on.

Figs. 1692 and 1693 represent a combined drilling and turning machine for boiler-maker's use. The machine consists of two uprights or drill standards which can be traversed along horizontal slides on beds which are fixed at right angles one to the other. The work to be drilled is carried on a turntable or work-holding table, the pivot and carrying frame of which can be traversed along a third set of guides lying between the other two and forming an angle of 45° with either of them.

Thus, by adjusting the relative positions of the turntable and the drill standards (each of which carries two drills), either a large or a small boiler can be conveniently operated on. Worm-gear is provided for revolving the turntable, either to divide the pitch of the holes, or when the machine is used for turning the edges of flanged plates, or for boring the large holes for flue tubes. Longitudinal seams may be drilled by laying the boiler horizontally on chucks alongside one of the beds, and traversing the drill standard from hole to hole.

Referring especially to Fig. 1693, A^1 and A^2 are the two wings of the bed plate, each being provided with V-slides to carry the uprights or standards B^1, B^2, on each of which is a drilling head C^1 C^2, these being each adjustable vertically on its respective standard by means of rack and pinion and hand wheels D^1 and D^2. The heads are balanced so that the least possible exertion is sufficient to adjust them. The vertical standards B^1 and B^2 are provided at their bases with a gear-wheel operated by means of pinions at G^1, G^2, so that they may be rotated upon the sliders E^1 and E^2, by means of which they may be traversed along their respective bed slides. The drilling heads are composed of a slider on a vertical slide on the face of the vertical standard

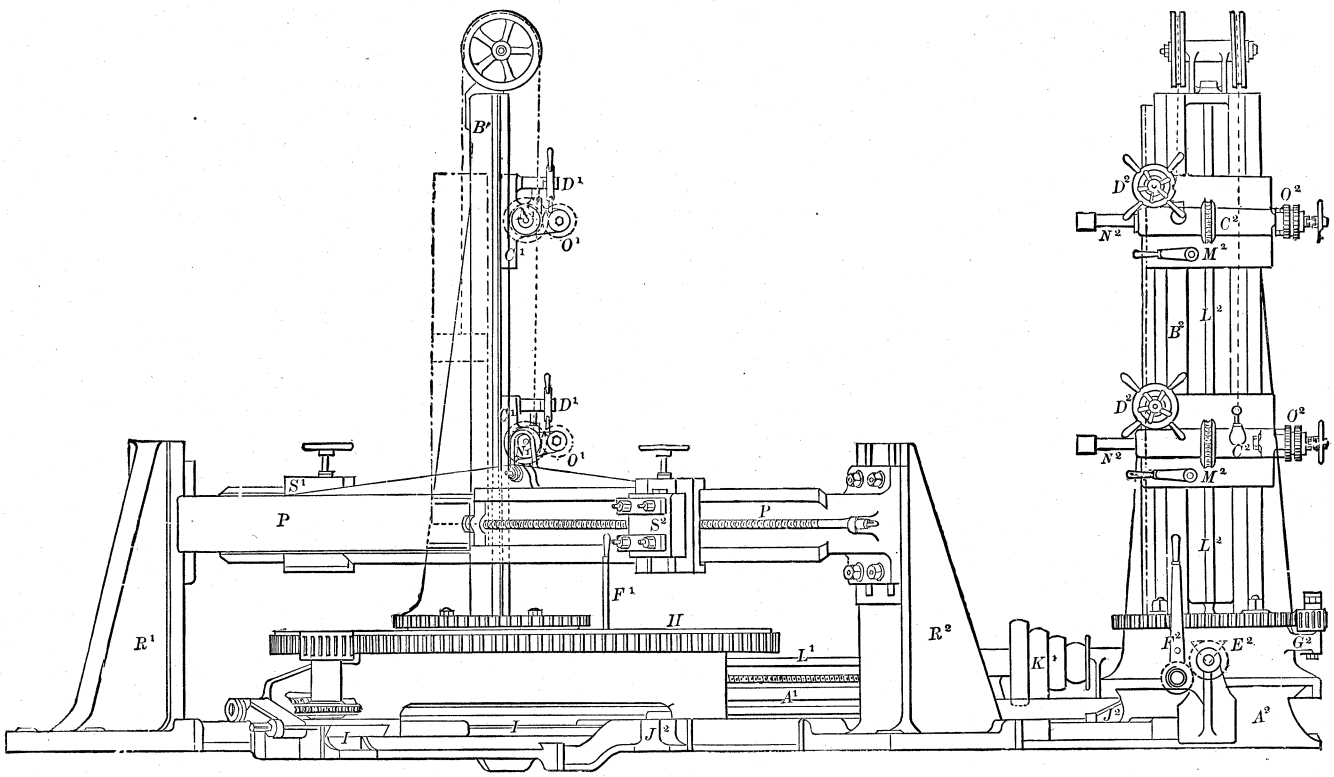

Fig. 1692.

or upright, rotary motion and the feed being operated as follows: Power is applied to the machine through the cones K^1 and K^2, working the horizontal and vertical shafts L^1 and L^2, &c. On the vertical shafts are fitted coarse pitch worms sliding on feather keys, and carried with the heads C^1 and C^2, &c. The worms gearing with the worm-wheels M^1 and M^2 are fitted on the sleeves of the steel spindles N^1 and N^2. The spindles are fitted with self-acting motions O^1 and O^2, which are easily thrown in and out of gear.

The shell to be drilled is placed upon the circular table H, which is carried by suitable framework adjustable by means of screw on the V-slide I, placed at an angle of 45° with the horizontal bed plates. By this arrangement, when the table is moved along I it will approach to or recede from all the drills equally. J^1 and J^2 are girders forming additional bearings for the framework of the table. The bed plates and slides for the table are bolted and braced together, making the whole machine very firm and rigid.

The machine is also used for turning the edge of the flanges which some makers prefer to have on the end plates of marine boilers. The plates are very readily fixed to the circular table H, and the edge of the flange trued up much quicker than by the ordinary means of chipping. When the machine is used for this purpose, the cross beam P, which is removable, is fastened to the

two upright brackets R^1 and R^2. The cross beam is cast with V-slides at one side for a little more than half its length from one end, and on the opposite side for the same length, but from the opposite end. The V-slides are each fitted with a tool box S^1 and S^2, having a screw adjustment for setting the tool to the depth of cut, and adjustable on the V-slides of the cross beam to the diameter of the plate to be turned. This arrangement of the machine is also used for cutting out the furnace mouths in the boiler ends. The plate is fastened to the circular table, the centre of the hole to be cut out being placed over the centre of table; one or both of the tool boxes may be used. There is sufficient space between the upright brackets R^1 and R^2 to allow that section

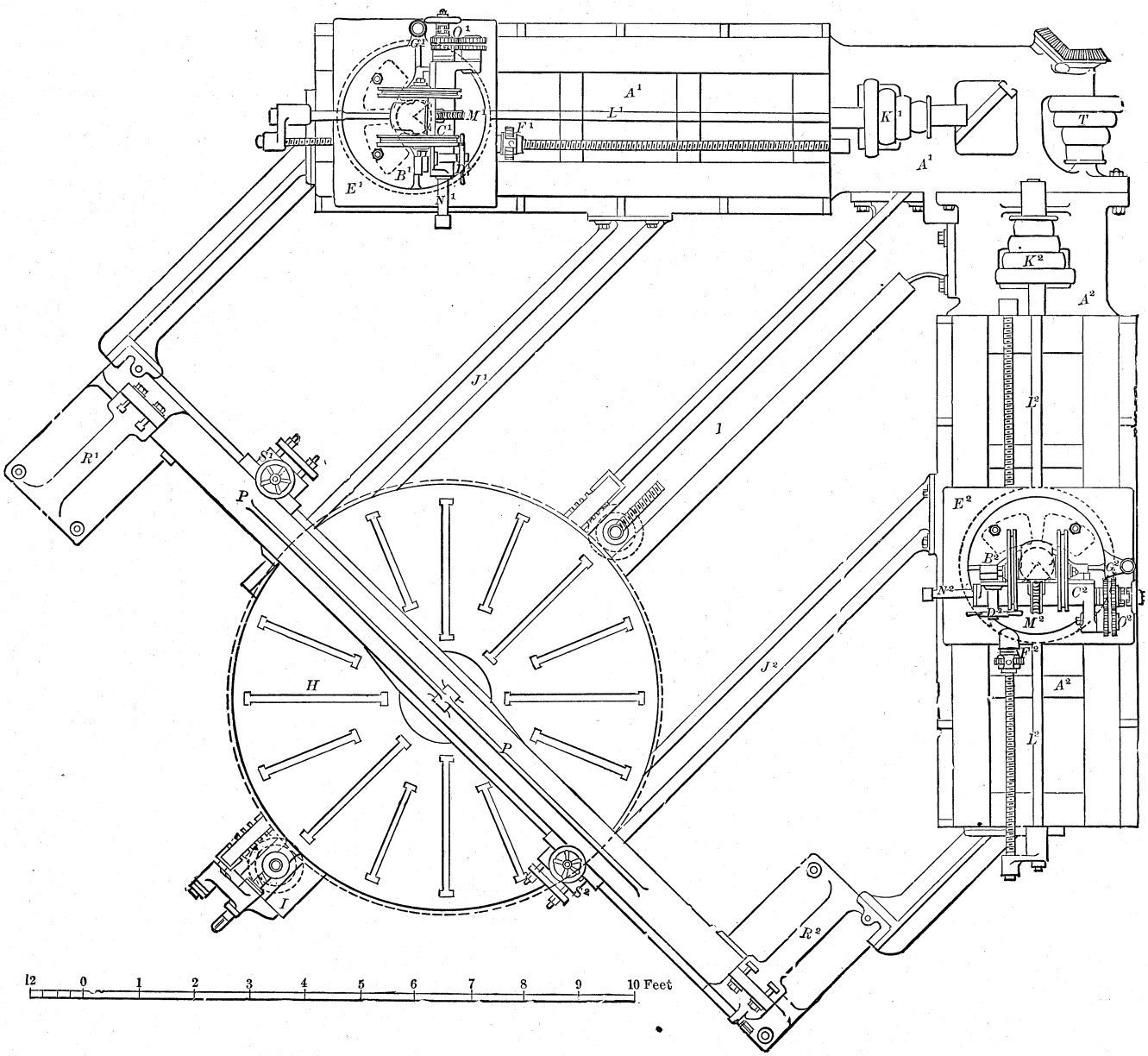

Fig. 1693.

of a boiler end which contains the furnace mouths to revolve while the holes are being cut out; the plate belonging to the end of a boiler of the largest diameter that the machine will take in for drilling. The holes cut out will be from 2 ft. 3 in. diameter and upwards. Power for using the turntable is applied through the cone T. The bevel-wheels, worms, worm-wheels and pinions for driving the tables are of cast steel, which is necessary for the rough work of turning the flanges.

As to the practical results of using the machine, the drills are driven at a speed of 34 feet per minute at the cutting edges. A jet of soapsuds plays on each drill from an orifice $\frac{1}{32}$ in. in diameter, and at a pressure of 60 lbs. per square inch. A joint composed of two 1-inch plates, and having holes $1\frac{1}{8}$ in. in diameter, can be drilled in about $2\frac{1}{2}$ minutes, and allowing about half a minute for adjusting the drill, each drill will do about 20 holes per hour. The machine is designed to stand any amount of work that the drills will bear. The time required for putting on the end of a boiler and turning the flange thereon (say, 14 ft. diameter), is about $2\frac{1}{2}$ hours; much, however, depends on the state of the flanges, as sometimes they are very rough, while at others very little is necessary to true them up. The time required for putting on the plate containing the furnace mouths and cutting out three holes 2 ft. 6 in. in diameter, the plate being $1\frac{1}{8}$ inches thick, is three hours. Of course, if several boilers of one size are being made at the same time, the holes in two or more of these plates can be cut out at once. The machine is of such design that it can be placed with one of the horizontal bed plates (say A^1) parallel and close up to a wall of the boiler shop; and when the turning apparatus is being used, the vertical arm B^2 can be swivelled half way round on its square box E^2, and used for drilling and tapping the stay holes in marine boiler ends after they are put together; of course sufficient room must be left between bed plate A^2 and the wall of boiler shop parallel with it, to allow for reception of the boiler to be operated upon.

In Figs. 1694 and 1695 is represented a machine which is constructed for the drilling of shells of steam boilers, to effect which the boiler is set upon a table, round which are placed four standards, each carrying a drilling head, so that four

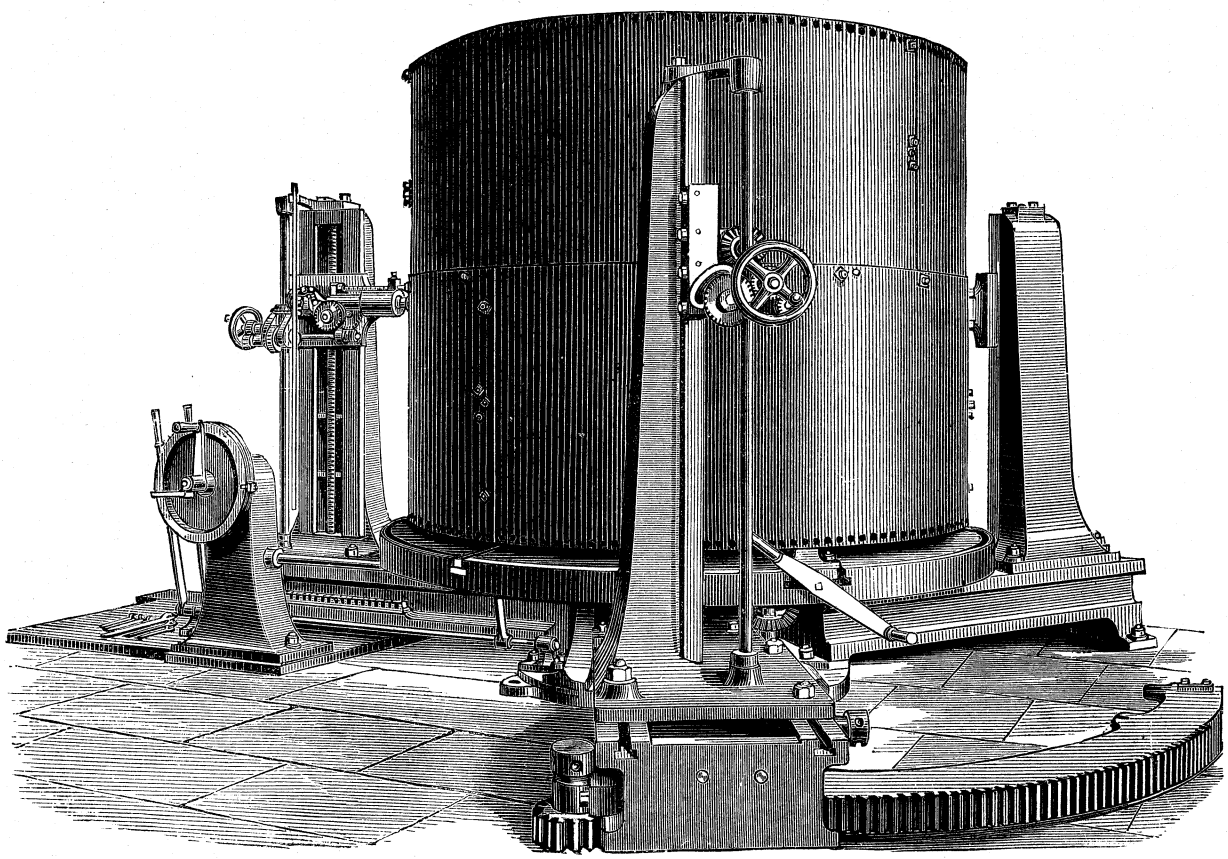

Fig. 1694.

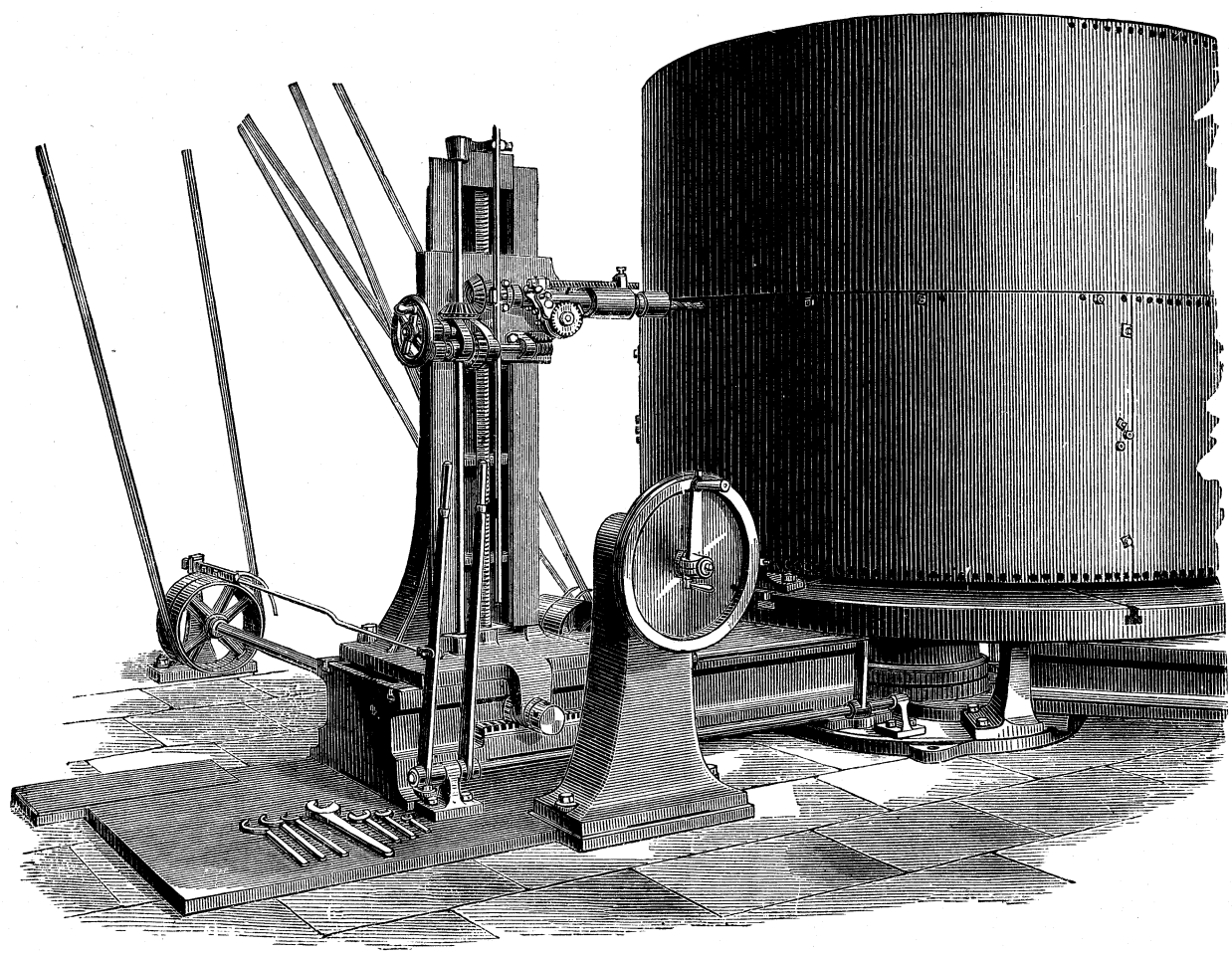

Fig. 1695.

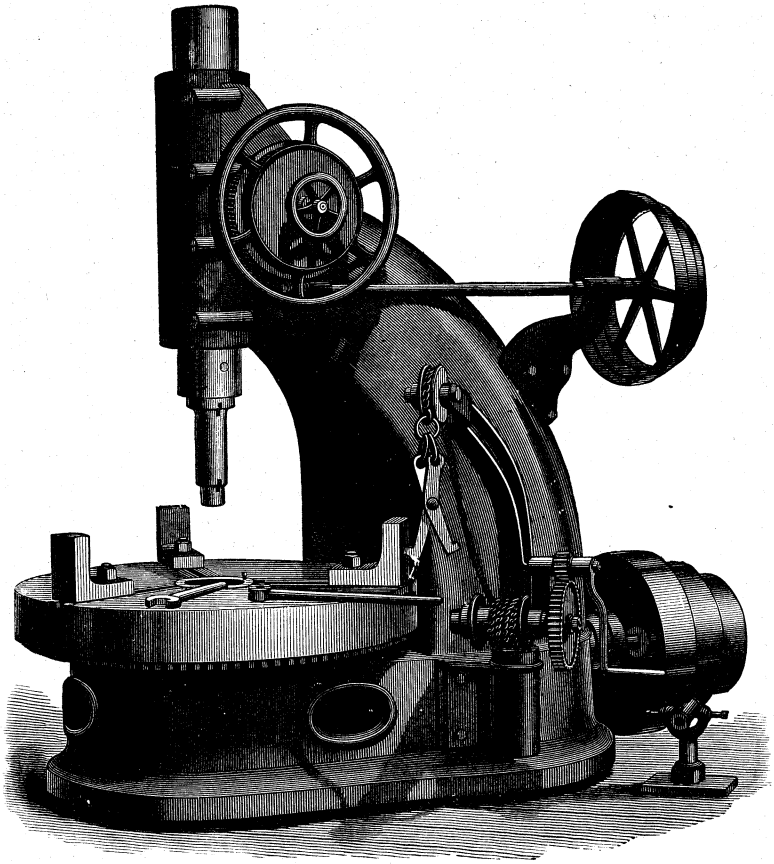

Fig. 1696.—CAR-WHEEL BORING MACHINE.

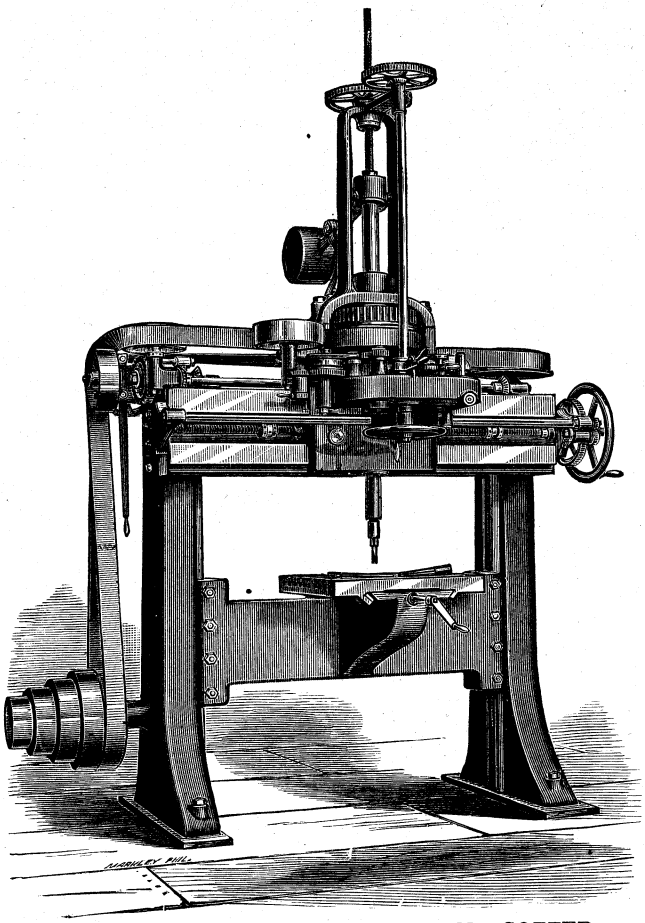

Fig. 1698.—COMBINED DRILLING AND COTTER-DRILLING MACHINE.

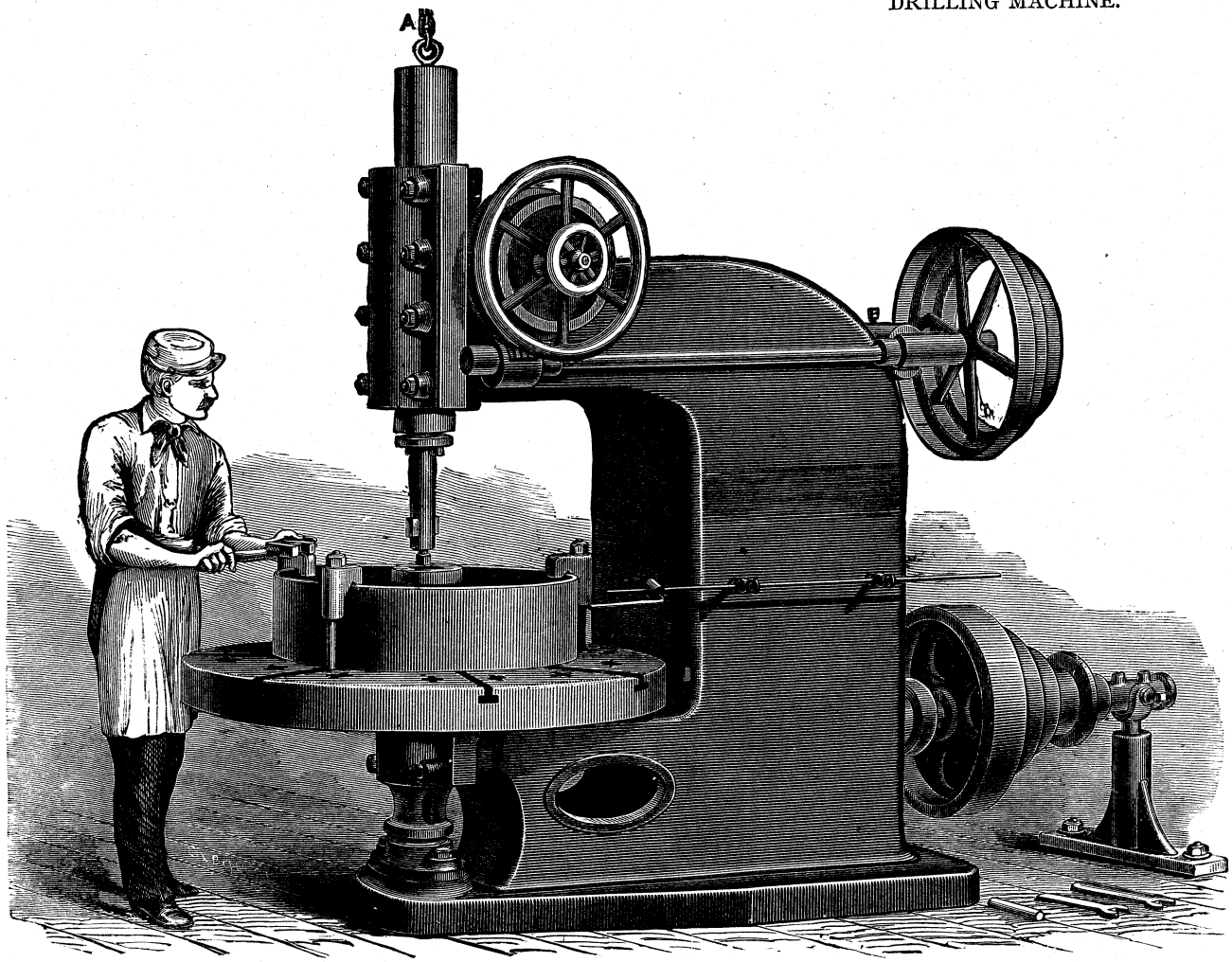

Fig. 1697.—PULLEY-BORING MACHINE.

holes may be drilled simultaneously, and is provided with a dividing motion that enables the table to be revolved a certain distance, corresponding to and determining the pitch of the rivet holes.

It is capable of drilling locker shells of any diameter between four and eight feet. The feed motion to each drill is driven from one source of power, but each drill is adjustable on its own account. The depth of feed is regulated by a patent detent lever which engages with the teeth of a ratchet wheel, till released therefrom by contact with the adjustable stop. The drill spindle is then instantly forced back by the spiral spring and the forward feed motion continues.

It is the duty of the attendant to turn his dividing apparatus handle the required distance for the next hole, directly the drills are withdrawn, the amount of clearance between the drill point and the boiler shell being such as to give him proper time for this purpose, but no more. Self-acting water jets to the drills, and reflectors to enable the operator to see each drill, will be provided, but were not in action at the time views of the machine were made.

With an ordinary boiler shell formed in three plates, the three drills work simultaneously, and the one movement of the dividing apparatus, of course, applies to all. If the object to be drilled be not divisible into multiples of three, any other divisions can be produced by the dividing gear, either one, two, or three drills being used, as the circumstances may permit. Two heads can be shifted round from the angle of 120°, at which they are shown, to positions diametrically opposite, as may be desired, and the third can be used or disused as wished.

Vertical gauge rods are provided, duly marked out to the various pitches that may be needed for the vertical rows of holes, and the movement of the drill spindle saddles is so simple and steady that accurate adjustment can be made without the least difficulty. In the same way when the drill would, in its natural course, come in contact with one of the bolts by which the plates are held together, the attendant can run all the drills downwards a couple of inches or so, then turn the dividing apparatus two pitches instead of one, and on raising the three drills again he can continue the circular row as before. The entire control of the machine is governed by the attention of one man to two levers and the one dividing handle, which are all conveniently placed for the purpose.

In Fig. 1696 is represented a machine for boring car wheels. The chuck is driven by a crown gear operated beneath by a pinion on the cone spindle. The feed motion for the boring bar is operated from the small cone shown on the cone spindle, there being three rates of automatic feed, which are communicated to the bar by a worm and worm-wheel operating a spindle carrying a pinion in gear with a rack on the back of a boring bar.

The worm-wheel is provided with a friction disk operated by the small hand-wheel shown, to start and stop the automatic feed, the large hand-wheel operating the rack spindle direct, and therefore giving a rapid hand-feed or quick return motion for the boring bar. The boring bar is counterbalanced by a weight within the frame. On the side of the frame is a small crane for handing the car wheels.

Fig. 1697 represents a special machine for boring pulleys, &c. The advantage possessed by this class of machine is fully set forth in the remarks upon Boring and Turning Mills, and with reference to Fig. 725. The tool bar is fed vertically to the rotating pulley, and has three changes of feed; viz. ·0648, ·0441, and ·0279 of an inch per rotation of the work. Its weight is counterbalanced.

The speed of rotation of the work table or chuck plate may, by means of the four steps on the cone pulley, be varied as follows:—63, 43, 19, or 10 revolutions per minute, which speeds are suitable for work bores ranging from 1 to 7½ inches in diameter, the power exerted at the tool-point being for the latter diameter 1800 lbs.

The tool bar feed is operated by the upper cone pulley, and the worm and worm-wheel shown, the small wheel giving the automatic feed by a suitable friction plate, and the large hand wheel operating the bar quickly to elevate it after it has carried its cut through. When the drill is given a traverse back and forth, it obviously cuts out a slot or keyway whose width is equal to the diameter of the drill, and whose length equals the amount of traverse given to the drill. Special forms of drill are used for this purpose, and their forms will be shown hereafter. The machines for using these drills are termed traverse or cotter drilling machines. In Fig. 1698 is represented a combined drilling and cotter drilling machine. This machine consists essentially of a drilling machine provided with automatic feed motions for cotter drilling; these motions consisting of a self-acting traverse to the sliding head carrying the drill spindle, and a vertical feed, which occurs at the end of each traverse, and during a short period of rest given to the sliding head carriage, or saddle as it is promiscuously termed. The slideway for this head stands vertical and extends across the top of the frame.

The belt motion is conveyed up one end and then on the top of the slideway, driving the spindle direct by means of a pulley. The traverse of the head or saddle in cotter drilling is accomplished by means of a peculiar arrangement of screws and adjustable nuts, which can be instantly set to the required length of slot, and insures a uniform motion, back and forth, at each stroke, the length of the stroke being uniform, as is also the rate of its advance. The vertical position of the drill spindle is of great advantage in cotter drilling wrought iron or steel, as the slot in process of cutting can be kept full of oil.

The feed motions for cotter drilling may be instantly thrown out of gear when not required, remaining at rest and leaving the machine a simple traverse drill with automatic feeds.