gether with limestone, quartz, feldspar and calcite used in the furnace. Pilot Knob, Iron Mountain, Knob Knoster, and many of the less important iron regions are represented by a great variety of ores, as well as coal and flux used in smelting, and pig iron manufactured from the ores. There are large masses of ore from some of these localities. One piece from Iron Mountain, presented by Mr. Edwin Harrison, weighs seven tons, and has the appearance of a huge hexagonal pyramid.

The Mine La Motte sends some very choice specimens of galena crystallized in octahedrons and rhombic dodecahedrons modified by cubes. There are from the same locality pieces of well crystallized marcasite and linnæite. Some specimens of barytes which resemble ivory on the edges of the crystals are very interesting, and from Newton County tripoli of good quality is exhibited.

The collection from the State of Pennsylvania comprises mostly iron, copper, zinc, nickel, and cobalt ores, and coal.

Mr. Joseph Wharton makes a fine exhibit of nickel and cobalt ores from the Gap Mine, Lancaster County, together with a complete series of products made from these ores at his works in Camden, N. J. The ores are chiefly nickeliferous, pyrrhotite and millerite, both containing more or less cobalt. There is next a suite of mattes and slags, formed during the process of reduction, and nickel and cobalt in cast plates or anodes for batteries, and in cubes and wrought bars for the use of electro-platers. Next comes a variety of salts of cobalt and nickel used in the arts, including double sulphate of nickel and ammonia used for nickel-plating, the chloride, sulphate, acetate, and oxide of nickel and a corresponding series of cobalt salts. There are also in this exhibit specimens of nickel and cobalt plate on different metals, and several alloys of nickel with zinc or copper, such as German silver, nickel three-cent and five-cent pieces, etc. The most interesting things, however, in the case are a nickel horseshoe magnet and a nickel magnetic needle, both of which are quite feeble. The horseshoe magnet is able to hold up four or five nickel-plated key rings.

Copper is also extracted from much of the ore from the Gap Mine, and specimens of the products are shown with Mr. Wharton's exhibit.

From the Cornwall ore banks of Lebanon County there is a fine exhibit of iron ores and pig iron made at different furnaces with this ore.

Mr. Douglas, of the Chemical Copper Company, of Phoenixville, has a collection of copper ores from the Cornwall banks, and from Berks County, which are treated at the works of this company by the Hunt & Douglas method. A complete suite of products of this method is shown, and some jars contain the precipitated copper in beautiful feathery crystals. An ore containing only 2.8 per cent copper can be successfully treated by this process.

Mr. Wheatley, of the Schuylkill Copper Works, Phoenixville, exhibits specimens of ores which are smelted at the works which he represents. There is also with these ores a set of furnace products, illustrating the different stages in the reduction of the copper from the first fusion to the production of the finished ingot.

The Lehigh Zinc Company exhibits zinc blende and calamine from Friedensville, Pa., which are used at the works of this company at Bethlehem. Spelter made from each of these ores and sulphur extracted from the blende are also shown.

Anthracite coal and a great many fossil coal plants from mines in Pennsylvania are to be seen in the collection. The Philadelphia and Reading Coal and Iron Company has erected on the trophy in the centre of the Government Building a column of anthracite coal, which is a section of the mammoth vein at Plank Ridge Colliery, near Shenandoah, Schuylkill County. The thickness of the vein, and consequently the height of the column, is 44 feet. The column is supported by an iron framework put up by the Phoenix Iron Company. Around the base of the trophy are grouped various products of the soil and mine, including masses of marble, copper, iron, nickel, and zinc ores, together with sheaves of cereals, bales of cotton, hogsheds of tobacco, casks of wine, etc. The copper ores exhibited from Pennsylvania include chalcocite from Chester and Montgomery Counties, chalcocite and variegated copper from Montgomery County, magnetite containing chalcocite from Berks County, and numerous specimens of malachite containing 38.62 per cent copper, copper pyrites with 31.94 per cent copper; and native copper from the Cornwall ore banks.

Chromite, both washed and as it is found in Delaware County, and fire clays, together with bricks made therefrom, are well shown.

New York has a large exhibit of iron ores from all the principal localities in that State. The Crown Point Iron Company sends a collection of magnetic iron ores with wall and bed rocks of the mines. Samples of charcoal and flux used in smelting, and pig and wrought iron made from this ore, are included in the exhibit. Port Henry, Moriah, and the chief iron-ore mines of the Lake Champlain region are well represented, some of them by large masses weighing from one to six tons. From Rosie and Clinton there are specimens of the fossiliferous red hematite, characteristic of the Clinton group; and from Putnam County there are pieces of magnetite from various mines. Some beautifully crystallized specimens of magnetite, with Jenkinsite, are shown from the O'Neil Mine, Orange County; and from several mines in Dutchess County there are large pieces of limonite, one from the Manhattan Mine showing considerable turgite. From East Fishkill there are exhibited two or three pieces of melanosiderite.

The Copake Iron Works shows some fine specimens of charcoal pig iron of all grades, each piece being fractured at both ends and chilled at one end. Some graphite is exhibited as found in its native state at Black Mountain, near Clintonville, and as prepared for various purposes, such as electrotyping, making pencils, etc.

The Capital Lime and Cement Company makes a display of hydraulic limestone from Rosendale, together with samples of cement made therefrom.

Adam Weber and B. Kreischer & Son, of New York City, have exhibits of fire clays and materials made therefrom, including gas retorts, muffles, fire brick, furnace tile, and a variety of curiously shaped articles. Some specimens of rose quartz and feldspar from Essex County, used in the manufacture of pottery, finish the display of New York.

New Jersey exhibits some fine specimens of zinc and iron ores. From Franklin and vicinity there is a great abundance of zinc ore, including zincite, franklinite, and willemite, associated with calcite and numerous other minerals. There are several large boulders and masses of this ore piece representing a section of the vein, while others show dikes or faults. In the glass cases are several very beautiful specimens of ruby zinc ore, and some yellow translucent crystals of willemite and crystallized franklinite occurring alone, and associated with the other minerals. Most of these specimens were presented by the New Jersey Zinc Company.

The Passaic Zinc Company sends a fine lot of crystallized calamine and franklinite, together with spelter and zinc oxide

prepared from these ores. Some sussexite, rhodonite, fowlerite, etc., are shown with the rest of the minerals.

Besides the zinc ores there are exhibited iron ores from nearly all the principal mines in New Jersey. The ores are mostly magnetites, and Morris, Essex, and Sussex counties are better represented than any of the others. Cooper & Hewitt send a lot of magnetites and limonites from different mines near Trenton, with limestone used as flux and pig iron made from these ores.

Mr. Edward H. Fletcher, of New York, makes a loan exhibition of minerals from Bergen Hill, some of which are very handsome. New Jersey also makes a good exhibit of clays for making pottery, china-ware, etc.

Massachusetts has a good representation of the recently discovered argentiferous lead ores from the vicinity of Newburyport, and also a few specimens of a similar ore, though not so rich, from other mines in the State.

James T. Ames sends from Chester a very neat collection of emery and associates, the latter including soapstone, diaspore, hornblende, margarite, andesite, etc. One large piece of emery rock shows crystals of diaspore on one side.

Barytes from Cheshire fills part of one case. This mineral is now being largely used for the manufacture of paint by mixing with white lead or zinc oxide. A display of Berkshire sand, which is as white as snow, is made on a little stand in the side aisle. Some large pieces of glass made by using this sand help to make the exhibit a very attractive one.

From Vermont there is quite a good exhibit. The Vermont Copper Mining Company, of Ely, Orange County, sends samples of copper ore, chiefly copper pyrites, and a suite of furnace products illustrating the different stages in the manufacture of copper. Limonite is shown from Burlington, South Wallingford, and a few other localities. That from South Wallingford is manganiferous, and is adapted for making spiegeleisen.

New Hampshire has no other exhibit than a set of geological rocks presented by Professor Hitchcock, the State geologist.

Connecticut has some good limonite iron ores to show, some of which contain turgite. Barnum, Richardson & Co., of Salisbury, send a large piece of their ore, which is limonite. From Roxbury some siderite or carbonate of iron is sent, but, like most of the New England States, the exhibit of Connecticut is chiefly of marbles and granites. Rhode Island sends one large mass and two barrels of graphitic anthracite from the coal fields of that State.

The collection of marbles, granites, and building stones comprises some of the finest specimens to be found in the whole Exhibition. It is arranged without regard to geographical localities, and the specimens are exhibited as polished slabs 2 feet by 4 feet by 2 inches, and as 12-inch and 6-inch cubes, polished on one face, rough dressed on another, and showing the fracture on a third.

The Rutland Marble Company, of West Rutland, Vt., has the largest exhibit. It embraces various grades of marble, from the white statuary to the mottled blue and beautiful "Brocardilla" marbles. Besides these dressed specimens, this company sends some large masses of statuary marble, one of which weighs ten tons, is fine grained, and perfectly white.

There are also marbles from the Columbian and Eureka Marble Companies of Rutland, and from Ripley & Sons, of Centre Rutland, Vt. From Sutherland Falls, East Dorset, and Mallett's Bay there are fine specimens of marble, those from the last-named place being of very beautiful variegated red and brown colors. George Barney sends some marbles from Swanton, Vt., which are adapted for tiles. The "Le Panto" and the "Lyonnaise" are the most attractive. The latter marble, which is a mottled brownish-red and white, is used in the floor of Memorial Hall.

From Moriah, N. Y., and Roxbury, Vt., some specimens of verd antique are exhibited; and from Lake Champlain, Vt., and Hawkins County, Tenn., there are shown fossiliferous marbles, which are exquisite.

A variety of limestone from Charlotte, N. C., called leopardite, from its resemblance to a leopard's skin, is very interesting; and some eocene-shell limestone from Newbern County, N. C., used for building purposes, is worth examination.

County, Ct., there are cubes of red and gray granites of superior quality.

A few specimens of dressed brown sandstone from Portland, Ct., East Long Meadow, Mass., and Anson, N. C., complete the collection of building stones.

Besides the ores and minerals already described, there is in the northwestern corner of the building a loan collection of crystallized minerals from the private cabinets of Rev. Dr. E. R. Beadle, Theodore D. Rand, Joseph Wilcox, and Clarence Bement, of Philadelphia, and William W. Jefferis, of Westchester, Pa.

This collection contains some exquisite specimens. It was not designed for a representative collection of all the crystallized minerals of the United States, but to show the rarest and most beautiful forms in which some of these minerals occur.

Messrs. Park Brothers & Co., of the Black Diamond Steel Works, Pittsburg, Pa., have an interesting exhibit illustrating the manufacture of crucible steel. The collection embraces specimens of Lake Superior and Iron Mountain hematites from all the different stages of its manufacture into steel, together with ingots of steel and various manufactured articles, such as pickaxes, knives, boiler-plate, wagon-springs, etc. Some of the ingots are broken to show the fracture, and bent or twisted to show the tenacity, while from others tools are drawn and finished. A column in the centre of the exhibit is composed of steel rods, bars, etc., of various sizes and forms, as manufactured for the trade.

Messrs. Hussey, Wells & Co., of Pittsburg, have a case in the side aisle containing a number of specimens illustrating the process of the manufacture of crucible cast steel in all its stages and with different qualities of iron. The fronts of the crucibles in which the steel was prepared have been removed, so that the contents can be seen.

The Albany and Rensselaer Iron and Steel Company, of Troy, N. Y., have an exhibit of Bessemer steel, which is placed in the central aisle. A large shaft, fractured at the upper end, supports a hexagonal framework of wood, around which car axles, rails, crowbars, boiler-plates, rivets, etc., are arranged. Many of these articles are twisted or bent cold to show tenacity.

Collins & Co., of Hartford, Ct., contribute some samples of steel used at their works, and a suite of specimens to illustrate the different stages in the manufacture of the axe.

From Tatham & Co., of Philadelphia, there is a very tastefully arranged exhibit illustrating some of the uses of lead. It consists of a cone of tin-lined lead pipe, about six feet high, placed on a black-walnut pedestal. Around the sides of the pedestal are arranged samples of sheet lead of various weights and degrees of thickness, from one to twenty pounds per square foot; lead pipe of different diameters and degrees of thickness, and shot of all sizes from dust to buck-shot. There are two meteorites on exhibition with the collection: one, the famous "Tucson" or "Irwin" meteorite, from Arizona, was brought from the Smithsonian Institution at Washington, on purpose for exhibition here. The other, the "Blake" meteorite, is from Tennessee, and has a very peculiar oblong shape. During the warm weather this summer this meteorite exuded drops of chloride of iron. A more detailed description of the meteorites is given in the SCIENTIFIC AMERICAN SUPPLEMENT, No. 43, p. 671. M. S. T.

THE HANDIWORK OF APPRENTICES AT THE CENTENNIAL EXPOSITION.

By JOSHUA ROSE.

THE EXHIBIT OF THE IMPERIAL TECHNICAL SCHOOL, MOSCOW.

FOUR of the prominent exhibits in Machinery Hall are distinctive as being produced by apprentices, and the largest of these is that of the Imperial Technical School of Moscow, Russia, whose entries are very complete, the object being to show rather the course of the studies, than to pick out individual specimens of good salable workmanship. In this respect the display stands alone. The whole course of study shows that the professors are themselves practical mechanics, for every piece of work in each course has a distinct purpose,

FIG. 1.

The collection of granites, although not so complete as that of the marbles, is still very good. Some of the finest specimens are from Quincy, Mass., and Westerly, R. I. A large polished slab of very fine-grained granite from the quarries of the New England Granite Company, at Westerly, measures 3 feet by 6 feet by 4 inches, and attracts considerable attention. From Leets Island, Ct., Blue Hill, Me., and New Haven

and could not be omitted without the loss of a definite and useful experience. In the prospectus of the school we read as follows: "No one will deny that a close acquaintance with hand labor, and a general practical experience in mechanical works, are matters of the utmost importance to every mechanical constructing engineer. The drawings of an engineer thus trained will always be distinguished by solid-

ity, and that practical judgment which is the result, not only of scientific truths, but also of the acquirement of a certain familiarity in their application to practice." Now, as if to give point to these very remarks, we find, on the drawings exhibited, red lines denoting those parts which require to be left larger on the pattern, so as to allow for machine manipulation and finishing, and on some of them the radius lines of curves are also marked so as to facilitate the operations of the workmen in lining out the work. To make such a drawing one must have a fair knowledge of pattern-making, as well as of moulding, since the draughtsman determines which way the pattern shall be moulded. This may not be, in all cases, absolutely necessary, but it is always highly advantageous, providing the designer is equal to the task. The cost of producing machinery is very often largely increased because the draughtsman has kept in view the designing only, without any reference to the best, strongest, and readiest way of making many of the parts.

FIG. 2.

The exhibited samples of blacksmith's work and tools are fifty-four in number, of good design and neatly made. In those having eyes to receive the handle, the eyes are well rounded, from the centre outwards, on each side—a matter in which most of our own blacksmiths and tool-makers are generally deficient, and hence loose handles, so often met with. The list of tools includes the usual swages, mandrils, fullers, tongs, sets, etc., to none of which can any exception be taken, save it be to the hand hammers, of which there are two. The first of these is of the pattern known in England as the fitter's hammer, and in the United States as the cross-pene hammer. The second is known in England as the cross-pene hammer, and in the United States as a chipping hammer. The blacksmith's hand hammer, weighing about 1½ lb., with a ball pene at the small end, and provided with a long handle, as used in all the principal blacksmiths' shops in both England and the United States, is conspicuous by its absence.

FIG. 3.

The samples of blacksmithing are certainly admirably chosen, as also well executed. Commencing with examples of forging square iron out of round iron, they include the production of round out of square, octagonal out of square, hexagonal out of round, and thence advance to the more difficult bolt heads.

Various kinds of flanges, eyes, and ears are taken up when welding is studied. These include the welding of washers or rings, scarf welding, split welds, pipe welding, and jumped welds. In bending, we are presented with flat iron bent to a right angle, the corners being brought square and neat. Next we have bent squares, welded squares, steel welded to iron, a welded cross, etc. The whole course of examples is progressive from beginning to end. We may now notice the turning tools. To the first examples—namely, the centre punches—there is the objection that they appear to be made of round steel, which is not, as a rule sufficiently refined at its centre to stand the heavy duty to which this tool is subjected. The chipping chisels are not made of octagon steel after the American pattern, but of a special steel made and used in England for chipping chisels only. It is flat on the top and bottom, and rounded on each side, and is admirably shaped for the purpose of holding in the hand. Samples of the old-fashioned hook tool are shown, serrated at the bottom so as to take a firm grip on the rest. Chisel, square, round, and V-nosed hand tools are shown, together with front, side, parting, and spring tools for use in the slide-rest. The callipers can not be said to be finely finished, but their shapes at the points are more correctly formed than is usually the case. There are several drivers or clamps with movable centres, which are admirably designed for throwing work out of the centre. A set of hand chasers, together with the hubs for making them, are shown, their sizes being, according to the English practice, denoted by the sizes of the iron they are intended to thread; thus the catalogue says, "Screwing tools, from 7/8 to 1½ inch diameter, according to Whitworth's scale." Of plain and screwed mandrils for nuts there are shown several specimens under the name of "pikes."

In the samples of outside turning work there is a plain cylinder, a bolt with a cylindrical head, a handle for a vise, a bolt with a "fashion" head, besides exercises of various channellings, and their stepped gauges, so that the examples furnish first plain cuts, next a plan and flange, then next a head and curve, then a curve and sweep, next a long taper and curve, followed by ogee sweeps and curves, and square shoulders, and so on, progressively. In chucking, the examples are, 1st, a pulley; 2d, a cylinder, entailing the first boring lesson, next a cylinder with a taper bore; 3d, a shell

for a step; 4th, a ball turned upon an axle; 5th, a finished ball; 6th, cones requiring sharp centres, and hence chucked. Then begins screw-cutting by hand chasers. So far all the examples have been of wrought iron, but here brass work begins: first, a stop cock and various grease-cocks, involving the fitting of cones; next, various conical valves, involving the fitting and grinding of seats while in the lathe; then a pair of connecting-rod brasses. We now come to a spindle and movable socket for a marking gauge, forming a lesson in work very liable to spring away from the cutting tool; also an eccentric, necessitating chucking in such a way that the strap can be tried on in the lathe.

A steam cylinder affords practice with the boring bar. A steam piston with a brass ring gives experience in the amount to be allowed, in such cases, for the expansion of the brass when under steam. A part of a governor necessitates the counterbalancing of the work on the face-plate of the lathe, and a cross-head offers an example of necessarily very exact chucking. Then comes a steam piston with cast-iron rings, as an example in the springing of work due to removing the surface skin. The last example is a crank shaft, involving plain turning, chucking, and counterbalancing, and requiring to be very true.

FIG. 4.

In the examples of drills and drilling there are drills intended to cut revolved either way, such as were used by a string or fiddle bow; lip drills, twist drills, pin drills, countersinks, and a countersink for brass. In all these examples the advantage of having the drill point as thin as is consistent with the necessary strength is plainly inculcated; while in the last mentioned countersink the cutting edge is a right-hand spiral, by which means it can be given a little rake without having any tendency to rip into the work.

The examples of tools and the specimens of vise work are not perhaps quite so noteworthy as those for lathe work. Samples of files, with the teeth greatly enlarged, show plainly the shapes of the teeth. The examples of chipping, flat, conical, convex, and concave surfaces are all well executed, and the examples of filing are complete and progressive. They consist, however, largely in the production of simple surfaces and apertures, and insufficiently perhaps in the matter of fitting parts together. This is no doubt due in a great measure to the fact that but seventy-two days in all are devoted to vise work, in which time it is impossible to crowd more examples than are here given.

The next entry is a marking-off table and a complete set of instruments, and samples of various classes of work are shown already marked off, in red lines, merely intended to instruct, being too coarse for actual workmanship. The display includes also various patterns and a few constructed machine tools. The former can not well be examined, because they are thickly coated with black varnish. They are, however, notable as being of good mechanical design.

THE CORNELL EXHIBIT.

The next exhibit is that of the students of Cornell University, under the tutelage of Professor Sweet. The entries include a foot lathe, shown in our engraving, Fig. 1, the particulars of which are as follows: It will swing 10 inches, and turn straight and taper 6 inches in diameter (over the slide-rest), and 26 inches long. The automatic feed has three changes of feed in addition to eleven change gear-wheels, by which twenty-six different pitches of threads may be cut, varying from four to sixty-four threads to the inch. The slide-rest is adjustable at the upper or cross slide, so that it may be set to any cone for either outside or inside work, the angle being determined by an accurately graduated circle. The upper part of the rest is also removable, so that a hand-rest may be inserted in its stead. The washer on the tool-post is rounded instead of being hollowed or cupped upon the upper face, and above the washer is inserted, through the tool-post slot, a packing piece flat upon its top and hollow to fit the washer on the bottom face, so that the dirt will not accumulate and obstruct the movement of the device; and hence the height of the tool can be very readily adjusted without the annoyance due to the turnings, binding, and cutting the surfaces, as is so commonly the case. The tool-post is provided also with a lever arrangement, by which the tool can be withdrawn during the back traverse of the tool in screw-cutting operations; hence the feed-screw need not be wound back, and the depths of the cuts may be made both more exact and uniform. The head-stock is provided with a three-lift cone, and internal back-gear, changed by a single action. It has also a hollow mandril and a graduated face-plate. The friction feed may be changed very quickly, and is thrown out of gear by the device which throws the screw-cutting gear into action. The leg at the foot of the lathe is pivoted in such a manner that the bed will not be affected by an uneven floor. The disk crank admits of the crank-pin being changed to the left of the treadle. The lever and connection to the crank are so arranged and proportioned as to give more than half a revolution of the main wheel during the down and less than half a revolution during the up stroke. In fact, every part of the design is admirably adapted to its purpose, and to obviate the practical defects and difficulties so often met with in foot lathes, while the workmanship throughout both in fit and finish is very superior.

The standard surface plates shown in our engraving at Fig. 3, and the angle surface plates shown at Fig. 2, are probably the best specimens of scraping exhibited in the Exhibition. Fig. 4 represents a straight-edge, and Fig. 5 a machinist's square, the workmanship of which is fully equal to that on the surface plates, and the design of which is admirable. The measuring machine and the stationary engine exhibited by the University, we have already described in a former issue. It only remains to be said that this whole exhibit is what might have been expected from the indefatigable exertions of Professor Sweet, to whom the duties of his profession are a labor of love.

EXHIBIT OF THE WORCESTER FREE INSTITUTE.

This technical school, which is located at Worcester, Mass., is in its scope and purpose essentially like those in Europe, but it gives especial prominence to practical mechanical manipulation. The apprentice class spend forty-two hours a week in the shop, and the course of study for mechanics is a half year longer than that for other students.

As specimens of the workmanship of the Institute, there are exhibited a 16-inch engine lathe, complete, and the whole of the working parts of a similar lathe not put together, so that the workmanship may be minutely examined. The lathe spindle is of steel hardened, and subsequently ground true. The bearings are toned with a suitable adjustment arrangement

to take up the wear. The back gear of the lathe is thrown into and out of gear by a lever and eccentric motion. The lathe is provided with a three-change spindle-feed motion in front, and a screw feed for thread-cutting purposes at the back. The tail stock is arranged to set over for turning tapers. The belt cone is made much broader than is usual, thus remedying a defect too often found in lathes. The bed is 8 feet long, and has raised V's for the slide-rest, the top surface of the V's being rounded to prevent the lodgment of dirt or grit. The workmanship on this lathe is highly commendable for its accuracy of fit, while for finish it equals almost any exhibit at the Centennial. The gearing is cut smooth, and runs very quietly.

A small lathe, termed a speed lathe, also in this exhibit, is simple in construction, handy, and well made. It has cone bearings, and a hardened spindle.

THE APPRENTICES' LOCOMOTIVE.

We now come to a locomotive exhibited by the Philadelphia & Reading R.R. Co. This engine has hanging upon its side a picture frame containing the portraits of the apprentices who made the engine, and just beneath this frame stands a connecting-rod end so badly fitted, that a three-cent

FIG. 5.

silver piece lies safely hidden away between the side of the key and the side of the keyway in the strap: nor is this an isolated instance of bad workmanship on this engine. There are split cotter driven home, but not split open at the ends, as they should be; and the pin connecting the slide-spindle to the rocker arm shows a great want of truth somewhere, since the inside head of the bolt is a fit on one side, while on the other it is gaping wide open; this remark applies equally as well to the washer on the crank-pin of the forward coupled wheel. These are defects we should scarcely expect to find in an exhibited engine, even though made by apprentices. Another of the locomotives exhibited by a prominent firm has the cross-head keyed to the piston-rod all out of line and truth, which it is sincerely to be hoped was done by an inexperienced apprentice, since it is discreditable to a high degree.

THE BRAINARD MILLING MACHINE COMPANY'S EXHIBIT AT THE CENTENNIAL EXPOSITION.

THE milling machine, while acknowledged to be a great labor-saving invention, and capable of producing with accuracy forms so intricate and irregular that their duplication to a standard form and size is impracticable, has not, so far, assumed its proper place in the ordinary machine-shop for use on general work. In lathe and planer work the truth and correctness, both in form and size, of the work, depend upon the skill of the operator. In the milling machine those elements are, after the machine is once set, assured. It is self-evident, then, that there is an excellent field in the ordinary machine shop for a milling machine, providing it is in design and scope fitted for general rather than for special work. Of the origin of the milling machine we have no certain information; but the writer well remembers one in use in a railway shop as early as 1849, and it was not, then, by any means a new machine. It was used for milling nuts. It was provided with a milling tool precisely the same in form as those at present in use, and with a notch dial-plate. It was self-acting, and was operated by a boy, who turned and shaped nuts by contract, the pieces being 6 cents per dozen for turning and milling all nuts from 1/4 in. up to 1 in. Of milling machines for general use there have been introduced but very few. A very successful one was built by F. O. Degener, the inventor of the Liberty Printing Press. It was made for his own use, and was employed for connecting rods, platen frames, links, levers, and, in fact, for any purpose requiring flat or parallel faces, and hence took the place of the ordinary planing machine, doing its work rapidly and well. This machine, however, was never duplicated. Brown & Sharp, of Providence, R. I., have for some years made a Universal Milling Machine, which has achieved a great success and a wide reputation. In the present article we describe the Brainard Milling Machine, ten sizes of which are exhibited at the Centennial. Of these we select for illustration the one known as the "Standard Universal," of which five sizes are entered, weighing from 525 lbs. to two tons, taking in work from 7 to 24 inches high, and having a feed from 9 to 36 inches, according to the size of the machine. That illustrated in our engraving is a size sufficiently heavy and powerful for moderately severe work, and yet is not unhandy for light work or for the use of small cutters. The frame of the machine consists of a square standard, with a wide-spreading base, and carries upon the top the driving and feed gear. The head is full-back geared like an engine lathe, the cone steps being made for a 24-inch belt. Over the bearings of the main spindle or arbor is sprung an arch, which braces the upper part of the machine and supports a projecting arm which carries a yoke, which, with its appendages, in turn supports the outer end of the mill or cutter spindle. This support is a matter of great importance, for without it the efficiency of the milling machine is confined to the use of cutters standing within a very few inches of the cutter spindle journal. With an outer steady bearing, as in this machine, cutters of considerable size and at a maximum distance apart or from the cutter spindle bearings may be employed. In certain cases, however, the outer supporting arm