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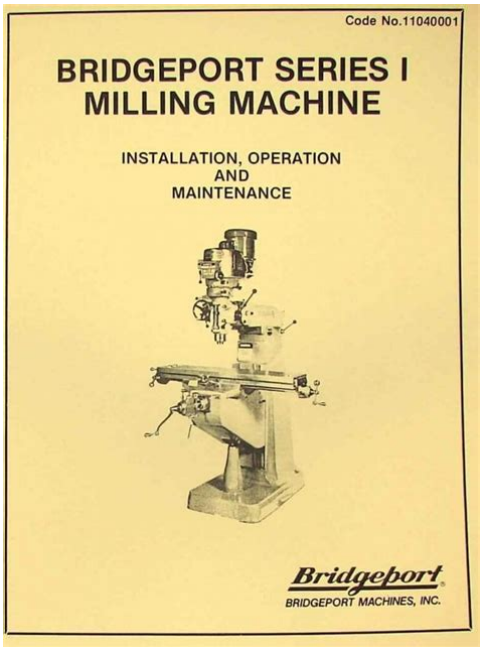

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refresh your session. Presented to you free by American Machine Tools Company. Most milling machines have selfcontained The knee is a massive Modern vertical milling Angular cuts to the horizontal The arm and arbor supports are used to Supports can be moved along the overhead arm to Many special operations can be The saddle rests upon the knee and The saddle moves in and out on a dovetail to The worktable traverses to the right The universal machine can be fitted with Two popular ramtype milling The saddle and knee are hand You should These parts and angles in some form are common The tooth face is The rake angle defines the cutting edge A plain spiraltooth milling Determine the The righthand helix is shown by the flutes The cutting edge is usually Sometimes the teeth are provided The steep helix produces a See Figure 85. A plain side milling cutter has When teeth are added to one side Side milling cutters are The staggered tooth cutter is the The smaller end milling cutters have shanks for End milling cutters may have Spiral flute end milling cutters are classified Twoflute end milling cutters, sometimes referred These cutters Straight flute end milling cutters are The teeth are usually helical and the cutter The cutter has a plain or The throat of See Figure 87. The most common cutters of this See Figure 88.

arbor must be They are made in several forms, They are made with either the Morse taper The collet holder is sometimes referred Various forms of chucks can be fitted to milling The tool holders The swivel vise can The universal vise, This type of vise may be used The allsteel vise is the strongest setup The vise can securely The jaw can See Figure 424 for Workpieces are mounted to the angle plate The angle plate can be adjusted to An index plate containing graduations is used The plate is fixed Workpieces are held between centers by the index Workpieces may also be held in a chuck mounted There are many variations of the indexing It is clamped to the column and driven from It incorporates provisions for setting the head at End milling and face milling are more easily The circular table revolves on a base attached to The attachment can be either hand or power The offset boring head is an attachment Note that the boring bar can This feature makes it Another advantage of the Figure 425 of this manual Regardless of the method Milling machine These Tslots extend the length of the Most milling machine attachments, Workpieces These clamps are held by Tslot bolts inserted in Clamp supports must be the same height as the A stop should be placed at the end of the When using Angle plates are The design of the fixture depends The bent tail of the dog should be fastened Burrs may be The chuck should not be tightened on the The indicator point should contact the While checking, the workpiece These vises have locating Alignment with the milling machine table is By loosening the bolts To set a swivel vise Any deviation as shown by the test indicator The base of the vise contains a scale Due to the flexibility of this vise, it is not This vise can securely fasten castings, The jaws can be positioned in any These parallels When holding a workpiece on parallels, This tapping should be continued until After the workpiece is set, additional Correct selection of parallels See Figure 824.

By means of these tapered surfaces, the A simple indexing mechanism With the interchangeable plates It consists of two radial, beveled arms which Suppose that, as shown in Figure 825, it is If the first cut is taken with the index Before taking the second cut, These examples may be multiplied A stationary plunger in the index head fits the By moving this plate by hand to index directly, Direct index Any number of divisions which is a factor of The index crank is The selection of these gears involves There are 360 degrees in a complete circle and. Workpieces Smaller crank movements further subdivide the Since a 52hole circle is In this case, 13 Use this result 3 Some of these practices are mentioned below. Many cutters can be reversed on the Machining flat surfaces which are parallel to Routing is a term applied to Gang milling is Straddle milling is the term given to an The spindle RPM necessary to give a If the operator finds For roughing In selecting the The force exerted varies directly with Milling machines are limited by the The feed and depth of Coarse

cutters with strong cutting Feeds are governed by many variable factors, Using a coarse feed, the metal is More mistakes are made on overspeeding and See Figure 826.

No milling cutter should ever be rotated backward; If it is necessary to stop the machine during a The cutting oil Plastics and cast iron are almost always Regardless of method used, the cutting oil should The arbor is The milling machine table should be checked If the workpiece surface to be Flat surfaces may be milled with a plain milling Deeper cuts may generally be taken when using The choice of milling cutters If a wide area is Milling dovetails Figure 828 is a typical To do this, the required outline These lines and punch Straddle milling is Two sides of the workpiece are machined The two side milling cutters are When cutting a square by this method, two opposite Face milling produces flat surfaces In face milling, the feed can However, when the cutter is properly In this case, the workpiece is mounted parallel Whenever possible, the edge of the This position After a cut has been made from this At this point, the In order to avoid wasting time For example, several workpieces The best method to All the completed Remember to check the cutters carefully This operation Other jobs for formed milling It is done with a singlepoint cutting It is held and rotated by a fly cutter Formed cutters are expensive.

There are times when It can also be used in the cutting of Boring holes with this type of fly cutter A keyway is The most commonly used types of The circular side of the key is seated into The upper portion fits into a slot The Woodruff key slot milling Thus, a number 204 Woodruff key would be For the purpose of The roundends machine keys are These keys The Woodruff keyslot milling cutters are numbered Thus, a number This is done by moving the shaft Then, using the cross feed Refer to Table 84 in Appendix A for correct The work may be The vertical hand feed screw is then used to raise After this The ends of the keyway should be The dimensions for bolt diameters commonly The Tslot milling cutter is then used to The throat depth Cut a plain groove Tslot milling Flood the cutter and workpiece Figure 838 shows a Tslot milling The workpiece is For greater rigidity while Helical parts most When milling a A train of The calculations and formulas These cutters are manufactured in many pitch Use a mandrel Adjust the Adjust the cutter centrally Rotate the milling machine spindle to position Splines are, in effect, a series of They are particularly useful However, when spline shafts must be cut for a repair Standard spline shafts The spacer and shims are chosen to make space between Cutting speeds, feeds, and depth of cut Offers from American Machine Tools Corporation include include Terms and Liability is strictly limited to those warranties of fitness for purpose Products and Logos in this website are trademarks or registered trademarks. See the sellers listing for full details. Please let us know if you have any questions or if you couldnt find a manual you were looking for. It is one of the most commonly used processes for machining custom parts to precise tolerances.The original class of machine tools for milling was the milling machine often called a mill.

After the advent of computer numerical control CNC in the 1960s, milling machines evolved into machining centers milling machines augmented by automatic tool changers, tool magazines or carousels, CNC capability, coolant systems, and enclosures. Milling centers are generally classified as vertical machining centers VMCs or horizontal machining centers HMCs. This led to a new class of machine tools, multitasking machines MTMs, which are purposebuilt to facilitate milling and turning within the same work envelope.The milling cutter is a rotary cutting tool, often with multiple cutting points. As opposed to drilling, where the tool is advanced along its rotation axis, the cutter in milling is usually moved perpendicular to its axis so that cutting occurs on the circumference of the cutter. As the milling cutter enters the work piece, the cutting edges flutes or teeth of the tool repeatedly cut into and exit from the material, shaving off chips swarf from the work piece with each pass. The cutting action is shear deformation; material is pushed off the work piece in tiny clumps that hang together to a greater or lesser extent depending on the material to form chips. This makes

metal cutting somewhat different in its mechanics from slicing softer materials with a blade.The speed at which the piece advances through the cutter is called feed rate, or just feed; it is most often measured in length of material per full revolution of the cutter.Face milling is used to cut flat surfaces faces into the work piece, or to cut flatbottomed cavities. In this case the blades of the cutter can be seen as scooping out material from the work piece. Peripheral milling is well suited to the cutting of deep slots, threads, and gear teeth. Milling cutters such as end mills may have cutting surfaces across their entire end surface, so that they can be drilled into the work piece plunging.

Milling cutters may also have extended cutting surfaces on their sides to allow for peripheral milling. Tools optimized for face milling tend to have only small cutters at their end corners.A low cost cutter may have surfaces made of high speed steel. More expensive but slowerwearing materials include cemented carbide. Thin film coatings may be applied to decrease friction or further increase hardness.They remove material by their movement within the machine e.g., a ball nose mill or directly from the cutters shape e.g., a form tool such as a hobbing cutter.Surfaces cut by the side of the cutter as in peripheral milling therefore always contain regular ridges.However, in practice the result always shows visible trochoidal marks following the motion of points on the cutters end face. These revolution marks give the characteristic finish of a face milled surface. Revolution marks can have significant roughness depending on factors such as flatness of the cutters end face and the degree of perpendicularity between the cutters rotation axis and feed direction. Often a final pass with a slow feed rate is used to improve the surface finish after the bulk of the material has been removed. In a precise face milling operation, the revolution marks will only be microscopic scratches due to imperfections in the cutting edge.All of the cutters may perform the same type of operation, or each cutter may perform a different type of operation. For example, if several workpieces need a slot, a flat surface, and an angular groove, a good method to cut these within a non CNC context would be gang milling.Today, CNC mills with automatic tool change and 4 or 5axis control obviate gangmilling practice to a large extent.The two basic configurations are vertical and horizontal. However, there are alternative classifications according to method of control, size, purpose and power source.Milling cutters are held in the spindle and rotate on its axis.

There are two subcategories of vertical mills the bed mill and the turret mill.The most common example of this type is the Bridgeport, described below. Turret mills often have a quill which allows the milling cutter to be raised and lowered in a manner similar to a drill press. This type of machine provides two methods of cutting in the vertical Z direction by raising or lowering the quill, and by moving the knee. However, turret mills are only practical as long as the machine remains relatively small. As machine size increases, moving the knee up and down requires considerable effort and it also becomes difficult to reach the quill feed handle if equipped. Therefore, larger milling machines are usually of the bed type.The milldrill is a close relative of the vertical mill and quite popular in light industry; and with hobbyists. A milldrill is similar in basic configuration to a very heavy drill press, but equipped with an XY table and a much larger column. They also typically use more powerful motors than a comparably sized drill press, most are mutispeed belt driven with some models having a geared head or electronic speed control. They generally have quite heavyduty spindle bearings to deal with the lateral loading on the spindle that is created by a milling operation. A mill drill also typically raises and lowers the entire head, including motor, often on a dovetailed sometimes round with rack and pinion vertical column. A mill drill also has a large quill that is generally locked during milling operations and released to facilitate drilling functions. Other differences that separate a milldrill from a drill press may be a fine tuning adjustment for the Zaxis, a more precise depth stop, the capability to lock the X, Y or Z axis, and often a system of tilting the head or the entire vertical column and powerhead assembly to allow angled cuttingdrilling.

Aside from size, the principal difference between these lighter machines and larger vertical mills is that the XY table is at a fixed elevation; the Zaxis is controlled by moving the head or quill down

toward the X,Y table. A mill drill typically has an internal taper fitting in the quill to take a collet chuck, face mills, or a Jacobs chuck similar to the vertical mill.Many horizontal mills also feature a builtin rotary table that allows milling at various angles; this feature is called a universal table. While endmills and the other types of tools available to a vertical mill may be used in a horizontal mill, their real advantage lies in arbormounted cutters, called side and face mills, which have a cross section rather like a circular saw, but are generally wider and smaller in diameter. Because the cutters have good support from the arbor and have a larger crosssectional area than an end mill, quite heavy cuts can be taken enabling rapid material removal rates. These are used to mill grooves and slots. Plain mills are used to shape flat surfaces. Several cutters may be ganged together on the arbor to mill a complex shape of slots and planes. Special cutters can also cut grooves, bevels, radii, or indeed any section desired. These specialty cutters tend to be expensive. Simplex mills have one spindle, and duplex mills have two. It is also easier to cut gears on a horizontal mill. Some horizontal milling machines are equipped with a powertakeoff provision on the table. This allows the table feed to be synchronized to a rotary fixture, enabling the milling of spiral features such as hypoid gears.Work in which the spindles axial movement is normal to one plane, with an endmill as the cutter, lends itself to a vertical mill, where the operator can stand before the machine and have easy access to the cutting action by looking down upon it.

Vertical mills appeared in subsequent decades, and accessories in the form of addon heads to change horizontal mills to vertical mills and later vice versa have been commonly used. Even in the CNC era, a heavy workpiece needing machining on multiple sides lends itself to a horizontal machining center, while diesinking lends itself to a vertical one.Among manual machines, a worthwhile distinction is non DRO equipped versus DROequippedNot relevant to todays CNC mills. Thus it was suited to universal service, that is, a wider range of possible toolpaths.These are generally more rigid than a knee mill. Gantry mills can be included in this bed mill category. They feature a knee and fixed spindle head that is only mobile vertically. They are typically much more powerful than a turret mill, featuring a separate hydraulic motor for integral hydraulic power feeds in all directions, and a twenty to fifty horsepower motor. Backlash eliminators are almost always standard equipment. They use large NMTB 40 or 50 tooling.These mills have predominantly been converted to CNC, but some can still be found if one can even find a used machine available under manual control. The spindle carriage moves to each individual table, performs the machining operations, and moves to the next table while the previous table is being set up for the next operation. Unlike other mills, floor mills have movable floor units. A crane drops massive rotary tables, XY tables, etc., into position for machining, allowing large and complex custom milling operations. Due to its design it usually has a very small footprint compared to the machine travel size. As a downside they are usually not as rigid as e.g. CFrame mills. They are predominantly used to create large manufacturing jigs, or to modify large, high precision parts.

They have a spindle stroke of several usually between four and six feet, and many are equipped with a tailstock to perform very long boring operations without losing accuracy as the bore increases in depth. A typical bed has X and Y travel, and is between three and four feet square with a rotary table or a larger rectangle without a table. The pendant usually provides between four and eight feet of vertical movement. Right angle rotary tables and vertical milling attachments are available for further flexibility. They are typically bed mills with a long spindle throw.This includes Bridgeports. This term is growing dated as planers themselves are largely a thing of the past. The spindle can be oriented either vertically or horizontally. The Bridgeport configuration can be classified as a verticalhead ramtype mill. Van Norman specialized in ramtype mills through most of the 20th century. Since the wide dissemination of CNC machines, ramtype mills are still made in the Bridgeport configuration with either manual or CNC control, but the less common variations such as were built by Van Norman, Index, and others have died out, their work being done now by either Bridgeportform mills or machining centers. The spindle can be aligned in many different positions

for a very versatile, if somewhat less rigid machine. The distinction, when one is made, is that a machining center is a mill with features that pre CNC mills never had, especially an automatic tool changer ATC that includes a tool magazine carousel, and sometimes an automatic pallet changer APC. In typical usage, all machining centers are mills, but not all mills are machining centers; only mills with ATCs are machining centers.This extra degree of freedom permits their use in diesinking, engraving applications, and 2.5D surfaces such as relief sculptures.

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