THE PRACTICAL

TOOL-MAKER AND DESIGNER:

A TREATISE UPON THE

DESIGNING OF TOOLS AND FIXTURES FOR MACHINE TOOLS AND METAL WORKING MACHINERY,

COMPRISING

MODERN EXAMPLES OF MACHINES WITH FUNDAMENTAL DESIGNS FOR TOOLS FOR THE ACTUAL PRODUCTION OF THE WORK; TOGETHER WITH SPECIAL REFERENCE TO A SET OF TOOLS FOR MACHINING THE VARIOUS PARTS OF A BICYCLE.

BY

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ILLUSTRATED BY ONE HUNDRED AND EIGHTY-NINE ENGRAVINGS.

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PREFACE.

WHEN the author of this work first started out as a machinist's apprentice, he was under the impression that in addition to the every-day knowledge to be gained in the shop, it would be possible to add more knowledge by means of text-books or technical works. After ransacking four of the largest and best libraries in the country, he made the astounding discovery that only a half dozen works of the kind were in print, and they were of little practical value except as experimental data for amateurs.

At a later time, when working as a tool-maker, still more difficulties presented themselves. Few tool-makers seemed to have had experience in more than one or two lines of work; and to become a general workman necessitated the tramping from shop to shop where the various machinery was in use. This the author actually did, and this work is the result in miniature of the experience thus gained.

The limited space available has left much to be desired, and many of the ideas may be to some readers old; but as the intention is to help the beginner, much good is hoped for in the field laid out for the work.

The almost limitless variations in tool construction are based on a few fundamental forms, and an effort has been made to present basic ideas and allow, or rather trust to the natural ability of the student, to adapt the best means to the purposes in view. Method is far more important than detail, and the dies, jigs, special fixtures, etc., given in this work, are intended as a ground-work for elaboration and variation according to conditions.

The author is aware that this book is limited in scope, and that many who read it will find much in it, a knowledge of which they already possess; but as an elementary work he hopes it may assist the army of beginners who, if they have the opportunity he has always found, will be eager to embrace it and thus acquire knowledge. He also hopes that this initial step may induce others to add works of a similar nature, so that what is becoming the greatest of all mechanical arts, may be brought on a line with others by having a literature of its own. For himself the author shall rest content if each reader be benefited by but one thought, and he shall even think he has accomplished much if only one has reached success through any of the ideas and experience contained in this book.

HERBERT S. WILSON.

BROOKLYN, N. Y., *May 1, 1898.*

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THE

PRACTICAL TOOL-MAKER AND DESIGNER.

INTRODUCTORY.

It sometimes happens that a mechanical term undergoes through a change of methods, a transformation as to its meaning. Such is the case as to the present definition of the name "tool maker." A hundred years ago, before the advent of machines of precision for working metal, a tool-maker was a sort of blacksmith. Such indeed was my paternal great-grandfather, who, way back in the early part of this century, and just following the Revolution, had the reputation of being the best tool maker in western Massachusetts. The tools he made were such as were in common use by butchers, carpenters, shoemakers, etc. His greatest skill seemed to lie in the making of the broad-axe, and specimens still in existence show a wonderful degree of quality as to temper and durability. At the present time, however, the name refers to a special branch of the machinist's trade, and has particular reference to the making of the tools and fixtures for such machines as the lathe, planer, drill-press, milling machine, screw machine, punching press, draw bench, wire mill, and of course all the accessory fixtures such as drills, taps, dies, reamers, milling cutters, etc.

Up to about the year 1840, the tool-maker was still unborn. Soon after this, in several gun factories a sort of system of tool work was made necessary. The tools at that time, however, were simple, and consisted mostly of the standard variety of machinist tools specially arranged for individual work. Soon after that date came the advent of the milling machine, of plain pattern, similar to the "Lincoln" type. This machine opened up new possibilities in the reproduction of irregular shaped pieces, and the milling tool maker was born.

About that time also, some skill in the construction of jigs was reached, mostly in gun-lock work. Outside of special lathes and drill-presses, no new tool came to the front until about 1854. During that year there were born in a little town in Vermont the screw machine and the Turret lathe.

Two or three years after came the Universal Milling Machine, and the Multiple Spindle Drill-press. At about the beginning of the Civil War, tool making reached the position of being called a separate trade, and the demand for such to work on government gun contracts soon exhausted the supply. At the close of the war came the sewing machine, and the first great demand for invention in tool construction came with it. Added to this were the breech-loading gun and the type-writer, and last of this era the machine-made watch. Of recent date, or in the last decade, is the bicycle.

In the manufacture of sewing machines, owing to the very slight changes made and the long period between the changes, each piece of the machine where practicable, had a special machine, as near automatic as possible, designed to do one or more operations on its surfaces.

To cut down the cost, short lathes were made and a dozen or more set in a row for one man or boy to run. A set of milling machines carried the table and arm from the rough casting to the finished piece, each machine doing only one thing. There was little or no attempt at revolving chuck work, and the pieces were chucked as many times as there were operations. To facilitate so much re-chucking, spots or small projections were cast on the pieces, and from these all measurements were made. At this time the machine-made twist-drill and the milling cutter which retained its form when sharpened, were both an unknown quantity. What few twist-drills were necessary were made by hand, and the "drill file" still appears on the list of some file makers.

To turn up, cut in the teeth and scrape to edge all by hand was the only way to obtain a milling cutter, and I well remember the small army of tool-makers it required to keep comparatively few milling machines at work.

This scraping of the edge of a cutter was long a puzzle to the uninitiated, and as a substitute to the file on this particular work is a six-to-one improvement.

Drop forgings did not make their appearance in any considerable quantity until 1870–1875, unless the very rough die forgings made under the trip-hammer could be called so.

At this date, when forgings so accurate in shape and size as to require only working surfaces to be machined are the rule, the contemplation of some of the old work is an object lesson as to the growth of forging.

Now also began the organizing of firms for the manufacture of small tools, and by the year 1876, milling cutters, twist-drills, taps and dies, reamers and gauges were in the market in limited quantities and uncertain qualities. In the next five years, however, the technical difficulties of temper, quality of steel, etc., had been overcome, and the tool-maker was required to file less drills and scrape fewer cutters.

Although grinding machines for grinding spinning spindles were in use fifty years ago or more, the grinding machine as a machine-tool is of late date.

This machine had its birth in the shops of those who made drills, reamers and cutters, and, being a good thing, was soon on sale to the public. From use in trueing up hardened work only, it has superseded the truth annihilating file on all fine machine work, and the tool-maker can now be assured of round work that is straight and that will fit.

In the early experience of the writer, accurate measurements were almost unknown. In the shop where he used his first piece of waste, there was kept in a velvet case a six-inch vernier calliper scale. On state occasions this scale was brought out to use, and he is certain that most of the workmen had doubts as to its accuracy as compared with the good old way of the calliper and scale, and many an argument has he listened to during the noon hour for and against the "old man's" new-fangled notions.

Later he had the temerity to purchase a micrometer, and then the debates became decidedly heated. Proof was produced in the form of an old and reliable (?) inch gauge (worn 0.006″ small) to show that the "mike" was untrue. Further evidence was not wanting, that no workman could work to one-thousandths anyway, and though the writer made many fine fits, and once reproduced a piece without the original (which was called luck), most of his shop companions were still doubtful.

At this date the accurate measuring of parts of machines is a common, every-day affair, and hardly attracts notice. From a curiosity, the micrometer has become a necessity, and is fast taking the place of the snap or fixed gauge for ordinary work. The inch has received a new division, and instead of the full and scant sixty-fourth there has dawned upon us the decimal inch. It remains to only change the number of inches to ten instead of twelve to complete the work. The increase of the length of the inch would make the ten-thousandth more practicable than it is at present.

Coming down to the subject of tool-making in general, I would offer a few remarks as to methods to employ. Much that I shall say will of course be open to modification under different conditions, and is not offered as advice, but as good practice in modern shops. To become a tool-maker one must necessarily be first a good machinist, next a close observer, to say nothing of having a decided turn towards invention. To be able to execute a drawing in a creditable manner is also desirable; but it is far more essential that he should be able to make rapid and clear sketches of his ideas, and above all be competent to do most of his experimenting on paper. A tool or fixture that can be made to work on paper stands a better chance of success than a mere rough idea simply sketched on some one's brain.

Not a small part of the profession—for I am so pleased to term it—is to know the best means to reach a result. Too frequently the machinery of a plant is purchased without a clear knowledge of the latest and best method of executing any certain operation or number of operations. Many times a factory may be equipped with engine lathes, when screw machines would not only do better work, but more of it. An ordinary column drill press may, with the assistance of enough men, hand-levers and perseverance, to say nothing of cost, do a job which one man could do in half the time with a radial drill. A man can fiddle around on a shaper, turning out work which would almost make itself on a milling machine. One could go on and cite plenty of instances of this kind, but this is sufficient.

Many times the workman in this line may be called upon to tinker up some kind of a "dingus" to meet an end, such as rigging over a lathe into a forming machine, for instance, but he can only arrive at such results as will be satisfactory to all concerned, by a previous knowledge of how it should be done on the proper machine. Hence comes the necessity of acquiring all the information possible on all subjects pertaining to the trade or profession.

Not a small part of the business is the too often neglected accomplishment of taking notes and sketches of every device coming under your notice. He who only remembers, is a " workman," but he who commits his acquired knowledge to paper, adorns a professsion.

The author's method is always to carry in his pocket a well-bound leather note-book of a uniform size of 3x5 inches. Each day all devices, whether of his own design or from observation, are sketched on the pages, with such notes as may describe any feature not readily understood from the drawing. One or two blank pages are left, on which any future notes regarding the manipulation of the device may be jotted down, or desirable changes may be cited. Each one of these books bears both a number and also the first and last date of entry on the outside cover.

There are also twenty-four other books, each lettered, from A to X, the last three letters in one book. These act as an index, and all sketches are indexed by name and in order. By reference to the index you may at any time refresh your memory upon a long-forgotten subject, or remembering about the date, the covers of the note-books will give you the key to what you want.

Not a small part of this note-book system is the constant practice of expressing your ideas both pictorially and in written descriptions. Those who have tried it under the writer's observation have acquired a degree of proficiency in describing their ideas, surprising from the short length of time in which it was attained.

As interchangeability plays a most important part in all tool work, a liberal equipment of gauges should always be provided, constantly keeping in mind the one idea, as to cost in relation to profit. Never go into luxuries unless they will pay. As an extreme example, do not build a set of tools costing $50 to do a job for which only $35 is received. There is no money in it.

As another example, if you can figure out that you can come out with an equal profit either with or without special tools, always make the tools. There is no loss, and they may prove a good investment.

The author has sought in this work to select such examples of fixtures and tools as would show a general system or method, which nearly every class of tool work could follow in plan. It will be found that in nearly every instance the principles of some of the designs shown in this work will apply to the wants of the case. Once the theory of a design is well grounded, it will be comparatively easy to apply the knowledge when wanted. Always study simplicity of construction. Confine yourself to rigid necessity only. Do not polish any part of the work not essential, but when you do polish a tool, let the finish be a work of art. It is possible to give a piece of work a finished appearance without polish. Quite an attractive method is to blacken the work in the fire and then oil, afterwards giving the finished surfaces a final polish, which will bring them out in relief.

When the work is hardened it should be oiled as soon as removed from the water or becomes sufficiently cooled off, which also leaves a neat finish if the polished surfaces be brightened up.

Too little detail is sometimes given to the convenience of adjustment. Such screws or parts as require frequent manipulation need to be very convenient of access. Avoid special shaped wrenches, spanners, etc. Use plenty of iron and steel on all fixtures. First figure out how heavy you think it ought to be, and then multiply by two. You will be on the safe side. Apropos of this is the story of the Scotch smith who forged himself an anvil, the greater portion of which was seemingly in the horn. When called to task about the matter, he said, "Am thinkin ye'll noo brak they hoorn aff when it be stronger than the block."

A problem to be solved quite frequently is the system of caring for the tools after they are made. This becomes a serious matter in large shops. Instances have come under the writer's notice where the sets of tools run up into the tens of thousands. One very large factory where they make hardware, has, I think, a very simple if rather bulky method. Where the tools are kept there are arranged tiers of strong boxes all of one length but of various widths, according to the shape or size of the fixtures. Each set is numbered to correspond with its box. The boxes are made only as wanted, and after the tools are completed. There is an index book having a page to each set, and also an alphabetical arrangement by name as to the article which the tools make or assist to make. In each box is kept a large card, where a memorandum is made of any standard tools, such as reamers, taps or drills, required. On the opposite side of the card is a history of the tools. First, whose design, second, the machinists or tool-makers who performed the work. Should the tool be broken, such fact is noted and by whom and when. Also date of repair and workman's name. By this method a biography of that set was always at hand, and the quickness with which the keeper could refer to the index and deliver any fixtures wanted, was astonishing. It might be mentioned that there were more than 3,000 sets of jigs alone.

Another feature at this same factory consisted in inspection after use. Every tool, of whatever nature, passed through the hands of an inspector before returning to the tool room, and was not put in place until in perfect repair. The foremen of the departments gave their checks for the tools at the tool room. After use they were returned to the inspector, who gave his check for the department check, thus showing at all times where the tools could be found.

Another feature desirable is the adoption of a standard size of screws, which should be as limited in range as possible. Screws of rather fine pitch are preferable, as it is much less difficult to tap a fine thread in steel than it is a coarse one.

The way to get a system is to start with a system at the beginning. It is a huge task to arrange a set of tools after a shop has been running for several years. No doubt a few of the readers of this book will have an opportunity of beginning with a new plant, and to such I would say systemize, and "begin too" with the first set of tools. No arbitrary method can be advanced that will fit all cases, but any system is better than none.

CHAPTER I.

THE MODERN TOOL ROOM AND ITS EQUIPMENT.

Tool making in a modern sense is that branch of the machinist's trade relating to the designing and building of special tools and fixtures for the various machines used for the rapid production of light or heavy machinery, and metal articles of every description. So wide, however, has become the term in its meaning as to embrace almost every kind of manufacturing. The old style methods are fast being replaced by entirely new processes. About the first thing thought of now in the equipment of a new plant is the tool room, and in most cases the first work is commenced there, to be followed later on by the gradual starting up of the machinery as fast as the tools and fixtures can be designed and built. In describing a modern tool room, the various machines necessary for fine work will be treated in rotation as to their importance, and the addition of duplicates of any or all machines, if desired, will be a matter of circumstance and judgment.

Lathes.

The most important item in a tool room is a lathe. In considering a regular tool maker's lathe, attention is called to the general features of the one shown in Fig. 1.

PLATE I.

Fig. 1.

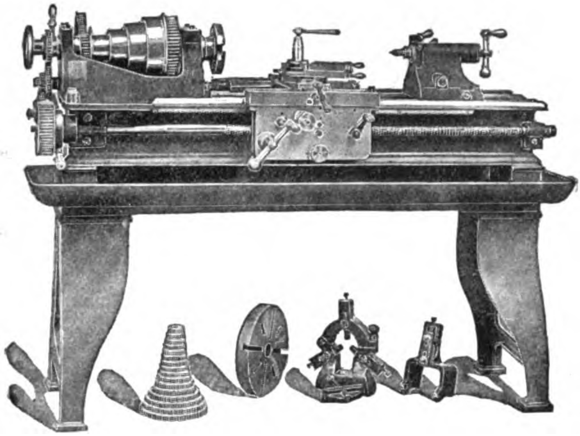
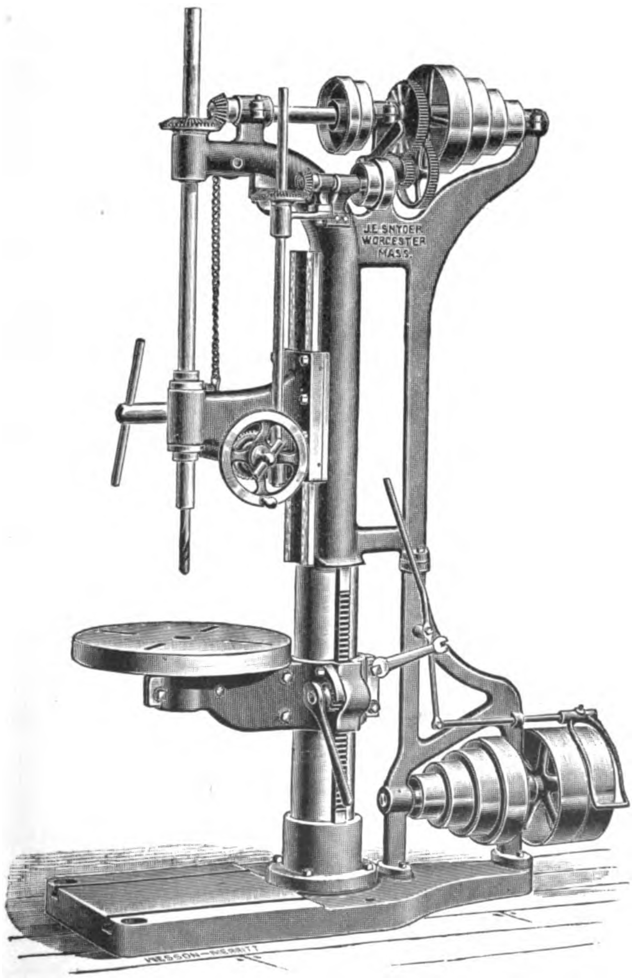


Fig. 2.



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Note that an oil pan is provided to receive the chips, oil and other waste.

Small lathes are best provided with a collet chuck for working up drill rod, and a convenient cabinet containing chucks, tools and fixtures will many times pay for the investment. Have everything where it can be reached at once, and without leaving the machine. This advice can be extended to every machine in the factory with good results.

When only one lathe can be purchased, it should combine the following features: Not less than 14-inch or more than 16-inch swing, with ten-foot bed; hollow spindle, ⅞-inch hole, or inch and one-eighth if to be had; taper attachment, rise and fall rest, and feeds in all directions. Should be well gibed to bed, front and back, with long-ways under carriage, and a liberal allowance for wearing surfaces throughout. The head stock should be long and heavy, and both it and the apron should have every possible part protected from dust or chips. A compound or triple back gear is a desirable feature, embodying a wide range of speeds. The screw should be used for cutting threads only, and all other feeds be operated by independent rods driven by belt. The tail stock must be long, and the tail spindle of good diameter, and be clamped with a clamp at each end. For quickness see that the tail stock clamps to the bed with a cam or other quick operating device. Smooth outline to the castings and liberal amount of iron are essential. The counter-shaft will please best if fitted with friction clutches, and by all means have all the cones fitted with flange at both ends. It is disagreeable to shift the belt off the upper cone onto the shaft. Note all the positions of the various handles for knuckle rappers. Both the screw in the tail stock and cross slide should be left-handed to produce a right-handed movement from a stationary screw. The hand wheel which moves the carriage along the bed, must on no account be at the right of the apron, but at the left. The lathe should be fitted with four-jawed independent and universal chuck, two-jawed chuck with flat independent moving jaws, a very true running chuck for holding rods when passed through the spindle, and a drill chuck fitted with taper to go in both head and tail stock; a complete set of dogs, an angle plate, several small parallels of different thicknesses, center reamers, and threading tools and turning tools of all desirable forms should find their place. Do not forget to have a nice trough raised on legs about a foot from the floor to catch all the chips, etc.

Drill Press.

Next in importance comes the drill press, Fig. 2. Its selection depends somewhat on the class of tools and fixtures in view. If there is to be much heavy drilling for milling machine fixtures, large jigs, etc., it would be well to procure a twenty or twenty-four inch column drill with back gear and power feed, as well as a side lever for drilling small holes. The lower bracket to the spindle head should slide up and down to give range,

PLATE II.

FIG. 3.

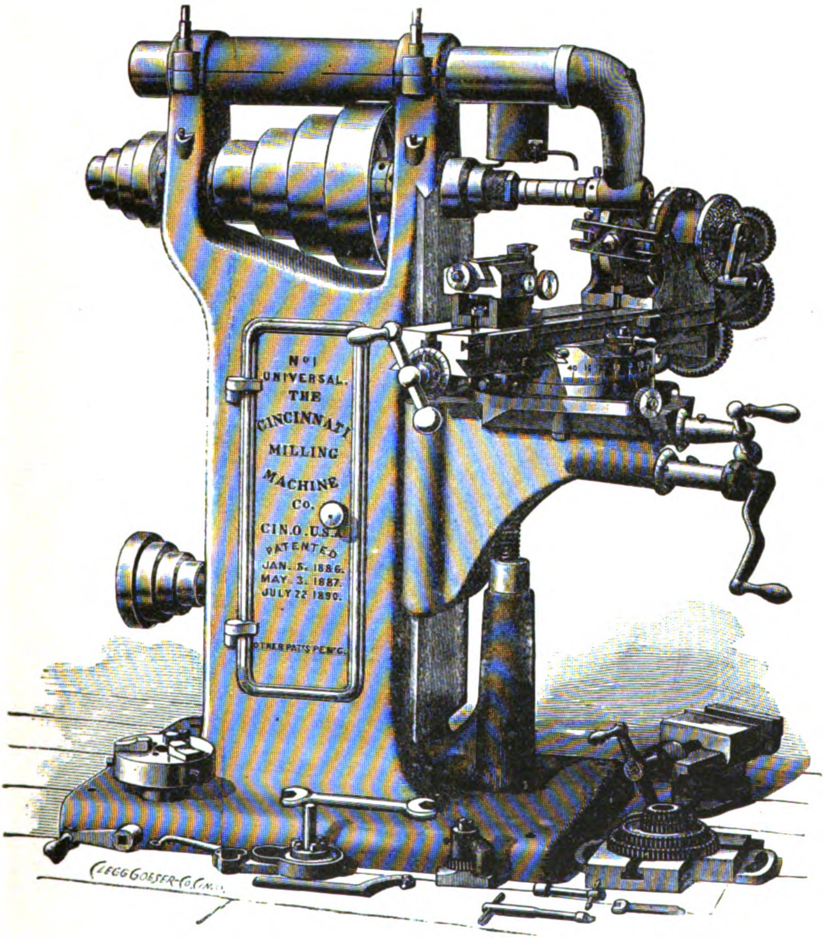

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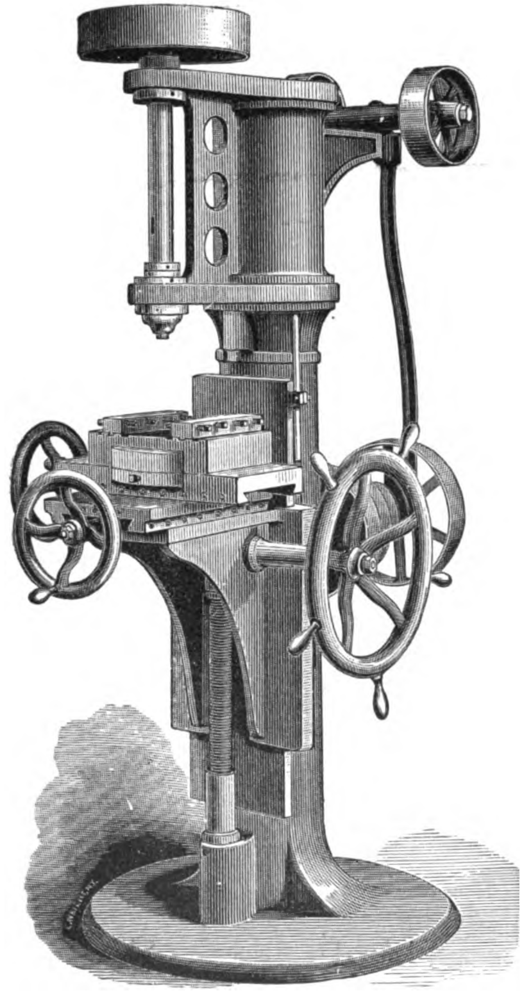
PLATE III.

FIG. 4.



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and the table revolve around the column, and adjust up and down. A good drill-press vise or chuck with angular movement of 90° will be a convenience. Two drill chucks, large and small, a complete set of drills adapted to the work, will complete the equipment of tools. A right and left hand arrangement of the belts will be a convenience in tapping holes true while in the same position as when drilled.

For small holes time and drills can be saved by the use of a sensitive drill press, having a very small and light spindle driven with a belt having a tightener, to regulate its driving capacity.

For the production of accurate work in constructing fixtures, the universal milling machine, Fig. 3, is indispensable, since many varieties of work will take form under the milling cutters that would be nearly impossible otherwise. In addition to the regular fixtures furnished with the machine there should be procured a draw-back Collett chuck for holding rods in the index head and a spring Collett chuck for the spindle to hold the various small reamers, end mills, etc., that have straight shanks. A vertical milling machine, Fig. 4, will be convenient for routing, die sinking, etc. If the work consists of much die work for drop-forging, etc., a special vertical machine, Fig. 5, will save its cost in a short time.

For milling cutters, select some good-sized straddle or side mills, Fig. 6, not less than two, right and left hand angular cutters, Figs. 7, 8, 9 of each of the following 50°, 60°, 70° and 80°, a variety of angular cutters for cutting spiral teeth, reamers and cutters, a set of cutters for grooving taps and one for fluting reamers, Figs. 10, 11 and 12. Several spiral mills, Fig. 13, of different widths and diameters. Some T slot cutters, Fig. 14, of different sizes, both right and left hand. Some large end mills, Fig. 15, with taper shanks. Screw slotting cutters Nos. 8 to 30, Fig. 16. Several large diameter metal slitting saws, Fig. 17, $\frac{1}{32}''$ $\frac{1}{16}''$ $\frac{3}{32}''-\frac{1}{8}''$ thickness. Cutter arbors short and long for $1\frac{1}{8}''-1''-\frac{7}{8}''$ and $\frac{3}{4}''$ holes in cutters. The special requirements of the work will soon accumulate a set of special cutters adapted to the needs of each special shop. Provide a few small planer jacks for leveling up irregular shaped parts to fixtures, etc. Should the equipment include a vertical milling machine, see that all the end and butt mills are arranged to interchange with the other machines.

In regard to the choice of a shaper or planer for the tool room, much will depend on the nature of the work. If there are a few fixtures to be made that cannot be reached with a milling machine, a rangey shaper will be found the handiest, but for general use a small planer, properly fitted with chuck and vise in the same manner as a shaper, will give the best of satisfaction, doing all the work that can be executed with the shaping machine, and many long pieces that cannot. A planer for the tool room must be true, run noiselessly, have a quick return of at least five to one, and have a wide range of feed and two cutting speeds, one fast and one slow for

PLATE IV.

Fig. 5.

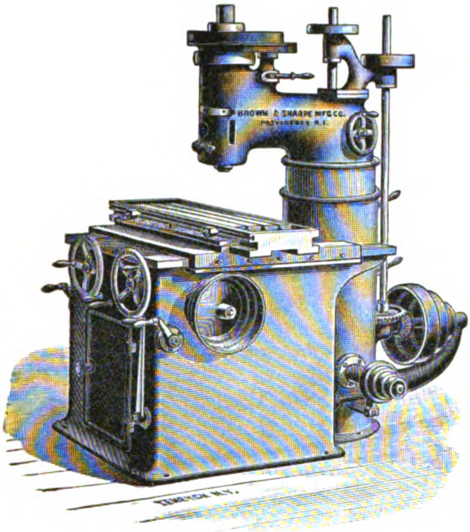

Fig. 6.

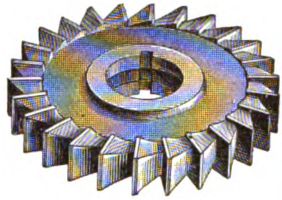

Fig. 7.

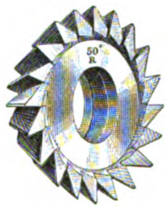

Fig. 10.

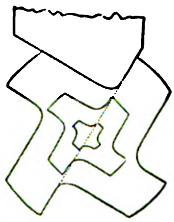

Fig. 8.

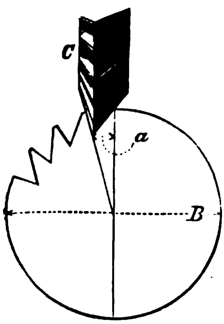

Fig. 9.

Fig. 13.

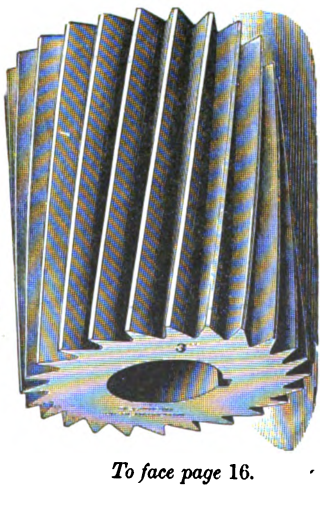

Fig. 11.

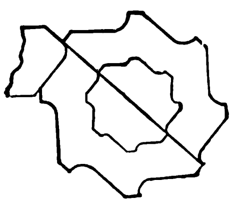

Fig. 12.

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PLATE V.

FIG. 14.

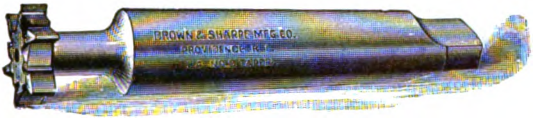


FIG. 15.

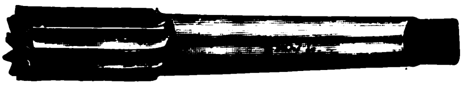


FIG. 16.

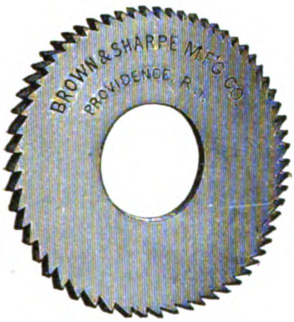
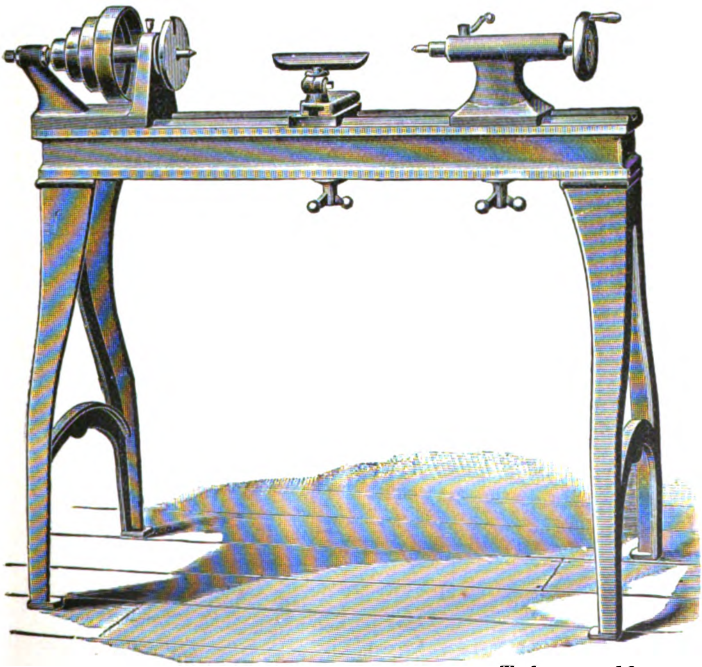


FIG. 17.

FIG. 18.



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steel. A long and solid vise, together with a smaller swiveling vise, is essential, a complete set of bolts of different lengths; several steel parallels, and some planer jacks, from one to six inches high, are part of the tools needed. A machine setting parallel with the line shaft will take up the least room, and be most convenient to the light.

Hand-Lathe.

On no account use your engine lathe for polishing with emery if you wish to keep it accurate. There are many reasons for this, the principal being the fact that such lathes are not properly protected from the emery and the dust, and are not usually intended for such work. Also they do not run fast enough. All work can be best polished at a high speed, and in a hand-lathe, similar to Fig. 18, which should be fitted with suitable chucks for holding all kinds of work. A small cabinet for containing the different grades of emery cloths, clamps, lead laps, soft and hard wood polishing sticks, hand tools, burnishers, etc., will enable the workmen to have at hand just what they want without looking for it. Drills of different sizes suitable for centering, with several center reamers carefully sharpened, are also handy conveniences.

Tool-Grinders.

For sharpening the tools, the modern tool-grinder, Fig. 19, with water-flooded emery wheel is by far superior to a grindstone. One having two wheels, a fine and coarse one, will be found the best for the purpose. Such a machine must be kept running true by the liberal use of a diamond tool, a convenience no tool room should be without. Improved machines of this class have trueing device attached. In addition there should be a small grinding head, to carry about four or five-inch wheels, provided with a number of wheels of different grades and diameters, some thick and some thin. The latter can be dispensed with if you have a universal tool grinder, Fig. 20, as there are provisions for extra wheels on all such machines.

Small tool-grinders should have one of the wheels arranged over a small flat elevating table, see Fig. 89, for convenience in grinding work perfectly parallel, which is accomplished by passing the work between the wheel and the table, allowing the wheel to make only a very light cut.

A Few Suggestions.—It is frequently the case that the cutter and tool grinder is operated by different men in the same shop, and no one person becomes as thoroughly familiar with the machine as would be desired. A few hints, therefore, may be in order.

The emery wheels should be kept clean, free from oil, and turned off with a black diamond, so that not more than a surface of $\frac{1}{16}$ inch to $\frac{1}{8}$ inch comes in contact with the work. This is particularly applicable to cup-shaped wheels. If it is desired to do heavy cutting, the emery wheel should be revolved slowly while truing it up. When the wheel does not cut as well as it ought, a coarse

PLATE VI.

FIG. 19.

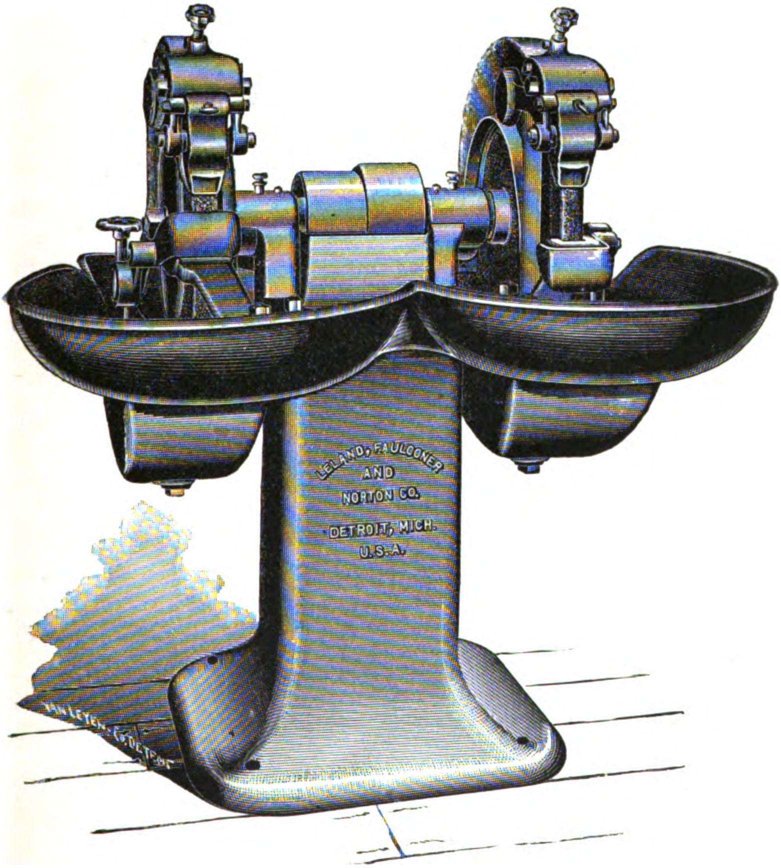

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PLATE VII.

Fig. 20.

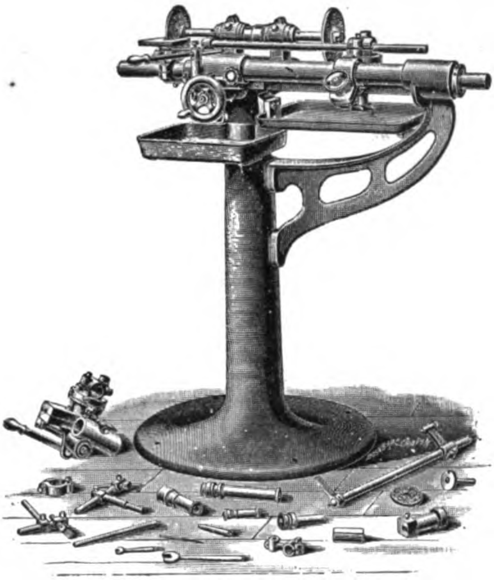

Fig. 21.

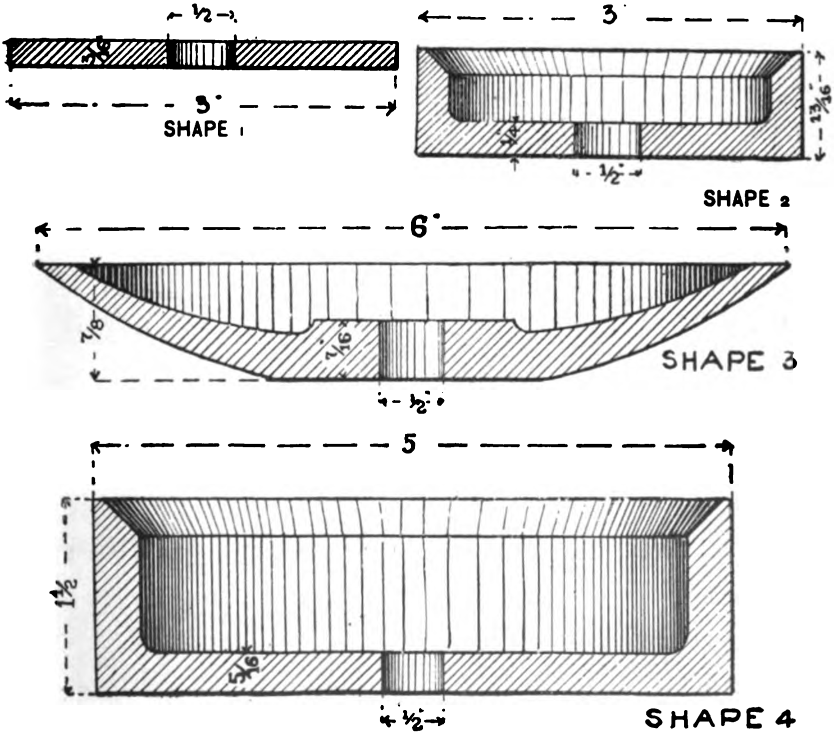

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PLATE VIII.

FIG. 22.

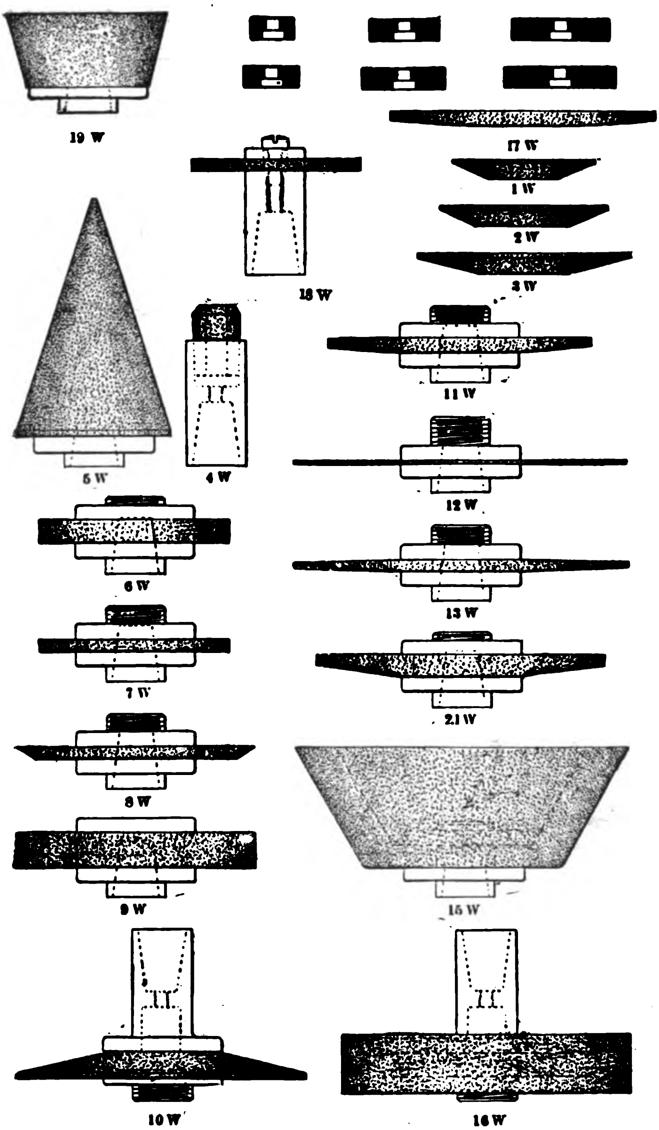

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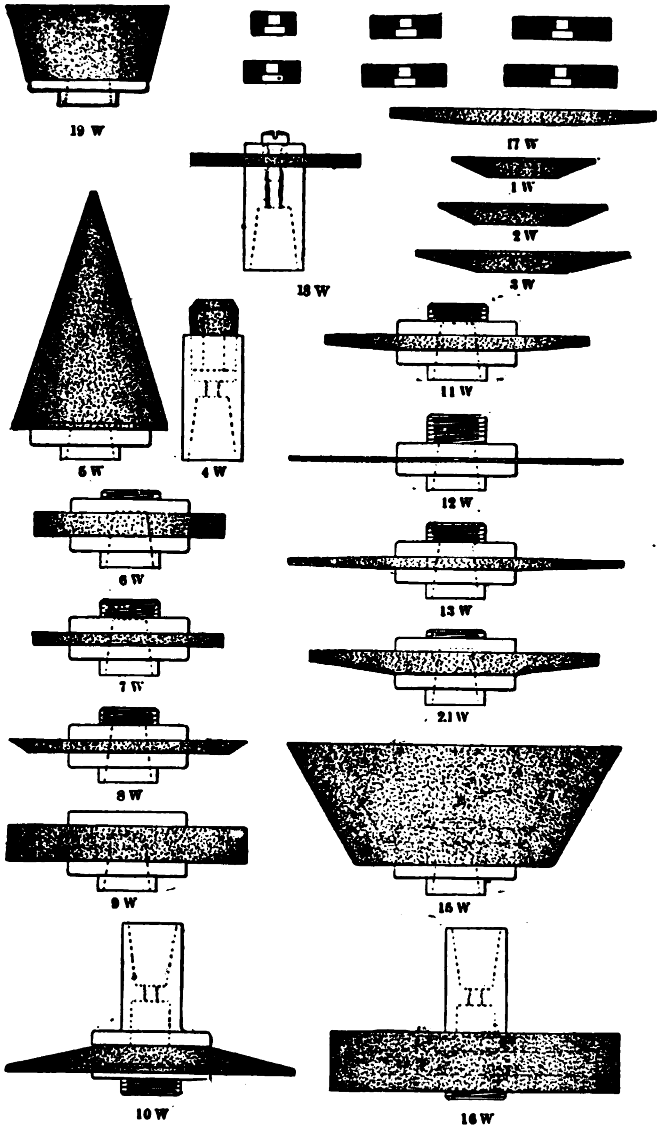
PLATE VIII.

Fig. 22.



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file may be used for going over it, in order to bring out new cutting points. Emery wheels kept in good condition will grind faster, truer, and what is most important, will not draw the temper of tools. If it is desired to put an exceedingly fine finish on such work as arbors, spindles, standards, etc., after they have been ground true, a wheel of 80 to 100 grade emery, with not more than a ¼ inch face, should be used for taking this finishing cut. However very finely finished surfaces can be obtained with a wheel as coarse as 40 grade emery, if the work is passed very slowly across the face of the wheel, and the wheel allowed to cut but slightly. If it is desired to do very accurate grinding or to obtain a fine finish, the wheel must be perfectly true, and in turning off the wheel the diamond should be secured to the table or slide.

All the parts in the machine subject to wear should be well taken care of, and not allowed to get dirty or out of order. The spindle should be kept well adjusted to its bearings and well lubricated. The slide should be well cleaned from time to time and oiled, using a good grade of mineral lubricating oil.

Many of the troubles often met with in tool grinding emanate from the lack of proper shaped wheels to fit the work. The cuts, Figs. 21, 22, showing the standard shapes easily obtained from the wheel makers, may prove of benefit to many.

Small grinders should have all their parts easily accessible, and for rapidity, the external and internal grinding features should admit of quick interchange without removing any of the parts or putting on any additional fixtures.

The Walker Tool Grinder, shown in Fig. 23, embodies most of the desirable features mentioned, and is offered as an example of several similar types of this useful tool. Several illustrations are here given, with descriptions of grinding various shaped cutters and tools by the Walker system.

Fig. 24 illustrates details of the Universal Tool and Cutter Grinder, grinding end and side face cutters. These operations possess many difficulties, especially when the teeth are cut near together, or when they approach the center. By this method the usual difficulties are all surmounted, and it is possible to grind teeth of the finest pitch with ease and rapidity, giving a straight line clearance, and grinding within one-sixteenth of an inch of the cutter center. Furthermore, the device is so constructed that all sleeves and sockets for holding the cutters are dispensed with. Every cutter is held by its own shank (either straight or taper), and is revolved upon the same, thus obtaining the most accurate results possible.

Fig. 25 shows a common form of facing cutter being sharpened, and Fig. 26 shows a variety of other familiar forms of tools that can be quickly sharpened upon the machine. A beveled cup-shaped emery wheel is employed, and amount of clearance can be varied when desired.

PLATE IX.

FIG. 23.

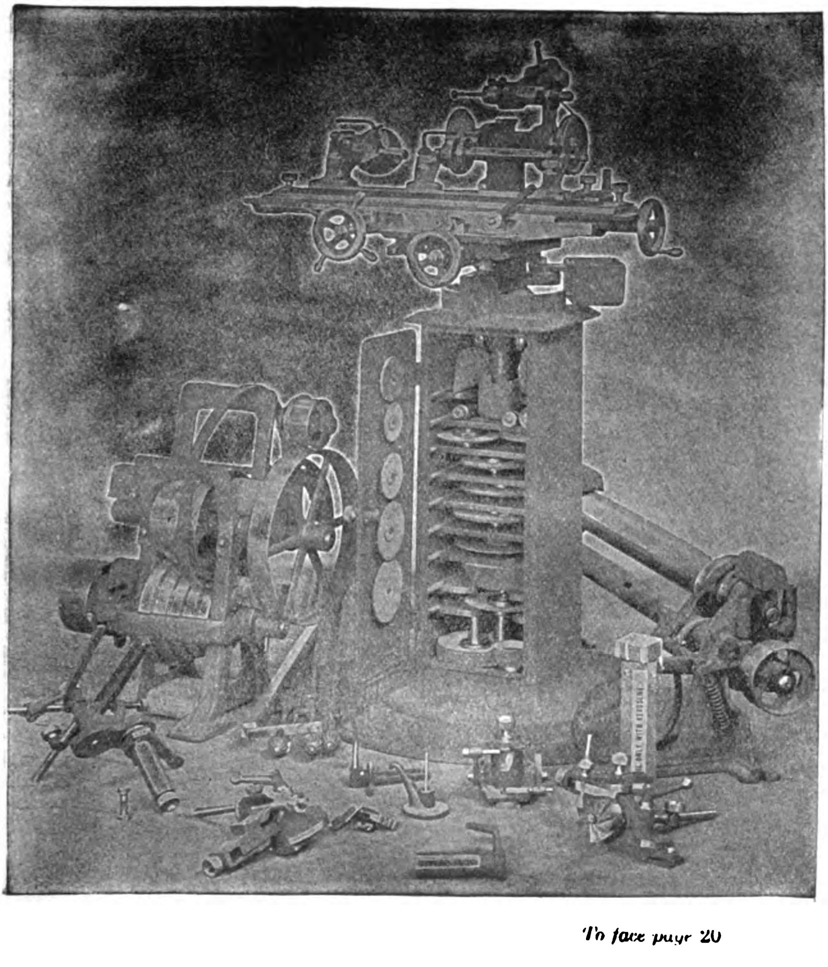

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PLATE X.

FIG. 24.

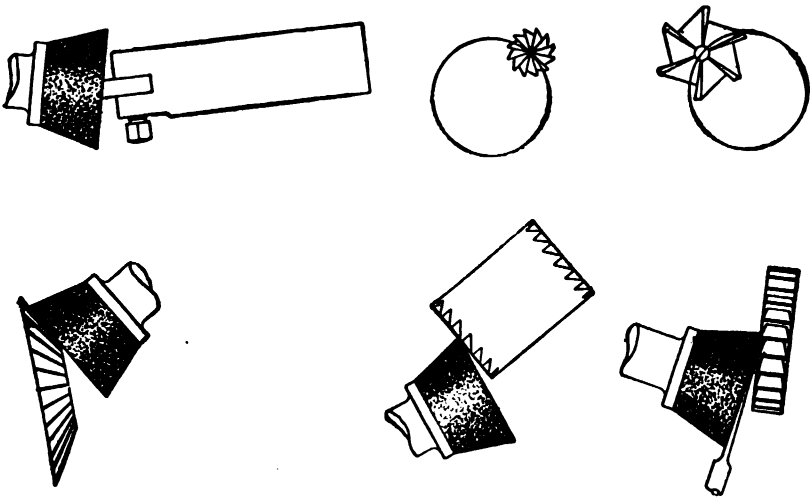

FIG. 25.

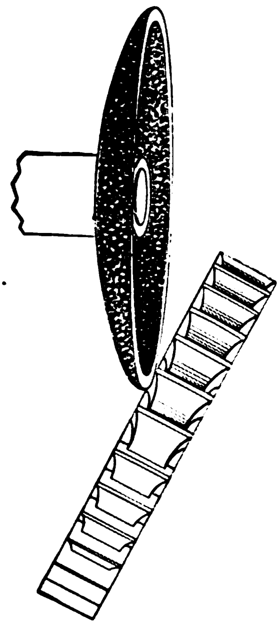

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PLATE XI.

FIG. 26.

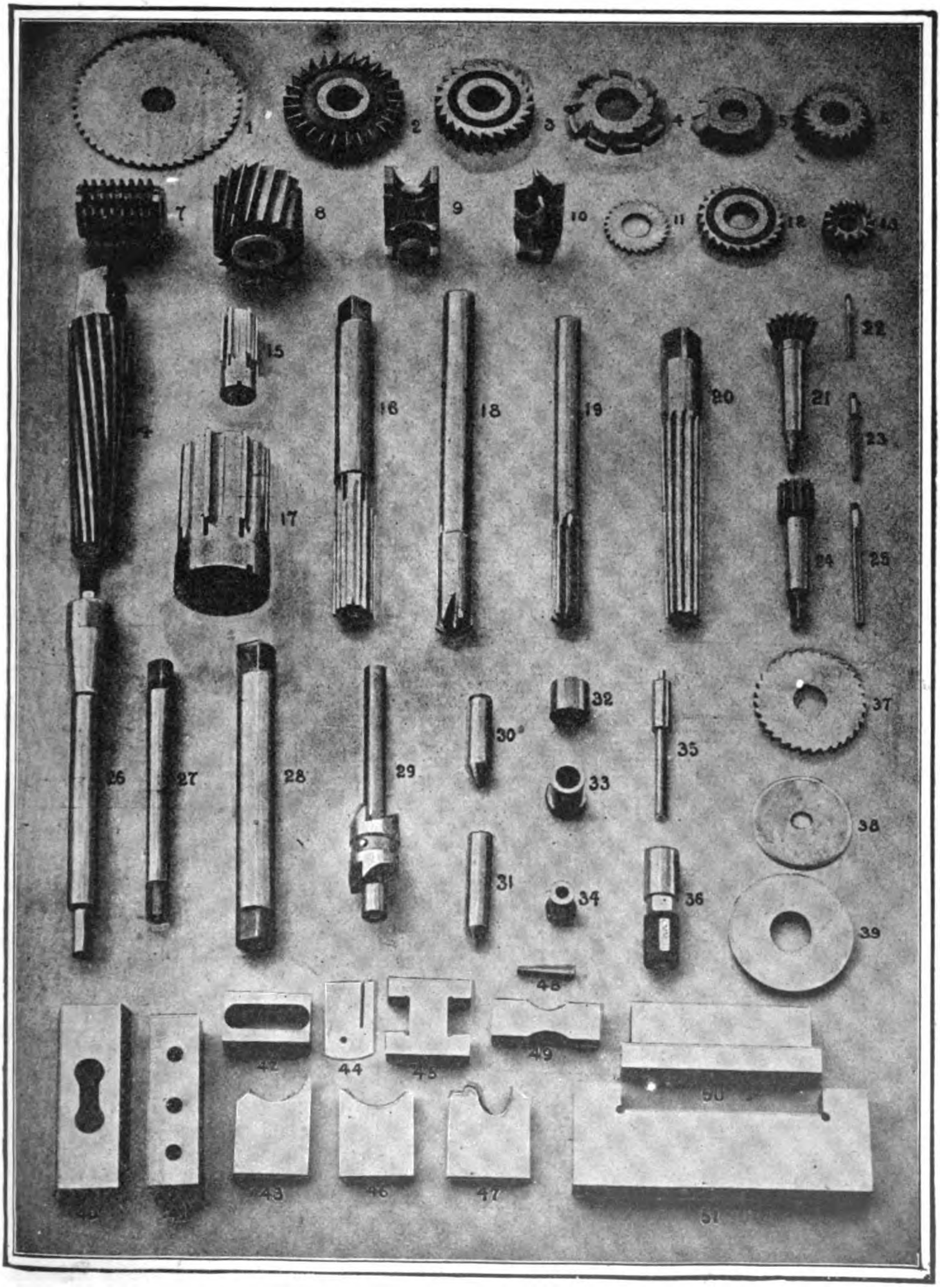

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PLATE XII.

FIG. 27.

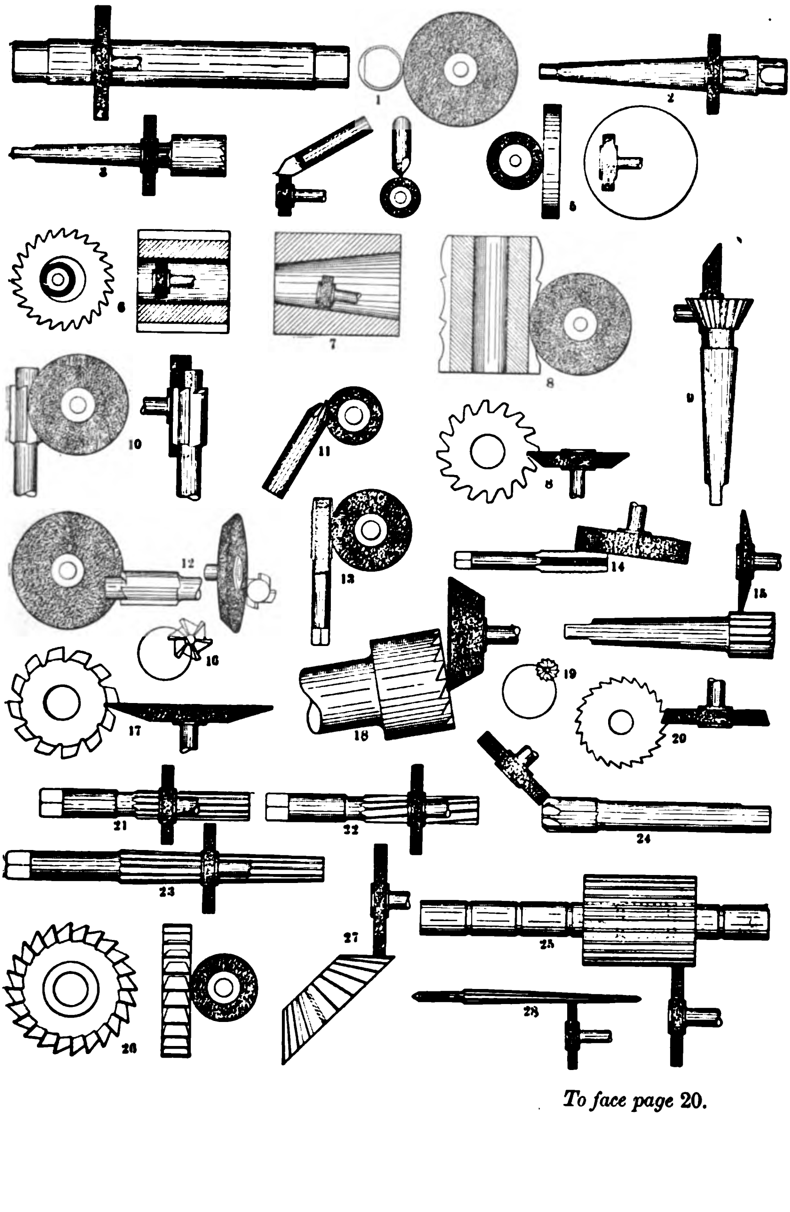

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PLATE XIII.

FIG. 28.

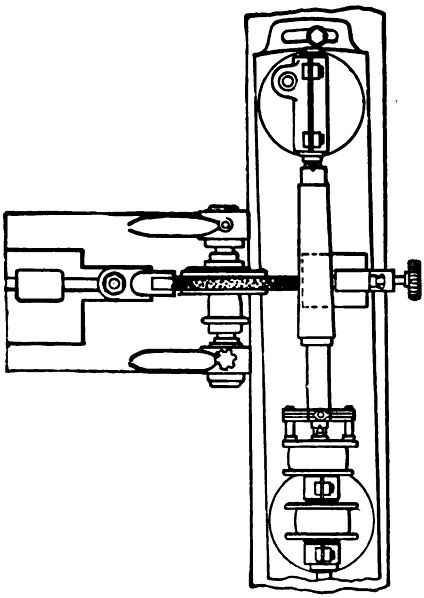

FIG. 29.

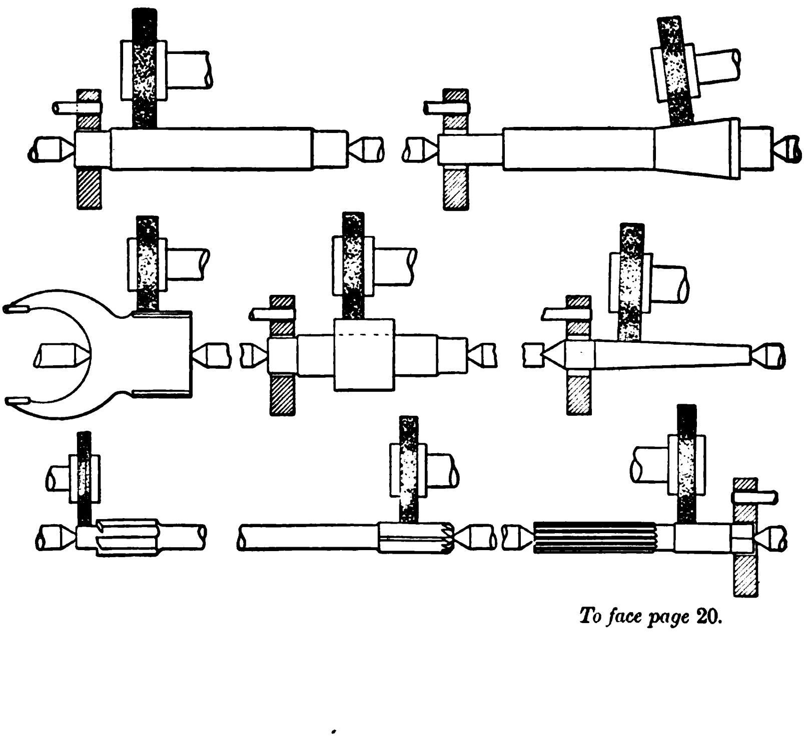

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Fig. 27 will be found a very convenient diagram to enable the workman to decide on the proper method of grinding various cutting edges. The kind of wheel to use and the way the cutting surface should come in contact with the work are so clearly shown as to require no detailed description.

Fig. 28 is a view of Walker grinder grinding a taper mandrel on centers. Note the position of the internal grinding fixtures when not in use.

Fig. 29 illustrates various examples of straight and taper cylindrical grinding, all performed with one size and kind of plain wheel.

Fig. 30 illustrates the operation of sharpening a taper or fluted reamer on centers.

Fig. 31 is an illustration showing a method of grinding a rose reamer on centers. Such an arrangement permits of quick adjustment, it being only necessary to swing the table to the proper angle using a plain wheel and tooth rest attached to wheel base.

Fig. 32. is a general view of the Cincinnati tool grinder, one of many types of similar machines. This machine permits of a very wide adaptability of adjustment, being so arranged as to grind both cylindrical and flat work, as it is provided with a convenient vise and all the desirable and necessary fixtures for sharpening every form of tool.

Fig. 33 represents a part sectional view of Brown & Sharpe Universal Grinder, and the method of arranging the steady rest for long pieces. In this arrangement the steady rest (made of wood or brass) is not dead, but moves with the carriage, and is designed more to prevent the wheel from forcing the piece away from the cut than it is for keeping the work true. For accurate work required to be perfectly parallel, the dead steady rest fastened to the wheel head is far the best, as it acts as a gauge, the work passing between the wheel and the jaw or slide of the rest proper.

Figs. 34 and 35 illustrate the Universal Tool and Cutter Grinder, and some details of its operations on chuck work; Fig. 35 showing the machine grinding the side of a face cutter, which is held in a universal chuck supported by a graduated swivel holder.

The chuck is a four inch Skinner Universal and combination. It is furnished with an extra set of jaws, and will hold all sizes below four inches.

The spindle is fitted with improved double taper bearings, and runs in a sleeve box that is detachably clamped in the swivel holder aforesaid, thus allowing the chuck and spindle to be quickly detached and other tools to be inserted in the holder.

Fig. 34 illustrates a few familiar grinding operations on work held in the chuck, including some internal grinding.

Fig. 36 illustrates the method of sharpening a gear cutter.

The sliding carriage is first swung around at right angles to the grinding spindle, and the cutter holding device is then fastened to the same near the left-hand

PLATE XIV.

FIG. 80.

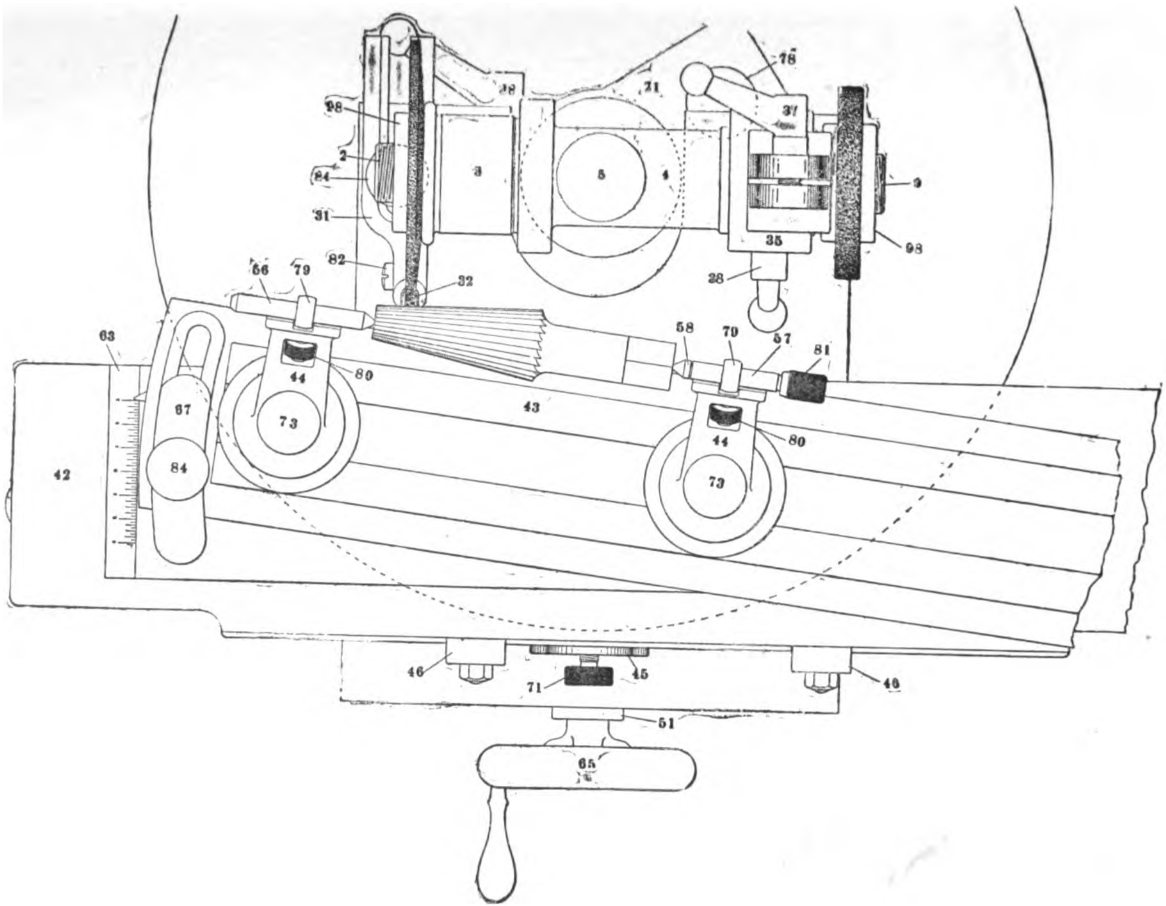

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FIG. 31.

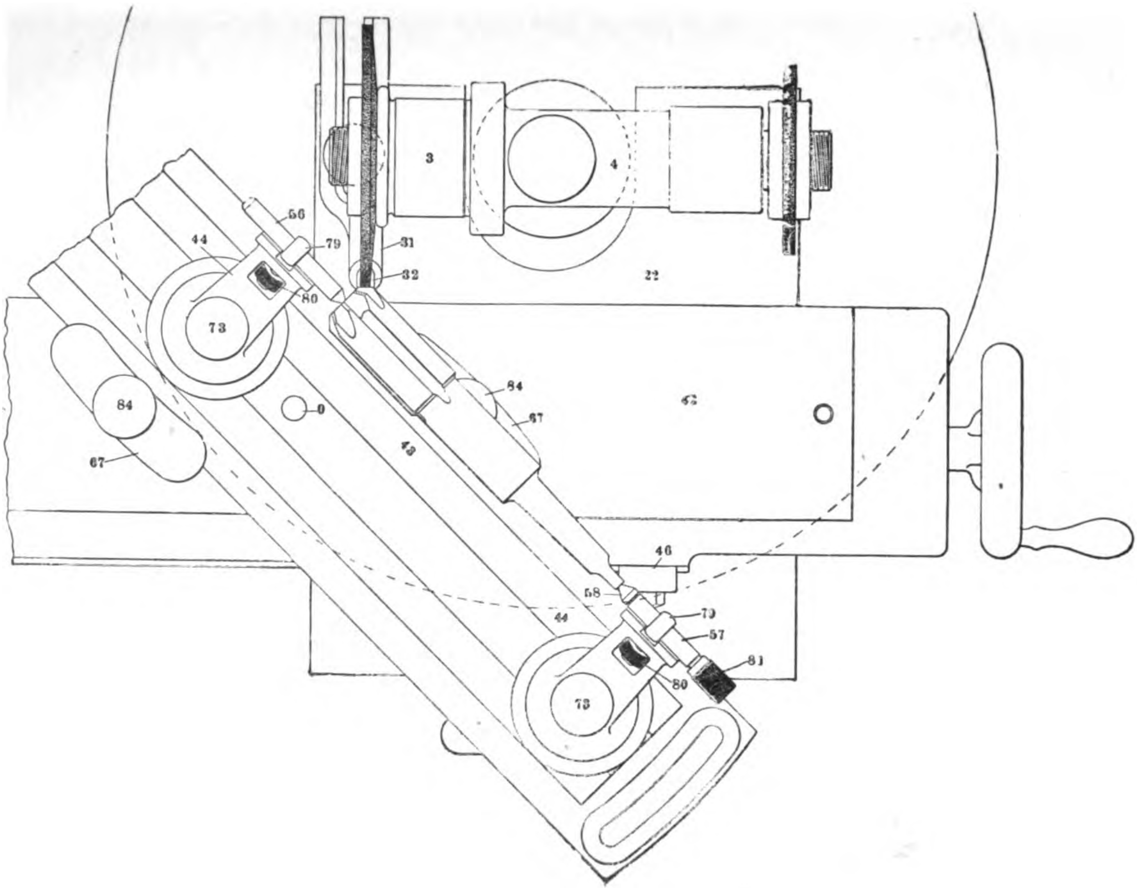

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PLATE XVI.

FIG. 32.

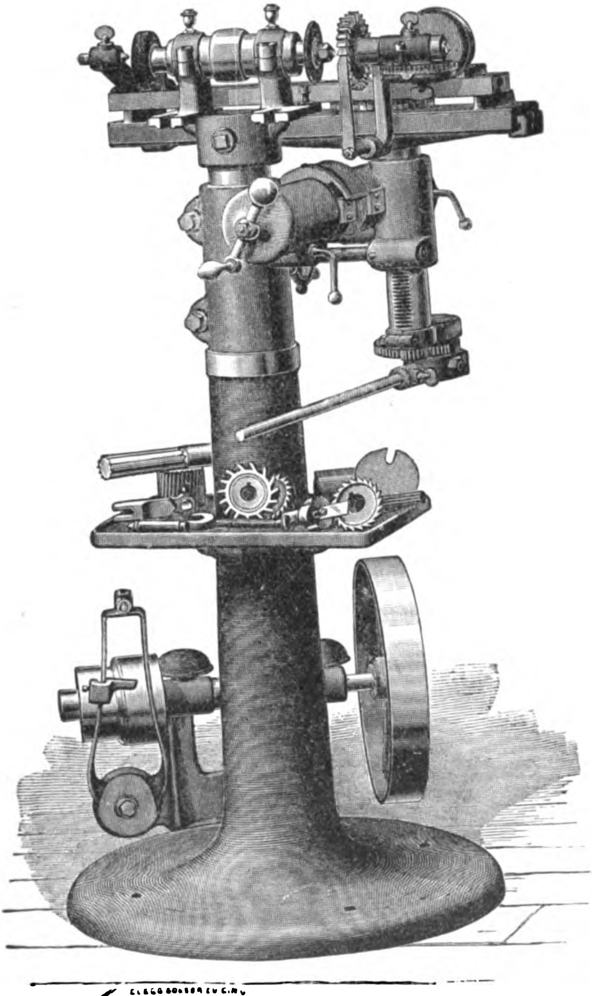

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PLATE XVII.

FIG. 33.

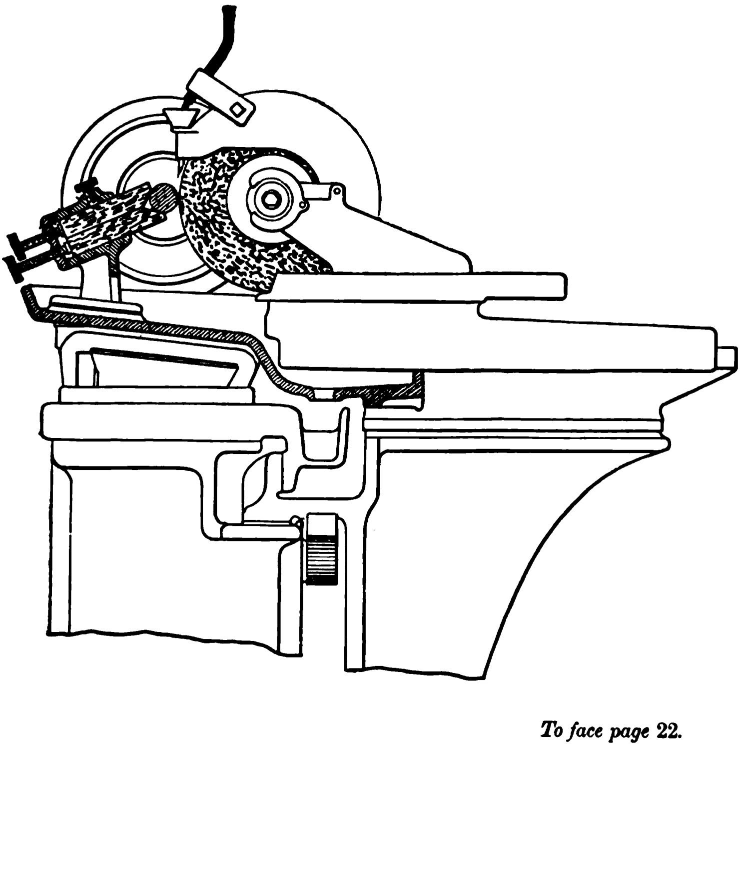

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PLATE XVIII.

FIG. 34.

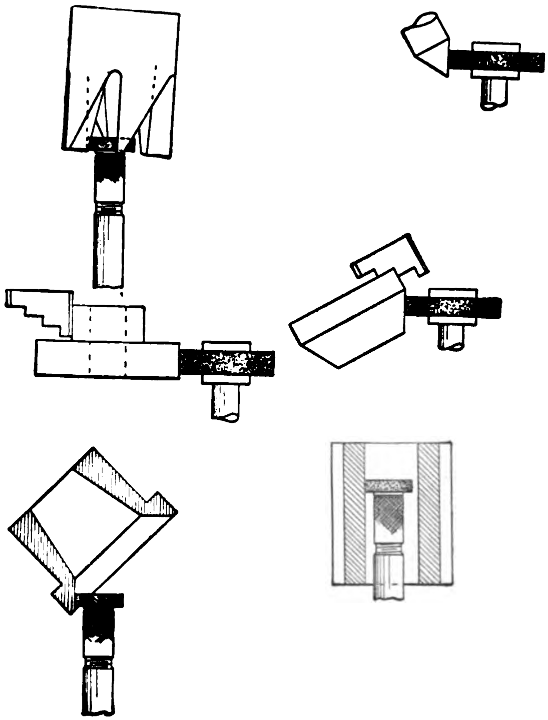
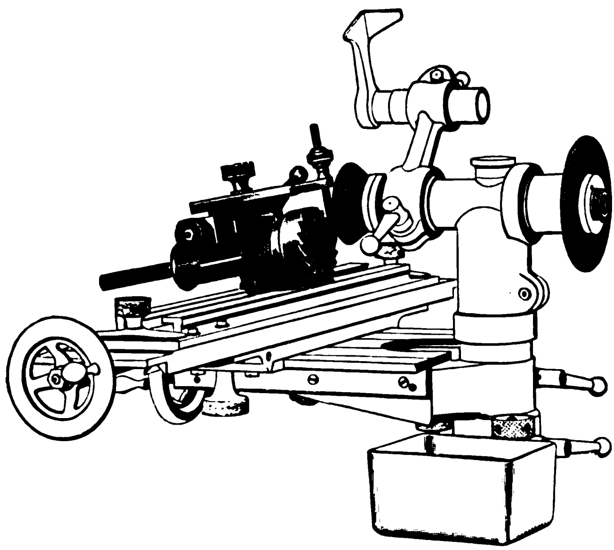


FIG. 35.



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end, in front of the wheel. The holder (124) is then adjusted and the tooth rest (126) is set so that its contact end coincides with the center of the cutter.

The cutter is then clamped and the holder (124) is swung down out of the way, and the rest (128) is adjusted in contact with the back of the cutter tooth to be ground.

The stop (46) is then set to limit the movement of the slide and the first tooth is then ground. To grind a new tooth, loosen screw (84) and pull back rest (128) to allow the next tooth to pass. Holding the rest (128) in place with the hand, swing the back of the tooth against the same and tighten screw (84) and proceed with the grinding.

By the above method all the teeth are ground exactly the same thickness.

For the general use of the tool room where only one machine can be conveniently had, it is far better to provide a universal grinder of range sufficient to cover the work. All the operations performed on the tool grinder are easily accomplished, and in addition, cylindrical pieces may be more conveniently ground either on the outside or internally.

It would also be well to note the following instructions as to the general care of such machines.

The machines should be kept as clean as possible, and in no case should the bearings be allowed to "gum up." When bearings are opened and exposed for any purpose whatever, they should be carefully wiped off, before they are closed again, to free them from any grit that may have found its way upon the surfaces.

A loose fit between the wheel spindle and its boxes will produce imperfect work, and when very fine work is required the bearings should run nearly, if not quite, metal to metal. This necessarily will cause the boxes to heat, but in this case the heat is not injurious, for, as the bearings are hard and the boxes bronze, the belt will slip, unless it is exceedingly tight, before abrasion can occur.

All end motion should be taken out of the wheel spindle before the wheel is used on the work.

A satisfactory emery wheel is an important factor in the production of good work. Too much, however, must not be expected of one wheel. A variety of shapes, sizes and grades of wheels are necessary to bring out all the possibilities of the grinding machine, the same as a variety of shapes and sizes of tools are necessary to obtain the best results from the Lathe or Milling Machine.

In selecting and using a wheel, be governed by the character of the metal to be operated upon, the shape and size of the work and the degree of accuracy desired. We have to consider the size of the particles of emery in the wheel, the hardness of the wheel and its width. We also have to determine the speed at which it is to be revolved, the speed at which the work is to travel or be revolved, and whether or not water is to be used.

Aim in grinding to obtain an accurate or true surface, but as a true surface is almost always a good surface, it should be remembered that generally the same methods are employed, whether an exact size or a fine finish is the object desired.

Generally speaking, a wheel should be softer as the surface in contact with the work is increased. For example, a wheel $\frac{1}{16}$ inch face should be harder than one $\frac{1}{2}$ inch face. If a wheel is hard and heats or chatters, it can often be made somewhat more effective by turning off a part of its cutting surface; but it should be clearly understood that while this will sometimes prevent a hard wheel from heating or chattering the work, such a wheel will not prove as economical as one of the full width and proper grade, for it should be borne in mind that the grade should always bear the proper relation to the width.

The width should be in proportion to the amount of material to be removed with each revolution, and as a wheel cuts in proportion to the number of particles in contact with the work, less stock will ordinarily be removed by a narrow wheel than by one that is of full width. The feed will also have to be finer if a narrow wheel is used.

The quality of the work as a rule is improved by using a wheel of full width if the wheel is soft in proportion. Judgment should be exercised in deciding upon the width of wheel to be used, as sometimes the work is of such size and shape as to make it necessary to use a wheel with a narrow face. Where this is the case the wheel should, when strength will admit, be only that width throughout, and care should be taken that the grade is kept in the proper relation to the width.

A wheel is most efficient in grinding just at the point before it ceases to crumble. The faster it is run up to this point the more stock will be removed and the more economically the work will be produced. Occasionally, however, it is necessary to run a wheel rather slowly, as the more slowly it runs the coarser it cuts and the less likely it is to change the temperature of the work. As a general rule, on any given stock, the softer the wheel the faster it should be run.

If a wheel is run rapidly, the particles of emery soon become dull, and have to be thrown away. To retard this loss it is well to run the wheel more slowly, as the length or area of the work increases. If the speed of the wheel is reduced, the speed of the work should be reduced accordingly.

As the length or area of the work increases, the feed should be coarser, so that the wheel may travel the entire length or area of the piece while its diameter is practically unchanged.

Water should be used on such classes of work as are injuriously affected by a change in temperature caused by grinding. It should be used upon work revolved upon centres, as in this work a slight change of temperature will cause the wheel to cut on one side of the piece, after it has been ground apparently round.

In very accurate grinding, water is especially useful, for it should be remembered that the exactness of the work will be affected by a change in temperature which is not perceptible to the touch.

In very accurate grinding it is also well to use the water over and over again, as by so doing there is less difference between the temperature of the water and that of the work than if fresh water is used. For many purposes soda water is the most satisfactory, as it has less tendency to rust the work or the machine.

For internal grinding it is especially important that a wheel should be free cutting and the work revolved so slowly as to enable the wheel to readily do its work. The wheels should generally be softer than for external grinding, as a much larger portion of the periphery is in contact with the work. Their small diameters make it impossible for the proper periphery-speed to be obtained, and this must be considered in regulating the speed of the work.

Soft free cutting wheels, such as are made by a number of the companies using the vitrified process, are the best for most purposes. The ideal wheel is the one composed entirely of cutting materials. The width of the wheel should be in proportion to the amount of stock to be removed at each revolution. The wheel should be soft in proportion to the surface in contact with the work. The speed of the wheel should be in proportion to its softness, and the speed of the work should be in proportion to the speed of the wheel.

The speed, diameter and width of wheels, and the number of the emery cannot be changed without changing the grade and cutting qualities of the wheels.

Wheels should always be kept true. They can be easily kept so by trueing them off with a diamond tool, known as the black diamond or carbon point, held by hand or in the fixture sent with several of the machines. A new wheel should be started slowly and trued gradually.

In mounting emery wheels there should always be elastic washers placed between the wheel and the flanges. Sheet rubber is best for this purpose, but soft leather will answer very well. In some cases manufacturers of emery wheels attach a thick, soft paper washer to each side of the wheel for this purpose, in which case no further attention is required in this direction.

In all kinds of grinding, the work should move in a direction opposite to that of the wheel at the cutting point, as shown by the arrows in Fig. 37.

Fig. 37 also shows another illustration of the class of work ground by swiveling the head stock, in which may be included grinding the sides of collars, washers, milling cutters, etc. The plate or disk shown is held in the chuck, and the head stock is turned at right angles to the sliding table. The wheel is brought against the work by the cross-feed, and the automatic table feed can be used for passing the work in front of the wheel. It is evident that the surfaces ground in this manner may be plain, concave or convex, according to the setting of the head stock.

PLATE XIX.

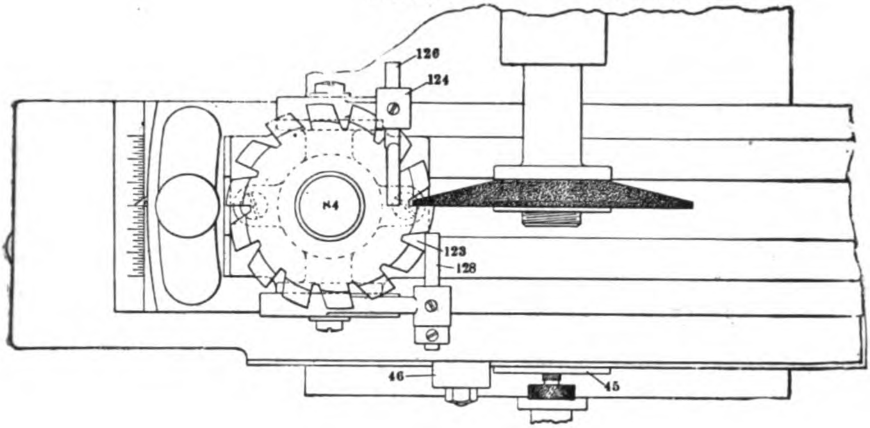


FIG. 36.

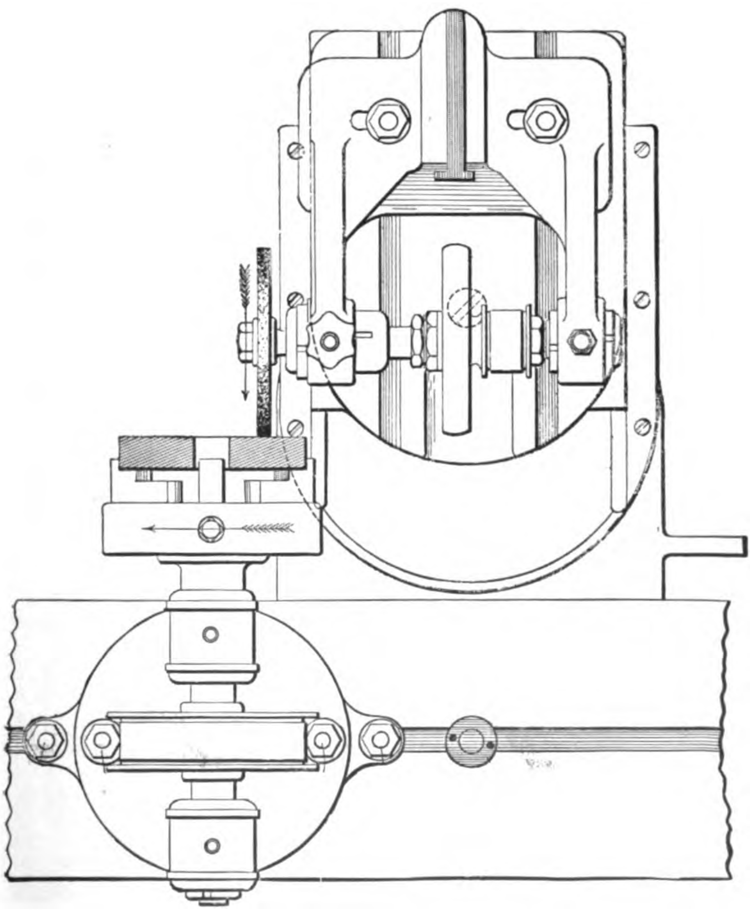


FIG. 37.

To face page 28.

As a convenience in making accurate sizes in fractional inches and meters, the following tables are given:

TABLE OF DECIMAL EQUIVALENTS.

8ths, 16ths, 32nds and 64ths of an inch.

8ths.

- 1/8 = .125
- 1/4 = .250
- 3/8 = .375
- 1/2 = .500
- 5/8 = .625
- 3/4 = .750
- 7/8 = .875

16ths.

- 1/16 = .0625
- 3/16 = .1875
- 5/16 = .3125
- 7/16 = .4375
- 9/16 = .5625
- 11/16 = .6875
- 13/16 = .8125
- 15/16 = .9375

32nds.

- 1/32 = .03125
- 3/32 = .09375
- 5/32 = .15625
- 7/32 = .21875
- 9/32 = .28125
- 11/32 = .34375
- 13/32 = .40625
- 15/32 = .46875
- 17/32 = .53125
- 19/32 = .59375
- 21/32 = .65625
- 23/32 = .71875
- 25/32 = .78125
- 27/32 = .84375
- 29/32 = .90625
- 31/32 = .96875

64ths.

- 1/64 = .015625
- 3/64 = .046875
- 5/64 = .078125
- 7/64 = .109375
- 9/64 = .140625
- 11/64 = .171875
- 13/64 = .203125
- 15/64 = .234375
- 17/64 = .265625
- 19/64 = .296875
- 21/64 = .328125
- 23/64 = .359375
- 25/64 = .390625
- 27/64 = .421875
- 29/64 = .453125
- 31/64 = .484375
- 33/64 = .515625
- 35/64 = .546875
- 37/64 = .578125
- 39/64 = .609375
- 41/64 = .640625
- 43/64 = .671875
- 45/64 = .703125
- 47/64 = .734375
- 49/64 = .765625
- 51/64 = .796875
- 53/64 = .828125
- 55/64 = .859375
- 57/64 = .890625
- 59/64 = .921875
- 61/64 = .953125
- 63/64 = .984375

TABLE OF DECIMAL EQUIVALENTS

Of Millimetres and Fractions of Millimetres.

Mm.	*Inches.*	*Mm.*	*Inches.*	*Mm.*	*Inches.*
1/50	.00079	16/50	.01260	31/50	.02441
2/50	.00157	17/50	.01339	32/50	.02520
3/50	.00236	18/50	.01417	33/50	.02598
4/50	.00315	19/50	.01496	34/50	.02677
5/50	.00394	20/50	.01575	35/50	.02756
6/50	.00472	21/50	.01654	36/50	.02835
7/50	.00551	22/50	.01732	37/50	.02913
8/50	.00630	23/50	.01811	38/50	.02992
9/50	.00709	24/50	.01890	39/50	.03071
10/50	.00787	25/50	.01969	40/50	.03150
11/50	.00866	26/50	.02047	41/50	.03228
12/50	.00945	27/50	.02126	42/50	.03307
13/50	.01024	28/50	.02205	43/50	.03386
14/50	.01102	29/50	.02283	44/50	.03465
15/50	.01181	30/50	.02362	45/50	.03543

TABLE OF DECIMAL EQUIVALENTS

Of Millimeters and Fractions of Millimeters—Continued.

Mm.	*Inches.*	*Mm.*	*Inches.*	*Mm.*	*Inches.*
$\frac{46}{50}$=	.03622	7=	.27559	17=	.66929
$\frac{47}{50}$=	.03701	8=	.31496	18=	.70866
$\frac{48}{50}$=	.03780	9=	.35433	19=	.74803
$\frac{49}{50}$=	.03858	10=	.39370	20=	.78740
1=	.03937	11=	.43307	21=	.82677
2=	.07874	12=	.47244	22=	.86614
3=	.11811	13=	.51181	23=	.90551
4=	.15748	14=	.55118	24=	.94488
5=	.19685	15=	.59055	25=	.98425
6=	.23622	16=	.62992	26=	1.02362

10 mm. = 1 Centimeter = 0.3937 inches.
10 cm. = 1 Decimeter = 3.937 "
10 dm. = 1 Meter = 39.37 "
25.4 mm. = 1 English Inch.

TABLE OF WIRE GAUGE SIZES IN DECIMAL PARTS OF AN INCH.

No. of Wire Gauge.	Size of each No. in decimal parts of an inch of the American Wire Gauge.	Size of each No. in decimal parts of an inch of the English Wire Gauge.	No. of Wire Gauge.	Size of each No. in decimal parts of an inch of the American Wire Gauge.	Size of each No. in decimal parts of an inch of the English Wire Gauge.
0000	.460	.454	19	.03539	.042
000	.40964	.425	20	.03196	.035
00	.36480	.380	21	.02846	.032
0	.32495	.340	22	.02535	.028
1	.28930	.300	23	.02257	.025
2	.25763	.284	24	.0201	.022
3	.22942	.259	25	.0179	.020
4	.20431	.238	26	.01594	.018
5	.18194	.220	27	.01419	.016
6	.16202	.203	28	.01264	.014
7	.14428	.180	29	.01126	.013
8	.12849	.165	30	.01002	.012
9	.11443	.148	31	.00893	.010
10	.10189	.134	32	.00795	.009
11	.09074	.120	33	.00708	.008
12	.08081	.109	34	.0063	.007
13	.07196	.095	35	.00561	.005
14	.06408	.083	36	.005	.004
15	.05707	.072	37	.00445	
16	.05082	.065	38	.00396	
17	.04525	.058	39	.00353	
18	.0403	.049	40	.00314	

TWIST DRILL AND STEEL WIRE GAUGE.

Table of Sizes of Gauge in Decimal Parts of an Inch.

No.	Size of Number in Decimals.	No.	Size of Number in Decimals.	No.	Size of Number in Decimals.	No.	Size of Number in Decimals.
1	.227	16	.175	31	.120	46	.079
2	.219	17	.172	32	.115	47	.077
3	.212	18	.168	33	.112	48	.075
4	.207	19	.164	34	.110	49	.072
5	.204	20	.161	35	.108	50	.069
6	.201	21	.157	36	.106	51	.066
7	.199	22	.155	37	.103	52	.063
8	.197	23	.153	38	.101	53	.058
9	.194	24	.151	39	.099	54	.055
10	.191	25	.148	40	.097	55	.050
11	.188	26	.146	41	.095	56	.045
12	.185	27	.143	42	.092	57	.042
13	.182	28	.139	43	.088	58	.041
14	.180	29	.134	44	.085	59	.040
15	.178	30	.127	45	.081	60	.039

Bench and Vises.

The bench and vises will need some care in both their selection and arrangement. The vises should be of different sizes, and all, except one large one for chipping purposes, should be finished smooth in the face of the jaws, grinding the faces about .010 open at the lower or under side of the jaws. This form of jaw will not slip and will ensure your work from being "decorated" should you forget to put in your coppers, with which every vise should be fitted. Vises with swivel jaws and swivel base are far preferable for convenience in turning towards the light and for general use. The bench should be of hard wood, carefully made and varnished, and provided with a drawer by the side of each vise.

The width should not be less than three feet nor more than three and a half. For the small vises the height is thirty-six inches and for the large vises thirty-three inches. For right-handed workmen place the vises a little to the left of the center of each window.

In shops where there are many presses requiring nice and accurate fits to hardened parts, the universal surface grinder readily finds a place. Its adaptation to a wide range of work, the time saved in finishing, and the extreme accuracy of the results are its principal good points. All the trouble about work springing in hardening can be avoided by making the pieces over-size, hardening and grinding to size.

For cutting off steel, a not very expensive, but very efficient, tool consists of an automatic hack saw frame actuated by a crank and using as a cutting tool a common hack saw blade.

CHAPTER II.

FILES, AND THEIR USE AND ABUSE.

It is rarely that a tool room is properly equipped with a complete set of files. Many so-called foremen have a notion that there is great economy in making a workman use a file just as long as it removes the smallest particle of metal. With improved machinery to facilitate their manufacture, the price of files has reached a point where few files are worth each more than the labor of one man for an hour. On this basis, just as soon as a file is only nine-tenths as good as a new one, it is as poor as you can afford to use. You will be losing time and money if it works slower than this point. Partially-worn files, however, have their uses in removing the rough scale from the work, or in filing across narrow surfaces, as a narrow surface is very liable to destroy the fine cutting edge of the file.

Too little attention is also paid to the proper handling of files of all kinds, and more particularly is this true in regard to small files. The handle should be in proportion to the size of the file, and every file should have a handle while in use.

Files have three distinguishable features, their length, their kind or name, and their cut. The length of a file is measured, not including the tang or shank.

The style or kind of a file has usually a reference to its shape, but may and is sometimes designated by a name of which the origin is unknown.

As to kind of file, there are flat, hand, mill, square, round, pillar, three square, half round, etc. Some files derive their names from their transverse sectional shape, and some from the purpose for which they are to be used, as, for instance, "mills" for filing mill saws, pit-saw, and hook-tooth for filing saws of the same name. There are also distinctive features of shape in their length, as blunt, as being distinct from taper, which is the regular shape. Flat with safe edge, square-equaling, round edge, etc.

All files, with one exception, are in size as to their length, the exception being in the case of equaling which are sometimes denoted by both length and width, as eight inches by one-half inch. The cut or tooth of files is devided into three kinds, and each kind into four or five grades. The kinds of cut are single cut, double cut and rasp.

Single-cut files are those having straight teeth running across the face of the file at more or less angle. The grades are known as rough, coarse, bastard, second cut and smooth. Double-cut files have two courses of chisel cuts crossing each other. These two courses fill the surface of the file with teeth, inclining towards its point, the points of which resemble the diamond-shaped cutting tools in general use.

Double files are graded into coarse, bastard, second cut, smooth, and dead smooth.

Rasp cut files are made with a sharp pointed chisel, which raises up a single tooth independent from all the others. They are used almost entirely on wood, leather, and other non-metallic substances. The grades are coarse, bastard, second cut and smooth.

There is another kind of file, which is not called a file, but a "float." Such files are exceedingly coarse, are cut nearly straight across, and are used for filing lead and other very soft metals.

In the selection of files for the tool-room, one of the most important things is their adaptability to the work in hand. It is poor policy to file a round hole with a square file, and just as poor policy to attempt to file a curved surface with a file having a curved surface derived from a larger circle than the curve of the work. Note this point about files: Variety and number of shapes are far more important than larger quantities of one or two individual lengths or kinds. Keep the workman provided with all the shapes needed for the work in hand, and of such a grade of cut as will enable him to first file the piece to shape and afterwards give it a finish if desired.

As regards the common tanged files of six inches or more in length, they are too familiar to need description, but the particular files devoted to the use of tool makers and die sinkers require special mention as to their shape, size and the use to which they are adapted. Only those shapes which are out of the common will be mentioned. Among the files adapted to the finishing of irregular, curved surfaces may be noted the oval, crossing, auriform and sharp-edge oval. For angular surfaces of less than a right angle, you have the slitting, barrette, balance, ratchet, rivot, screw head, knife, cant, three square and lozenge. A very useful file is the crotchit, which is about the same as a warding, but with round edges. This is a very useful file on die and tool work, and should be provided in large and small sizes. Another convenience is the blunt file, especially round, three square and square. Also provide a set of riflers or short bent files. Scrapers of the same section as the commoner kinds of files are to be had, and are a great convenience.

The greater range of shapes and sizes of files the tool maker is provided with, the better and quicker will he do his work.

Very small files should be of the "needle" variety, and small tanged files provided with long, slender handles, nearly if not quite straight. As before mentioned, "keep a handle on every file in use."

A not uncommon practice is the tumbling of files into a drawer or box when not in use. Such a practice is slovenly and an injury to the files, this being especially the case with coarse and fine files when mixed together. Files should be kept apart, as the striking of the surfaces together will dull them very rapidly.

A neat way to determine the kind of file needed by the workman is to keep a sample of each file arranged on cards, and hung in a convenient place, where the men may look at them and judge of the shapes they will need for their work. By such a plan there is no unnecessary handling of the files, as if they are numbered the tool-room keeper may give out without delay just the one wanted.

A convenient method of holding files consists of a wheel arranged on a standard, with notches around its edge to hold the files. The revolving of the wheel permits of bringing any of the files within reach at will.

CHAPTER III.

STEEL AND TEMPERING.

ONE of the first requisites of tool making is good steel, of as near uniform quality as possible. Once you have a make and grade which you can handle successfully, let no one persuade you to change. In this case a bird in the hand is worth two in the bush. Always use circular die blocks for punching and drawing dies wherever it is possible to do so. For small round punches, taps, small reamers, etc., it is nice to have a stock of drill rod, either stubbs or crescent being about equally good. In preparing the steel to be worked, always carefully anneal, for which purpose, if very much tool work is to be done, a small or medium-sized oven should be constructed. For taps, dies, and other threading tools, do not use steel of too high carbon percentage. It is not necessary to anneal polished drill rod. It is much better to invest in an oven than in files, drills and tool maker's time, which usually cost money. The usual method of heating and then burying the steel in ashes or lime is all right for small quantities. If you have a muffle oven, you can make use of that for annealing your steel, leaving it in over night. Where it is necessary to anneal a piece of steel quickly, the following method may be practiced:

First heat the piece to a cherry red, and allow to cool till it will lose all red color, and then cool off in soap water, which should be at hand ready prepared. Some steel will require to be annealed twice to remove the hard spots. Steel which is right should show, when hardened and broken, a clean fine white fracture free from coarse spots or flakes. If the steel is also of correct carbon percentage, it will harden at not too high a temperature. Steel which requires too high a heat to chill will not stand much strain, but will be found generally unsatisfactory, having a tendency to chip off, crack, spring, and otherwise behave in anything but a proper manner.

In hardening steel tools some general, but necessary rules, will be of great service: First, the fire should always be of charcoal, hard coal, gas, or may be an oil furnace. The charcoal may be used in an ordinary forge, but hard coal must have special arrangements for its use. A common practice is to use a fire-pot or salamander, heating the steel from the flame of the coal projected against a brick surface. To harden work uniformly and so that it will look white and clean, two things are required: A solution which will protect the steel from the fire, and another which will chill the steel quickly, and also give it a nice white clean appearance. For the first, use a strong solution of equal quantities of sal soda and borax in water containing about one ounce of cyanide of potassium to the gallon. For the second, use a strong brine made of salt, and also about the same amount of cyanide as the first solution. This last should be made with hot water, and after cooling, have added to it from one to two ounces to the gallon of oil of vitriol or sulphuric acid. Keep away from the fire in a cool place and also keep covered up. These solutions I have called the "Standard" and have always found them reliable under all circumstances.

The standard chilling solutions are used as follows: Should there be any holes near the edge of the steel or any thin parts liable to crack off, a little clay will be of great service to fill up the holes and prevent too rapid chilling of any thin portion of the tool. After a judicious application of clay, dip the work in the first mixture and place immediately, and while still wet, in the fire. Heat slowly and carefully, avoiding, if possible, heating any portion of the work too fast. The slower and more uniformly the heating is done the better the results will be. As soon as the heat has reached the proper temperature, which should be a clear bright red, dip the work in the second pickle or hardening mixture, when, if you have performed the operation properly, the result will produce work of silvery whiteness and uniform temper. If you are in doubt about the steel, try a test piece first. In chilling all kinds of tools it is necessary to be careful how the piece is plunged in the chill. Long pieces, such as punches, reamers, taps, etc., will spring less if held vertical. Thin pieces should go in edge-wise, and all work should be rapidly revolved around so that the steel may be as quickly cooled as possible. Do not swing from side to side while in the solution. As soon as the piece has become thoroughly cooled, remove from the chilling mixture and slightly warm over the fire. This latter operation will remove the strain incident to any unequal heating or chilling which may have taken place during the operation.

Another method for hardening objects which are to be as free from scale as possible, is to chill in oil of vitriol or sulphuric acid. For small objects use the acid full strength and for large pieces make a mixture of half acid and half water. The work will come out a dull gray and perfectly free from scale. If before heating the steel is coated with carbonate of soda, it will chill in the acid to silvery whiteness. If the pieces are to be left for any length of time, they must be oiled to prevent rusting.

After polishing or grinding the finished surfaces, the tool may be drawn by means of a sand bath, which is nothing but an iron box filled with sand and heated over the fire; the work to be drawn is laid on top of the sand.

Another way is to draw the work over a gasoline burner, which produces very fine colors on the surfaces that are polished.

A very modern way is to heat the work in an oil bath provided with a thermometer, using the tables usually furnished as to temperature required for special purposes. You may also draw the work in the good old-fashioned way by holding over a red-hot piece of iron. The slower the process of drawing is carried on the tougher the steel will be after the operation. The price of success in hardening and tempering steel is eternal vigilance, and always remember how you failed the last time.

Very small articles may be heated up in closed iron boxes, and when all of the pieces have reached the proper uniform heat or color, they may be dumped into either the standard chill or oil, as the nature of the work may require. Another way is to heat the pieces in an iron wire basket submerged in melted lead kept at the proper red heat. As iron and steel will float in melted lead, a cover must be put on the basket, and it will be necessary to hold it down under the lead or part of the pieces will not be heated. Keep the top of the melted lead covered with finely-powdered charcoal or coke, preferably a mixture of both.

For hardening screw machine collets and dies, chilling the pieces in oil seems to toughen the steel. Much impracticable information can be written on this subject, but as the author is writing for the benefit of the actual workman, only tried methods will have a place.

In doing all kinds of hardening, do not have the forge furnace or other heating arrangements where there is too strong a light, and especially beware of such a location where the sun will shine in for a part of the day. It will be found very difficult to get uniform results unless you have a uniform light, as you will be liable to heat too hot when there is a bright light, and not hot enough when it becomes darker.

Should you use an oil bath for drawing the work, the following table of temperatures will be found useful. If the work is first polished, the colors will show as indicated.

Color.	Temperature.	Tools which Require this Temper.
Very Light Yellow.	420° F.	Butt mills for brass, burnishers, lathe tools for brass, drawing mandrels, scrapers, milling cutters, and all cutting tools for soft materials.
Light Yellow.	448° F.	Cutting tools for iron, hand tools, threading dies for brass, embossing dies.
Bright Yellow.	468° F.	All kinds of hand taps, and dies, reamers, small milling cutters, drills for brass, dies for cutting press, trueing blocks.
Brown or Dark Yellow.	491° F.	Shear blades, large dies for press, collets, and chuck jaws, bending and forming dies.
Spotted Red, Brown.	510° F.	Tools for wood not requiring to be filed, axes, chisels for wood, hammers and dies for drop.
Purple Blue.	529° to 531° F.	Tools for wood which must be filed, suitable for hand springs, jaw pieces, etc.
Blue.	549° F.	All kinds of percussive tools for metal, cold chisels, and quick springs.
Dark Blue.	601° F.	Springs, pieces subject to shock, clutch bolts, cams with sharp corners.

In describing the making of different kinds of tools, reference will be made to the special temper required for each piece. You can harden thin articles, such as circular cutters or other flat objects, by clamping, while hot, between two thick iron plates. This method keeps the work from springing. If there is much of such work to do, the chilling plates may be backed with a water jacket to keep them from getting hot, as they will not chill unless cold. Rub the surfaces of the chill plates with some heavy-bodied grease, to act as a conductor of heat between the work and the chilling plates. Work which is to be hardened in oil will come out much cleaner if dusted with cyanide before heating.

CHAPTER IV.

MAKING JIGS.

A JIG is a tool for accurately drilling one or more holes in various directions and positions. Only two general styles are in common use—the clamp jig and the box jig. Clamp jigs are for holding such pieces as have the holes all drilled in one general direction. Box jigs may be so constructed as to permit of drilling the holes at any angle with each other. For drilling with jigs, drill presses, having a number of spindles parallel with each other and running at different speeds, are employed. For larger work the feed may raise and lower the table, but for smaller holes, sensitive drills having each spindle operated separately are preferable.

In manufacturing all interchangeable machinery or other metal work requiring accurate fits, a perfect working model, exactly like the finished product is to be, should first be constructed, all the fits of which should be as nearly right as possible. The machine should then be taken apart and numbered for future reference, and construction of fixtures for their reproduction. Having such a part, no measurements will be required as to location of holes, thickness of parts, or shape of surfaces.

PLATE XX.

FIG. 38.

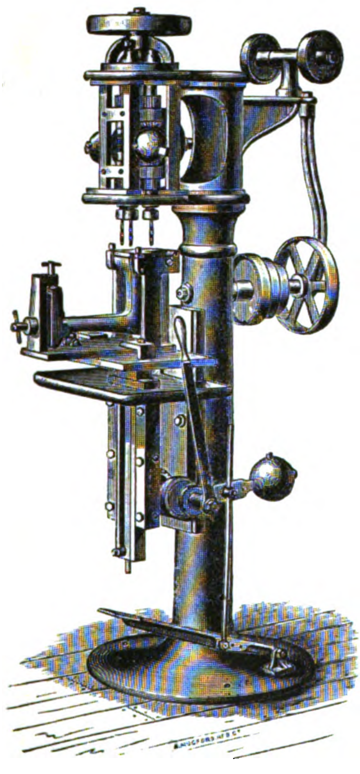


FIG. 39.

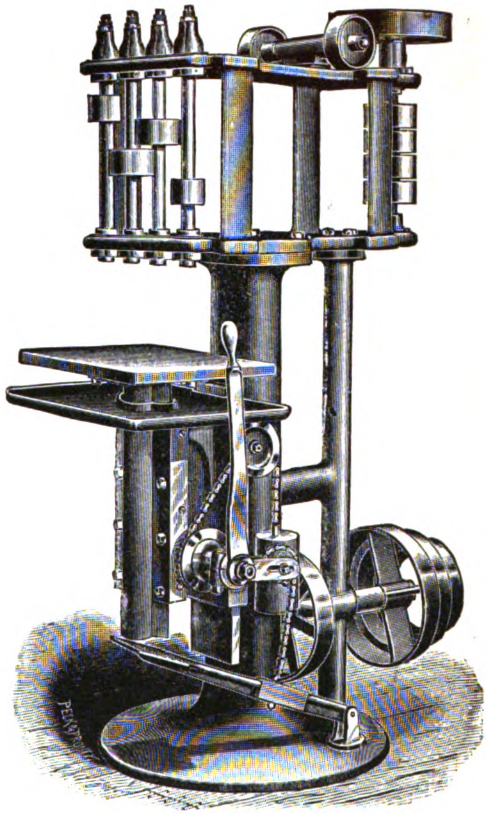
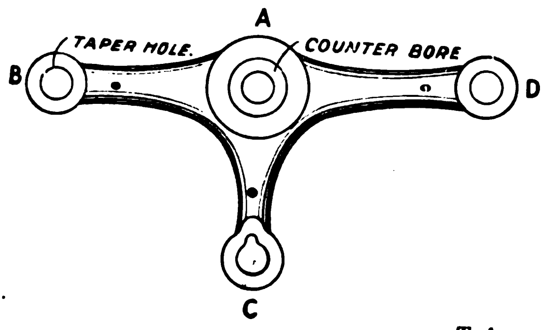


FIG. 40.



To face page 44.

Fig. 38 shows a special three-spindle combined drill and tapping machine, manufactured by the Pratt & Whitney Company, Hartford, Conn. This machine was designed to drill and tap the holes for connecting sewing-machine beds and arms. The table, column and head are similar in design to the gang drill, Fig. 39. The fixtures holding the work are attached to the table, and are balanced by the ball weight. The spindles are counter-balanced independently, and move through a distance sufficient to operate the reversing attachment. When used in drilling, the reversing attachment for tapping is thrown out of gear by a screw not clearly shown in the engraving.

Clamp Jigs.

Clamp jigs generally consist of a surface or angle plate with the piece to be operated on clamped against its surface. For cast pieces there is always an element of variation in size to be accounted for. For this reason, some prominent or important feature, preferably the part joined to some other portion of the machine, is always selected as a starting point from which every operation must be located or measured. Another point is the certainty of the pieces being more or less crooked, which makes it necessary to select three principal points of contact as unchangeable, thus making it possible to rechuck or clamp the piece at any time in any number of jigs exactly in the same position as when first drilled. For a similar reason clamp washers, etc., when clamped against the rough iron should have three feet or resting points. For the same reason that a three-legged stool will always set solid, no matter how uneven the ground, three-legged clamps will hold firmly without any tendency to draw the work out of true. Some of the bushings, however, are sometimes made to screw down against the piece and act as clamps.

Fit in all bushings taper and without any shoulder, and when they get worn too large for accuracy, you may shrink them the same as drawing dies, the taper fit providing for the bushing being smaller where it fits the jig. All bushings should be made very hard and polished very smooth on the inside. Do not make the bushings too long, as they will lose size rapidly owing to the pressure of the chips. Depend upon keeping the holes fitting the drills, rather than their length, for accurate work.

Keep the drills sharp and centrally ground, and thin on the point. Bushings which have to be removed for counter boring, facing off, etc., can be provided with handles and fitted in taper seats. Fig. 40 represents a piece having nearly all the variations occurring in pieces drilled in clamp-jigs, Figs. 41 to 43. As *A* is the bearing where the lever is to fit the main part of the machine, it is made the key to all the operations of machining the piece. The three points of contact are marked on the corners *B*, *C*, *D*, as dots thus •. Referring to drawing, a centering cup screws up against the hub *A* from the under side, acting as a support

FIG. 41.

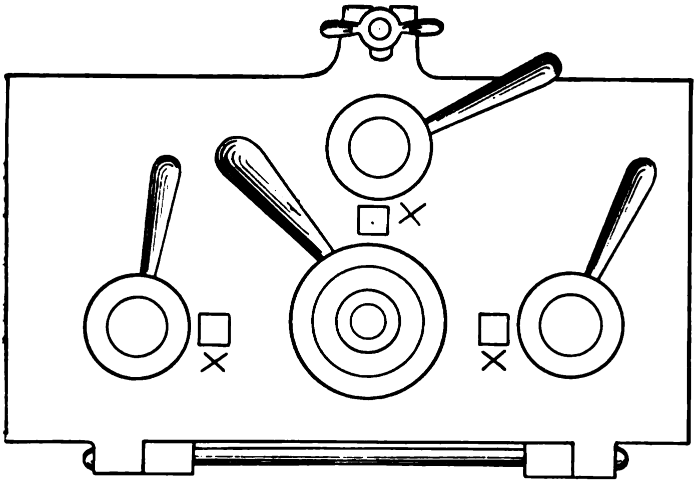


FIG. 42.

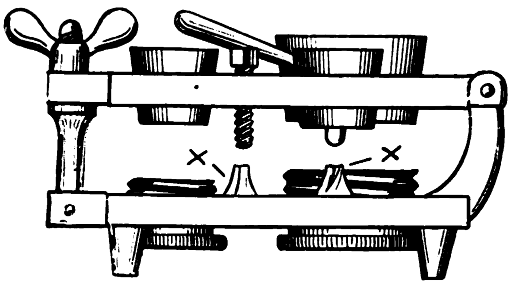
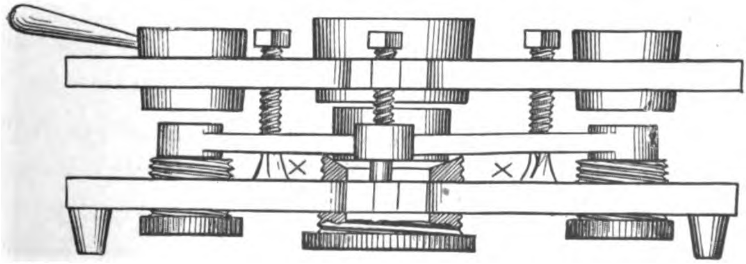


FIG. 43.



To face page 46.

against the pressure of the drills and as a device to make the hole in *A* drill central. Supports having holes through them, and flat ends, are made to screw up against the under side of the three hubs, *B, C, D.* For convenience in chucking the bushing plate is shown hinged to one side of the plate, and provided with swinging bolt to fasten it down. To chuck the piece the four rests under *A, B, C, D* are screwed back, and the casting laid on the three clamp rests *X.* Next the cup-shaped piece under *A* is screwed up sufficiently to center the hub, and the jig plate closed down and fastened, the three clamp screws over the points *x x x* screwed down tight, the three rests under *B, C, D* screwed up to contact, and the piece is ready to drill. For convenience in facing off the hubs all the drills are provided with mills and all the bushings are removable. The counter boring and facing of *A* is performed at one operation, the end of the mill being shaped up for the purpose. In tapering the hole in *B* the reamer should have a straight part just above the cutting portion fitted to a separate bushing, which method will prevent dodging of the reamer. The hole which intersects *C* is drilled with a bushing reaching down into the hole in such a way as to act as a guide. Provide this bushing with a dowel pin to prevent turning.

Should the holes all require reaming smooth after drilling; the same jig fitted with a separate set of bushings will answer, but in re-chucking the piece centering or locating pins should be pushed through *A*, and any one of the other holes. For reaming in the drill press short pod reamers with left-hand spiral seem to give the best results. All kinds of jigs should be provided with small legs or feet to prevent chips from throwing the fixture out of true.

Box Jigs.

The name of this fixture is indicated by its box-like shape, it being simply a hollow iron case with the work enclosed inside. The various faces or sides of the box are made to correspond to the direction of the holes to be drilled, the flat surfaces provided with elevating feet acting as chucking faces. No matter how many and varied directions the holes may have to be drilled, they can all be reached with a box. Many individual forms occur subject to the fancy of the designer or the special features of each part, but the principle remains the same in all. Parts of machinery may be fastened into a removable clamp and inserted and removed, clamp and all. One or more sides can be left open and the piece chucked through the opening, clamping, as in the case of flat jigs. The box may be hinged in various ways that the work may be suitably clamped and the fixtures afterwards closed up, or it may be made to unjoint through the center. All these being only variations for convenience, for it still remains a box.

As an example of box jig work, Figs. 44 and 45 represent a drop forged bicycle crank hanger and the box jig for drilling and milling all the holes at one operation. This piece presents a series of holes all at different angles and only two in the same general direction.

FIG. 44.

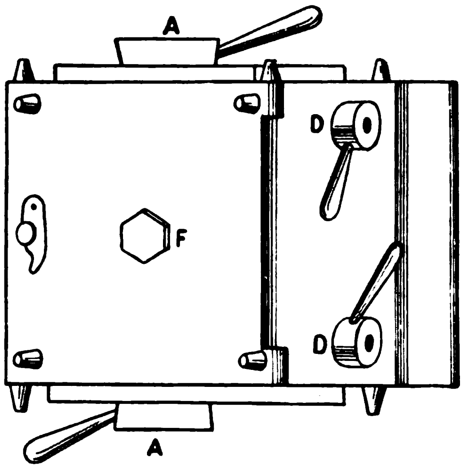
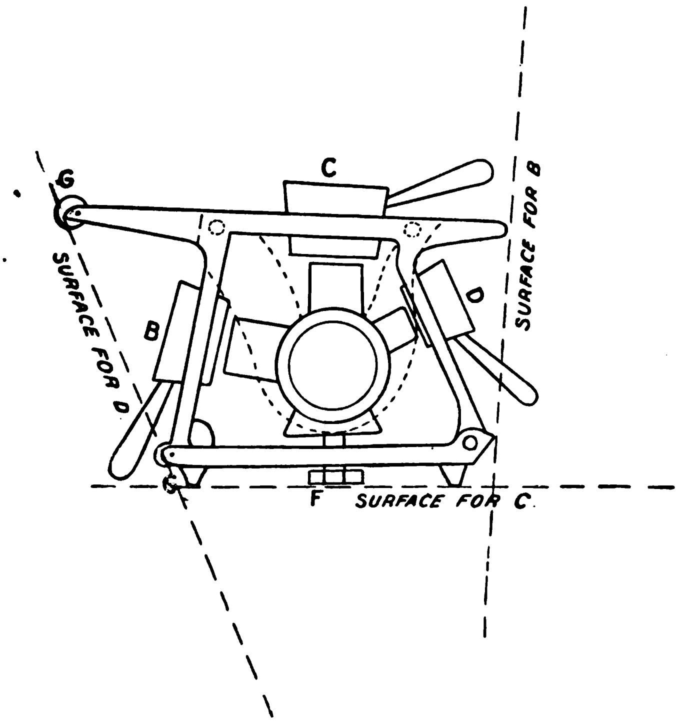


FIG. 45.



To face page 48.

Every hole is provided with a surface on which to rest the jig while drilling. In order to get the slight angular difference between *D D*, revolving feet are arranged to elevate and lower one side at *G G*. All the work in this piece must be very centrally located, as the amount of stock left after drilling is very thin, and the outside surface is not machined, being filed or polished only sufficiently to remove the scale and flash of the drop die. The hole through *A* is counter-bored at each end to receive the bushings. *B C* and *D D* are milled outside to the inside diameter of the frame tubing and drilled out to obtain lightness.

The three points of contact selected are the ends of *A* and the connection *C*. The ends of *a* are clamped and *C* is centered by a screw bushing which not only centers the end with its cap-like end, but also prevents the whole piece from either revolving or moving endwise. The box jig, as shown in Fig. 45, consists of a frame with two open sides and one of the closed sides made to swing open on hinges as a convenience in chucking the piece. To facilitate the casting of the box, the pieces which receive the bushings for drilling through *A* are fastened to each side by suitable screws. There are two semicircular rests to receive the ends of *A*, and in the center of the hinged part is a clamp screw swiveled into a shoe to act as a clamp for holding the forging in place. In chucking the work the forging is placed in the rests and the hinged part closed up and locked. Next the clamp *F* is lightly screwed up and then the bushing over

C screwed down sufficiently to center the end. The screw *F* is now screwed up tight and bushing over *C* given a final twist, and the piece is ready to drill. In drilling so large a hole as *A* with only a thin shell of metal left after the hole is drilled, it is necessary, to prevent wringing and bulging of the thin shell, to first drill a smaller hole, and then redrill or ream the hole to the finished size. After drilling *A* you may remove the bushings and counter bore and face the end at the same time with a pin drill of proper shape. For fine work this last job should be executed with a pin mill having five cutting edges and made with plenty of clearance. One of such open form as to allow of grinding without changing its shape is preferred, and will not only produce uniform sizes, but smooth finish if kept carefully sharpened. All the other holes are first drilled out and then milled off with a hollow mill having an internal pin or guide, removing the bushings for the purpose. The pivot *C* should be the last hole drilled.

To operate this fixture without changing drills will require a six-spindle drill, similar to the four-spindle drills in Fig. 39. All such drilling machines should be provided with a pump of liberal size for pumping the soda water or oil required to keep the tools cool and the chips washed away from the jig. No half way measure will do for fast and accurate work. The drills must simply be flooded. A soda mixture suitable for drill work consists of 8 parts soda, 1 part lard or sperm oil, and 15 parts water. Melt the soda in boiling water, add the oil, and cool off before using.

Cast iron is usually drilled dry, but may be forced by using soda water, the result being much smoother work and longer life to the cutting edges of the tools. Where water is used on cast iron, some trouble will occur from the fine chips getting into the pump. By having a settling basin overflowing into the supply tank to the pump, the chips will settle to the bottom, and the surplus water overflow into the tank, leaving the iron chips in the first basin. Brass work may also be lubricated with soap mixture, such as will be recommended for drawing brass, which will leave the newly cut surfaces with a very bright finish, and prevent unnecessary heating of the drills and work.

The almost endless variety of shapes occurring in practice precludes any universal construction of jigs, but all jigs, as before explained, are based or founded on the two general principles of clamp and box fixtures. For small pieces, jigs having a hinge like a bullet mould or a pair of tongs may be constructed to receive the work inside, the strength of the hand being sufficient to clamp the piece, while the hole or holes are being drilled. Such a tool may be provided with several different faces and bushings for drilling holes at different angles. Box jigs may be constructed with a clamp fixture made to fasten the work into, and then be inserted in the box, clamp and all. Pieces of varying diameter may be clamped with jaws moved by a right and left screw, thus insuring accurate centering regardless of their size. Where only one hole is to be drilled, pieces may be drilled in a jig having a base rigidly attached to the table, and top part or bushing plate in the form of a hand clamp, thus providing a very rapid means of handling. Holes may be tapped square after drilling, using for the purpose a tap holder as described under the head of screw machine tools, the drill press being provided with a back and forward motion, or a special tapping chuck. In all kinds of jig work, aim to drill every hole without re-chucking or handling the piece. In that way if you have made the tool right, every piece will be right and uniform in every particular. Do not allow the bushings or drills to become worn out of size; keep the former shrunk to size, and replace the latter with new ones. Great care must be taken to have the drills ground central; when ground one-sided they have a tendency to drill a hole larger than themselves, pressing against the sides of the drill and bushing, prying the piece loose and out of true, and making bad work all around.

For locating the holes in all kinds of jigs, what is known as the reversing method can be practised to advantage, using as a guide or jig the sample or model piece taken from the model machine. In doing this, clamp the model on the bushing plate and drill through the holes with drills of the same size, thus making a jig of the sample piece. With care this may be accomplished without injury to the model. Afterwards counter-bore out the holes to receive the bushings, taking care to have the guide pin fit the hole nicely.

CHAPTER V.

MILLING MACHINE FIXTURES.

ONE of the principal errors liable to occur in finishing surfaces on the milling machine is the tendency of the work to spring away from the cutting edge of the cutter, the result principally of the width of the cut and weakness of the piece being operated on. To obtain great accuracy two cuts must be made, the second one very light, and the cutters very carefully sharpened. In milling operations on cast iron there is always more or less springing out of true, both in casting, and when any considerable amount of stock must be removed from any one surface. The castings will also vary much in size which enters into the difficulty of properly chucking the piece. For these reasons it is necessary to select some principal and important point from which to locate all future operations. Such point may be one of the principal bearings or large hole and should always be machined first, and every subsequent operation chucked or located from it. Fig. 46 represents a casting having both drill and milled work, and requires that the surface *B* be parallel with the holes in *D* and the holes of uniform height above the surface *B* as shown at *A*.

To provide a starting point, drill the holes *D D D*, facing off the outer sides or faces of the hubs, chucking the piece in the jig centrally as regards *D D D*. Using these holes as a guide, we can proceed to mill the surface *B*, constructing a milling fixture as shown in Fig. 47. This fixture consists of an angle plate *D* provided with a bearing and clamp, *E F G*, intended to clamp a mandrel passed through the holes already finished. One of the screws, *I*, should be taken as a gauge, and after the first piece never moved, taking up the wind and other imperfections by adjusting all the other screws to coincide, screwing down the clamps *J E* as the last operation of chucking. By this method the piece may be rechucked for the finishing cut in exactly the same position as in the first instance, and should any spring occur from the removal of the scale during the first cut, the re-adjustment of the movable screws will take it all out. In screwing in the screws great care must be taken not to raise the work away from the fixed screw. It is preferable to have the screws for adjustment turn up with the fingers. They can also be made to simply push in and be fastened with set screws against their side.

In the above illustration the cutter used is a facing mill, a form of tool capable of doing very rapid work if kept in order. It, however, has the defect of leaving circular tool marks on the work, to avoid which it is always necessary to keep the end play out of the spindle.

The principles of chucking and re-chucking cast pieces in milling machines are all embodied in the foregoing description, and the main parts are, first, the proper

PLATE XXIII.

Fig. 46.

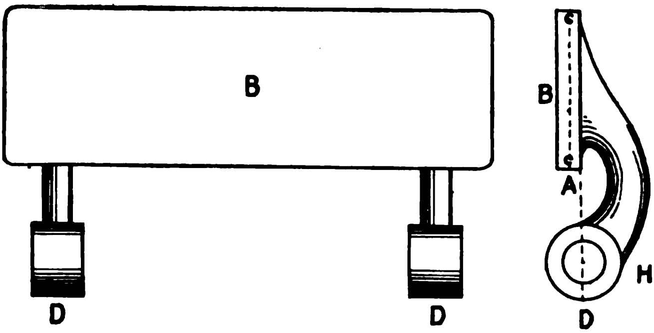


Fig. 47.

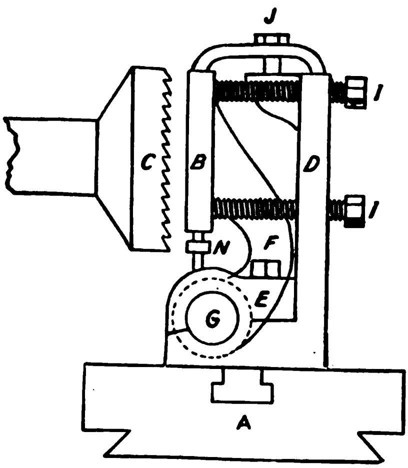
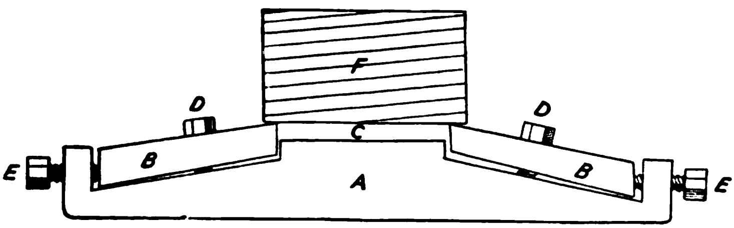


Fig. 48.



To face page 54.

selection of some main feature from which to locate all the different operations, and the fixed position of some point of contact or support for a renewal of any or all future work. When the casting is of such form as to permit of clamping in a horizontal position, three points of contact, selected for their regular location, may take the place of the mandrel and the one resting place described.

To face off the inside of the hubs *D D*, a pair of centers made to fit the holes will ensure quick and accurate results, using two large headers for the purpose. Bear in mind, as explained under the head of jig work, that any further work—drilling, counter boring, etc.—can be interchangeably located by using the holes through *D D* as a guide. This method of using a single locating feature for all the operations performed in one piece is the key note to accuracy and interchangability. Where two pieces join together in any way, and each have much machine work, their principal connecting feature, or where they join together, should be selected as a starting point.

Wherever parallel surfaces occur, and the nature of the work will permit, make use of a pair of straddle mills. By this method a perfectly square piece, having parallel surfaces at right angles to each other, is certain to be the result.

To increase the amount of work turned out by each machine, parallel the work, that is, operate on several pieces at once. To explain, supposing you are milling taps, reamers, or similar work. Make a fixture which will carry several pieces side by side, and have an equal number of cutters, to cut all the taps or reamers at the same time, you may gear the parts together and revolve them all from one handle. On some classes of work where the pieces are short, two fixtures may be placed on one machine, one on each end of the table, and while the cut is being made on one, the other may be chucked, thus getting double duty out of one machine. Long and slender work may be held between centers and kept from springing with a "dead" steady rest, which is a rest fastened to the upright part or body of the machine. Such a rest has the feature of always remaining immediately under the cutter, the work sliding between the rest and the cutter.

The tendency to spring, before referred to, would indicate the necessity of stiffness brought about by using plenty of metal, and large screws and bearings. Clamps of all kinds are best made with three feet, which will cause them to rest square and firm against the work.

Where oil or soda water is to be used, provide suitable channels or rims around the fixtures to guide the oil or water to one point of escape, thus preventing unnecessary slopping and waste. The best machines are provided with pumps which permits of a copious supply of oil which is an excellent feature. For quantities of thin, flat work the fixture, Fig. 48, provides a means of chucking or holding without danger of springing or necessity of hammering the pieces down. The work turned out by this tool is unexcelled for accuracy. The cut represents an end view, and the fixtures may be made as long as desired, having the binding screws *D D* and adjusting screws *E E* about three inches apart.

CHAPTER VI.

TOOLS AND FIXTURES FOR THE SCREW MACHINE.

THE variety of work that may be executed on a screw machine or turret lathe, Fig. 49, covers a very wide range. It is possible, with suitable tools, to make any form of piece that can be turned either on the hand or engine lathe. Many of the tools are standard and in universal use. Tap and die holders, with or without trip, box tools of various forms, knurling fixtures for both the slide and turret, butt mills, and screw cutting dies are a few of such tools.

Chucks for small work should always be automatic when possible. Most screw machines are provided with automatic chucks and rod feed, and need no explanation.

Figs. 50 to 59 show ten samples of turned work and the method of producing each piece, and the different tools used will be carefully described in turn.

Fig. 50 is simply a piece cut off to length, which may be done as follows: Set the stop for length in the turret, and cut off with tool in slide, grinding the cut off tool a trifle longest on the right side, which will cut the piece in two without a pin on the end of the piece. Use oil on steel and iron, and work brass dry.

PLATE XXIV.

FIG. 49.

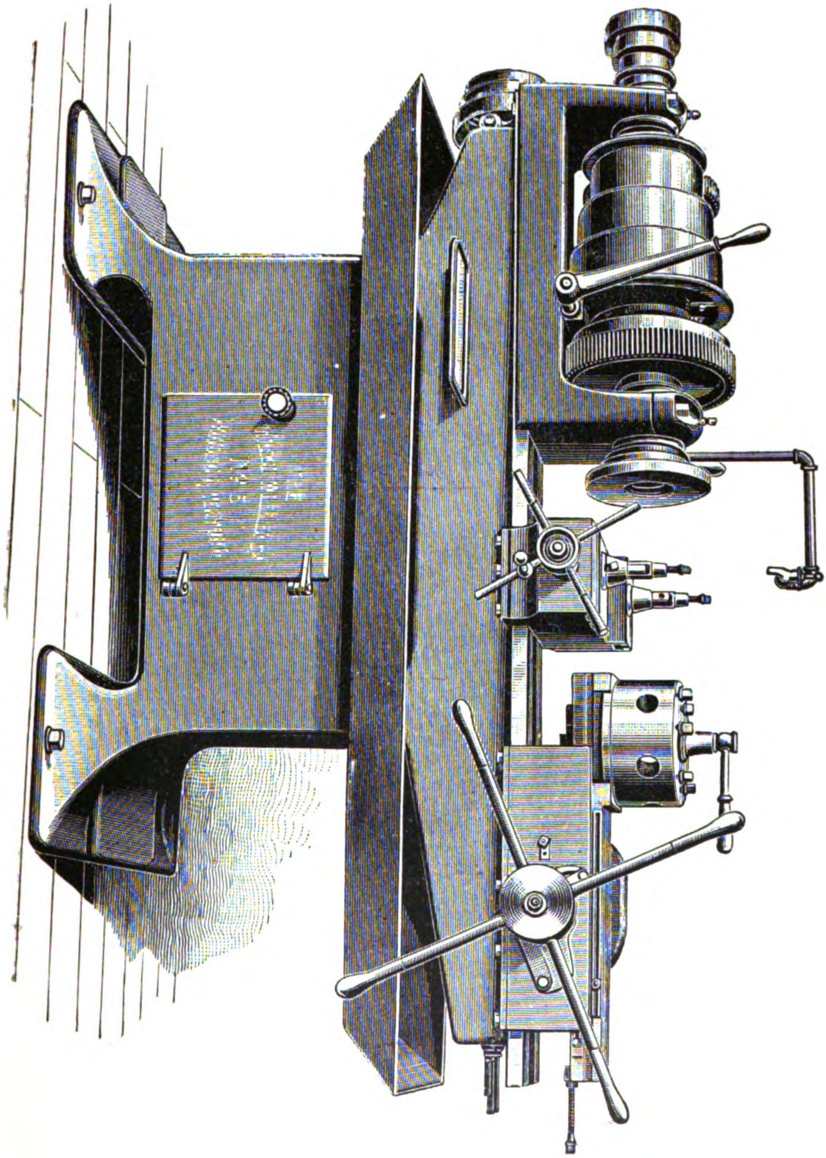


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PLATE XXV.

FIG. 50.

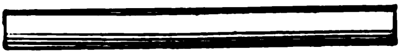

FIG. 51.

FIG. 53.

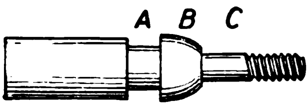

FIG. 52.

FIG. 54.

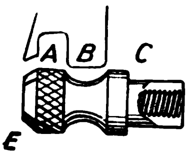

FIG. 55.

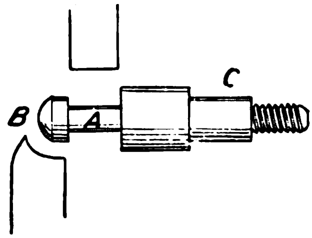

FIG. 56.

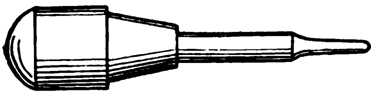

FIG. 57.

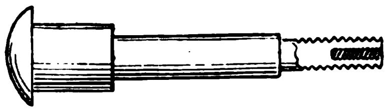

FIG. 58.

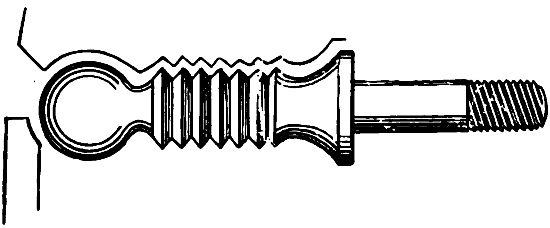

FIG. 59.

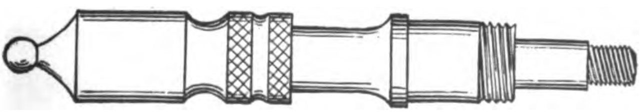

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Fig. 51. Set stop same as before. Mill or turn up smaller part with box tool or butt mill, having the turning tool cut the right distance for shoulder, as the stop screw on turret slide strikes. Cut off same as No. 1. Fig. 52, proceed as in 51, to make small end where threaded, both may be turned at same time with double tool box. Thread with die in trip holder, and cut off same as before.

Fig. 53 presents some new features. The groove at *A* must be cut in by tool on back of cross slide. Some machines have tool post for putting the tool upside down as shown in Fig. 49, that it may cut without reversing the machine; where the tools are both of one level the lathe must be reversed to use the back tool. The best time to make the cut is after the machine is reversed to back off the die after cutting the thread, which saves reversing the machine once. To cut down the end at *C* and get the shape at *B*, a box tool with two tools will finish both at one operation. If the size varies somewhat from the heavy cut required, two motions and two tools will overcome the trouble. The threading and cut off are same as before.

Fig. 54. This piece also will require both tools in the cross slide, and as we must mill or knurl the part at *A*, we must make use of the knurl holder in the turret. We can also burnish with the roller burnisher such parts as require a finish. On iron or steel, burnishing it is very important, as it is more difficult to buff a nice finish, than on brass. Much time can be saved by burnishing

brass also, as very little buffing will bring the work to color after the roller burnish. The hole *D* will be drilled and then tapped with the tap holder, being careful to set the stop so that the tap will not butt, as if it does it will break. The operations in rotation are as follows: Set to length. Mill part *C*, drill and tap *D*, without changing direction cut in with back tool parts *B* and *E*, burnish *B*, knurl *A*, cut off. All these operations will require one more tool than there are holders. The best way to overcome this is to put a drill inside of the mill and drill and mill off the part *C* at one motion.

Fig. 55 presents the feature of being large in the center and small at each end. Two tools will be required in the slide, one to cut in the groove at *A* and one special cut-off to cut off the piece and form the end at *B*. The milling of the two shoulders and cutting the screw have already been described.

Fig. 56. If you have two box tools you can make the three shoulders on this piece in two operations, otherwise a small butt mill will turn up the small end. A special cut-off will round up and cut off the large end.

Fig. 57. This piece has the same number of shoulders as Fig. 56, but in addition is threaded on the outside and drilled and tapped on the inside of the small end.

Fig. 58. In making this piece we must make use of the under cut tool, care being taken to mill off and thread the small end as the last turret work. Some difficulty will occur in cutting off and forming the small ball, which operation must not be hurried. The double knurling can be made with the turret tool.

Fig. 59. The only particular point about this piece is the lapping of the two cuts where they meet between the cut off and the under cut tool. The extra lines show the approximate arrangement of these two tools. All kinds of under-cut work must be well centered or supported by a suitable revolving center in the turret, as the strain from so heavy a cut will cause the work to not only chatter, but may break it off. You may turn off a special center to use while making the under cut, and afterwards mill to a finish, removing with the last cut any marks or imperfections left in the temporary center by the strain in forcing the under cut.

Fig. 60 shows a fourteen-inch turret-head chucking machine and tools for gas cocks.

In grinding the cutters for all box tools avoid all rake to the tool and be careful to get just the right amount of clearance both in the direction of the cut and in relation to the surface of the work. Always oil-stone the edges to a fine edge if you wish a fine finish. Be very careful about the centering of the guides or follow blocks, for if you get them too tight, your work will vary in size, and if you get them too loose it will chatter.

When a great number of pieces of one kind are to be made, it is best to make use of butt mills for the work, as the tools can be fitted up in sets and put in the machine much more quickly than box tools can be adjusted. Fig. 61 illustrates the best form of mill, which should be fitted with a clamp collar, Fig. 62. The great advantage of this type of mill consists in the ease with which it can be sharpened and its convenient adjustment to size. Fig. 63 is a "trip" die holder for holding small flat or button dies. These fixtures enable the machine to cut a thread up to the shoulder by means of a clutch pin on the front and a left-handed ratchet on the rear end. The work is threaded by running the die till the stop strikes and the clutch pin pulls off at the proper time, causing the die to revolve with the work and preventing its cutting farther than wanted, when, on reversing the machine, the ratchet will back the die off. A similar fixture has a smaller hole or chuck for the reception of taps, which are operated in the same manner as the dies. There are several expanding or trip dies in the market, which are of advantage on long threads, saving much time in backing off the dies. See Fig. 64.

Hollow or butt mills are often used on short cuts immediately preceding threading dies, but on long, straight cuts, and especially on square stock, and in cutting large-headed screws from a bar, they should be followed by a box tool. Mills can be readily sharpened by grinding the ends, without materially changing the cutting sides.

Spring screw threading die. This die, Fig. 65, is adjustable by means of the clamp collar that is furnished with each die-holder, but not with the die, unless especially ordered. The die is readily sharpened by an emery wheel. For uniform and well finished threads two dies should be used, one for roughing and one for finishing cut.

PLATE XXVI.

FIG. 60.

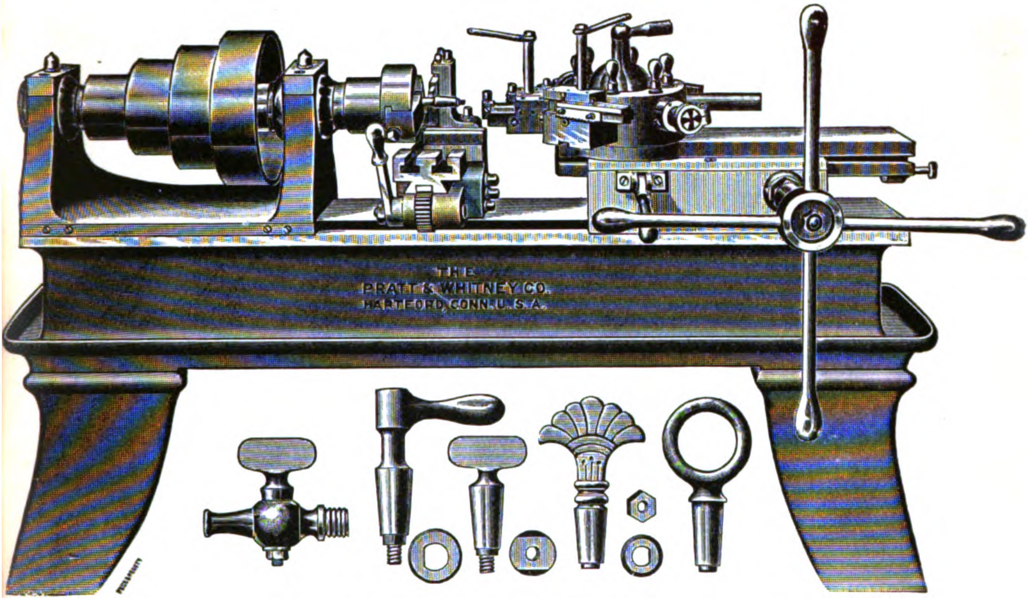

FIG. 61.

FIG. 62.

FIG. 63.

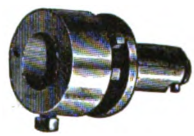

FIG. 64.

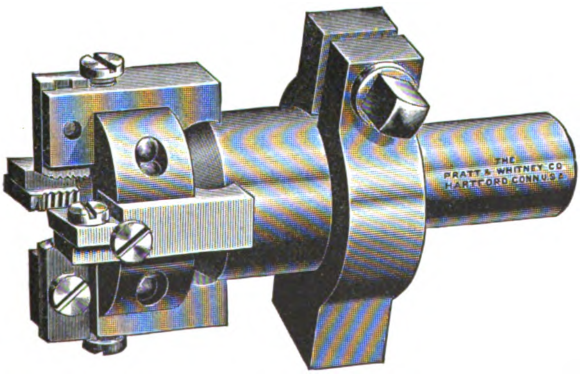

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Fig. 66 is a combination of cut off and knurling tool for the cut off slide, the knurling fixture setting on top of the cut off and being held by the same tool post. The upper tool is provided with a hinged part which folds back out of the way when the lower tool is in use. It sometimes happens that two tool posts will be needed to hold these tools. The need of such an arrangement will be apparent where the knurling is very much at one side of the work performed by the lower tool.

Where it becomes necessary to check or knurl long pieces for nearly or the whole of their length, the checking knurl consisting of two knurl wheels having a single cut across their face, one wheel being a right spiral and the other a left, forms a very efficient universal tool. In the illustration, Fig. 67, the tool shown is for use in an engine lathe, and the operation consists in feeding the tool along the work in a similar manner as when cutting a thread. For the Monitor lathe and screw machine a modification attached to the turret, which can be set to different sizes, will knurl or check straight work.

A convenient method of making tools for forming up pieces, or special shapes, is that used and sold by the Pratt & Whitney Co. They make any form required to order, and can always duplicate any former order.

Only a few of the forms that may be made are shown in the cuts, Fig. 68. The cutters are held rigidly, and the work done is of best character. Though their cost appears high, it will be found, upon consideration, that it is better to use them than forged tools that must be fitted to a template by filing, because they can be sharpened and used longer without changing their form.

Fig. 69 illustrates only a few of the various kinds of screws that may be easily produced on the screw machine, with the tools above described.

For producing a fine finish it will be necessary to make use of a roller burnisher, which is nothing more than a smooth knurl. Extra pains must be used to have such rollers hard and with as smooth a polish as you can make. Use with oil on all kinds of work, and where the object to be burnished is of irregular shape, the roller must fit very nicely to get good results.

A great convenience on all screw machines and turret lathes is a pump. For steel and iron work a pump is an absolute necessity for rapid work, as it insures a continuous and ample supply of oil without any stoppages to refill tanks.

Automatic screw machines must be run quite slow if good results are expected. The low cost of the work on such machines consists in the number of machines one man can tend, and not in the speed of each individual machine. Always advise the purchase of automatics if the quantity is sufficient to run continuously for eight or ten days on one piece.

Monitor Lathes or Turret-Head Chucking Machine.

These machines are used for drilling, boring and reaming holes at a much faster rate and with more uniformity than similar work can be done on lathes form-

PLATE XXVII.

FIG. 65.

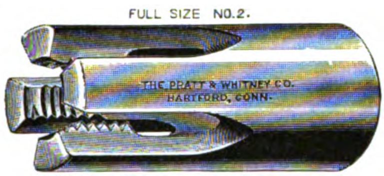

FIG. 65.

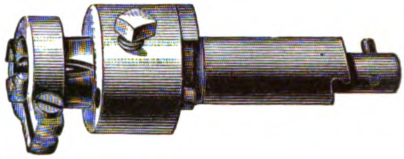

FIG. 66.

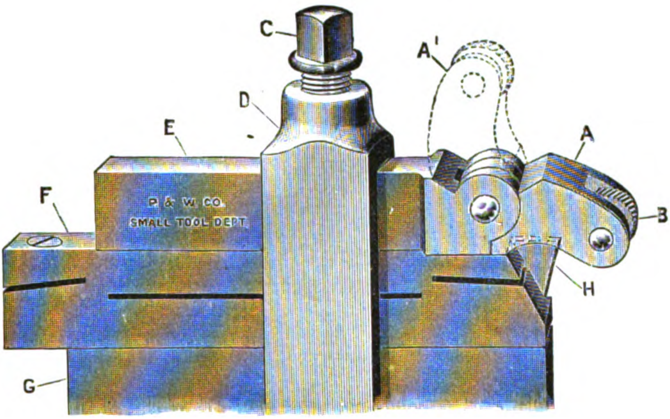

FIG. 67.

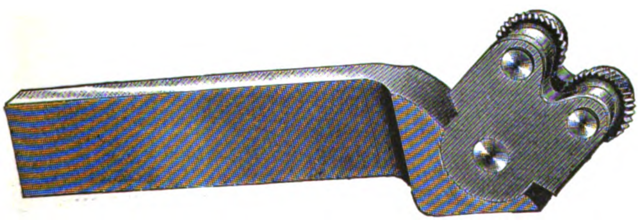

FIG. 68.

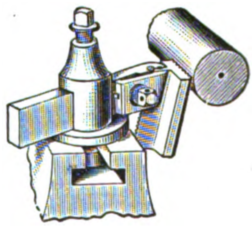

FIG. 68.

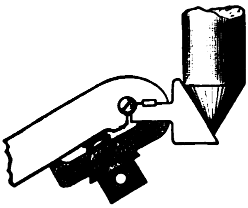

FIG. 68.

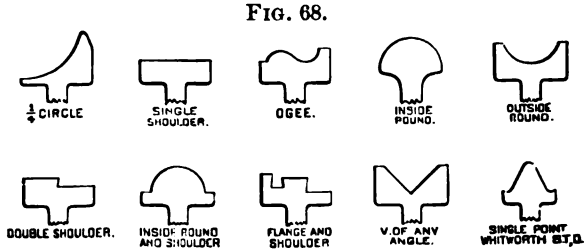

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PLATE XXVIII.

FIG. 69.

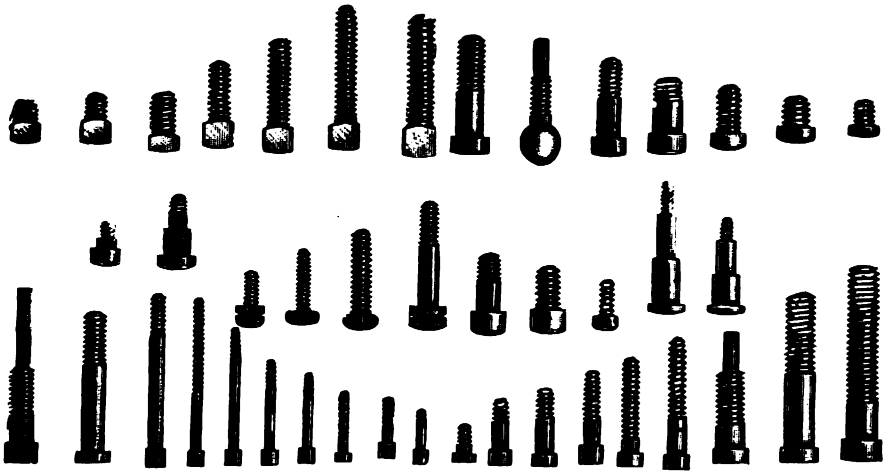
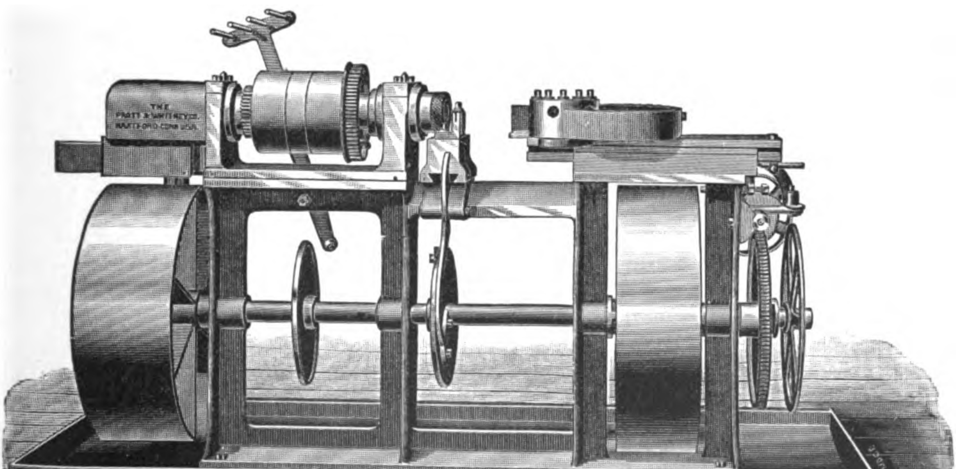


FIG. 70.



To face page 64.

erly used for the purpose. They are also largely used to finish parts of machinery, cast or forged pieces of irregular outline and circular cross section, when fitted with necessary tools. They have the same construction as the revolving head screw machines above the bed, but are not furnished with wire feed apparatus, oil tank, or dripper, being intended for work on materials not requiring use of oil in cutting. The heads have provision for vertical and horizontal adjustment of the spindle in case its alignment with the turret holes is lost by wear.

Fig. 70 shows a *Spencer automatic screw machine.* The machines are designed for making screws, studs, or other circular pieces of various outlines from a bar of round, square or hexagon metal. All the operations are wholly automatic, being controlled by a series of cams on a shaft running lengthwise of the machine in the lower part of the frame. These cams are adjustable, so that the length of stroke of turret-slide, or of feed-tube, or of cut-off slide, can all be varied to suit size of screws to be made. The motion of the cam-shaft can also be made fast or slow, as may be desired for the tools when being brought to a position to do work, or when actually cutting. This variation is given by means of movable stops attached to a disc on the cam shaft, which ship the belt from one pulley to another. The tools are held in the revolving turret, which turns automatically when turret-slide reaches the end of its backward movement, thus bringing another tool into position to do its work. The work is held in a wire feed collet in spindle, which is driven by an open and crossed belt on two loose and one tight pulley, thus giving reversing movements for tapping. This belt is shipped by means of a disc on camshaft having movable dogs, enabling the time of shipping to be varied as required. The cut-off slide is operated by means of a cam and levers, which are also adjustable to any length of stroke within the limits of machine.

In ordinary screw machines with wire feed there are four styles of chuck jaws: the draw-in, the push-out, straight-face and bevel-face. When more than one machine is to be used, some should be push-out and some draw-in.

In turning up work which has much cutting on the face or flat sides, good, serviceable tools can be made by turning the shape up on the end or cutting edge of a mill. For shaping up work with the cross slide tools like the cuts, which can be sharpened without changing their shape, are very serviceable, and, though the first cost is more, the ultimate result will prove a money saver. See Fig. 68 for standard shapes.

The usual set of tools for the turrets of the machines consists of one hollow mill and holder and one box tool (or two box tools), one or two die-holders and dies, one cutting-off tool, and one stop-gauge.

The die holder may receive a tap in place of a die. The shank of the holder revolves in a sheath, or sleeve, which has its ends formed into right and left-hand clutches, which engage with pins or projections on the shank and head of the die-holder. The effect is to allow

PLATE XXIX.

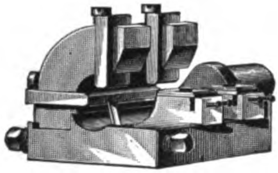


Fig. 71.

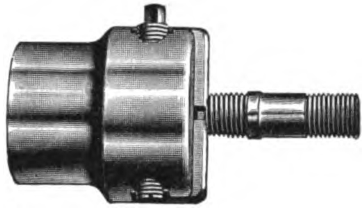


Fig. 73.

Fig. 72.

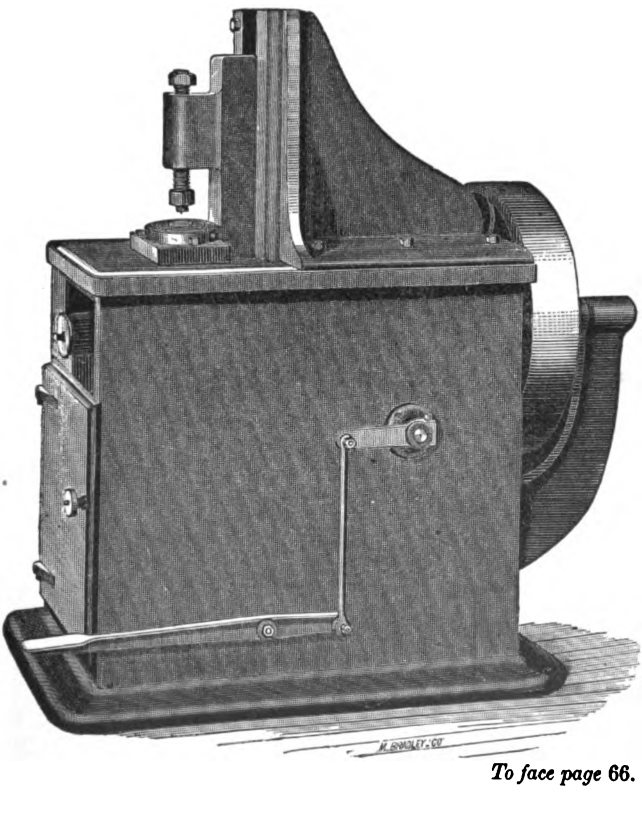


Fig. 74.

To face page 66.

the die or tap to remain stationary at the instant of reversing the motion, and to be backed without jar or danger of being broken, while the die may cut close up to a shoulder, or the tap be sent in to an exact and unvarying distance.

The box tool, Fig. 71, is made to receive from two to five cutters (including one in the hollow shank), of a form adapted to the work they are intended to produce.

The cutting-off tool, Fig. 72, consists of a cutter dovetailed into a holder so as to be readily adjusted. The cutter may be sharpened by grinding without changing its form.

The chuck, Fig. 73, has two jaws operated by a right and left-hand screw, and is furnished with machines that are not provided with wire-feed apparatus or drawback collet when ordered.

CHAPTER VII.

BROACHING.

BROACHING is the term applied to the operation of finishing the inside of irregular-shaped holes in all kinds of malleable or cast-iron work. Fig. 74 shows a broaching press. The process is simply punching out or broaching the hole with a punch and die. To get good results the bottom of the punch should be hollowed out a little, that it may cut a nice clean chip from the inside of the hole, and not have a tendency to dodge to one side should the rough or cored out hole be crooked. The stripper must be arranged to pull the work off square or the hole if very long will be injured when the punch is withdrawn. The special presses provided for such work are back geared and very powerful. Do not speed the press too fast, and use in all cases oil as a lubricant. When the cut is very heavy it will be necessary to do the work in two operations, too heavy a cut having a tendency to make the hole rough. Socket wrenches or similar fits are easily made in this way. If the cuts are made light enough, it is possible to broach cast iron in this way, using for the purpose several punches or broaches of different sizes. Such punches should be slightly larger at the cutting end, and for the finishing

PLATE XXX.

FIG. 75.

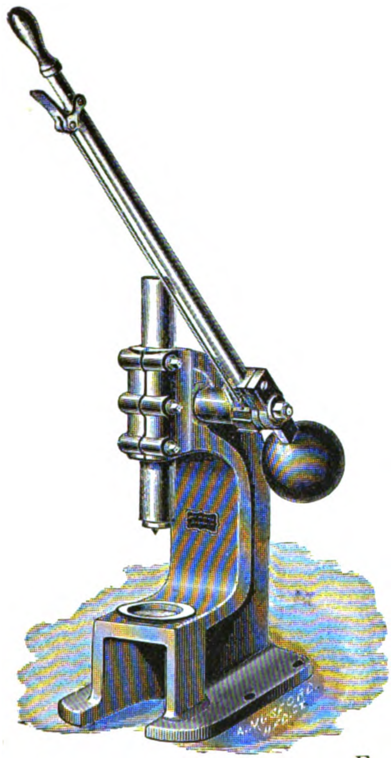
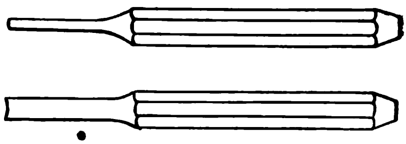
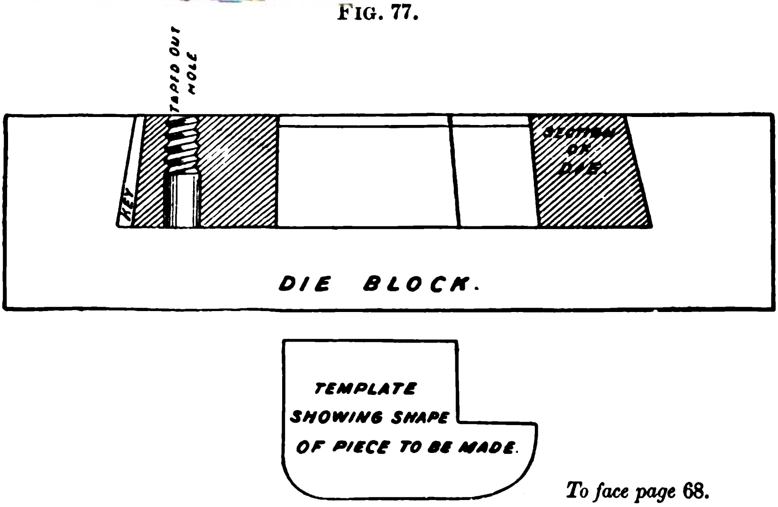


FIG. 78.



SIDE AND EDGE VIEW OF DRIFT.

FIG. 77.



To face page 68.

cut or last operation, if clear through the piece, should work into a die, or you will break off or tear away the lower edge. The temper should be a trifle harder than for common punches and dies.

Fig. 75 shows a hand-sizing press. It has been found in sewing-machine manufacture, and other interchangeable work, that a large number of holes can be made much nearer to uniform gauge, and the surface left in better condition for wear, by forcing a hardened steel mandrel through the hole as a final operation.

Hand broaching presses, Fig. 75, are convenient to force parts together, or as a substitute for driving mandrels in or out of pieces to be turned in the lathe.

It is always necessary in tapping with tapping machines to provide fixtures for holding the work in place. Large pieces can be held against the flat surface of the tail rest if the nature of the surface will permit. A two-jawed chuck having slip jaws similar to a turret lathe makes a very convenient attachment. Always set the machine to pull off the clutch just as soon as the tap has gone in the proper distance. Do not run the machine too fast, as the sudden shock of starting the tap will cause a high percentage in broken taps. Keep the taps sharp. Use oil on wrought iron and steel. Work brass dry and, when the tap does not work right, do not oil it—*sharpen it.* For cast iron if the tap is occasionally stuck into a cake of bee's wax, the result will be very nice threads and long life to the tap.

CHAPTER VIII.

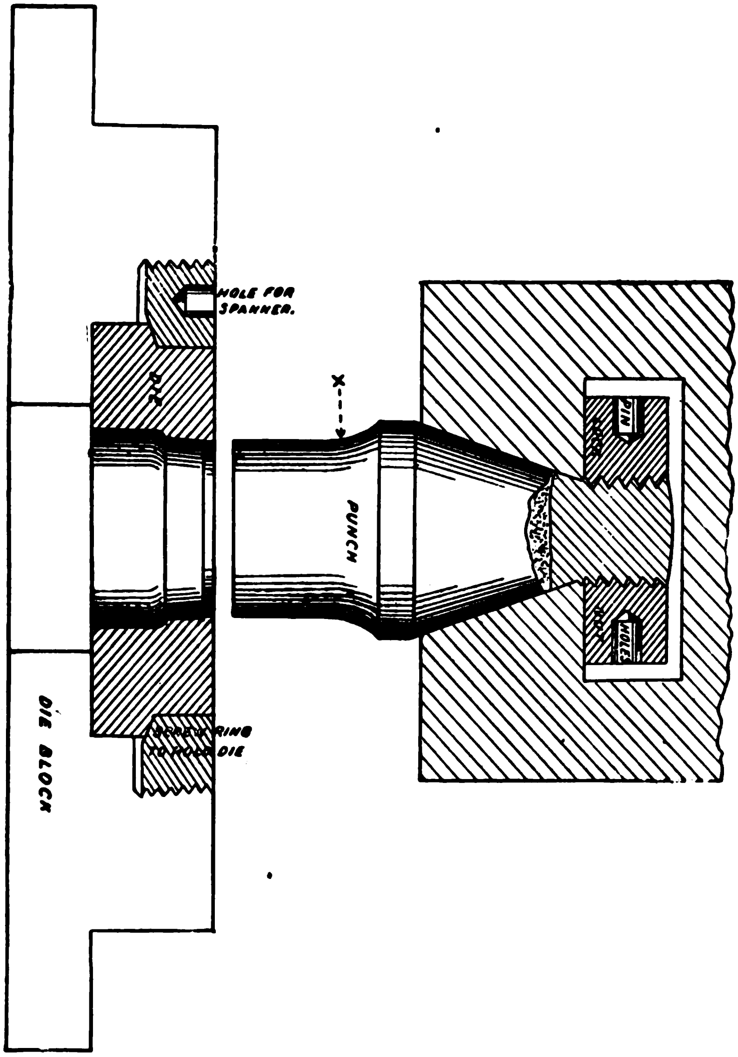
PUNCHES AND DIES FOR THE CUTTING AND DROP PRESS.

In treating this subject, the author aims to give such information as will overcome the "hard spots" usually experienced by those who try and have more or less failures for want of previous experience. For plain, round dies, intended for heavy duty on steel, iron, or heavy gauges of brass or copper, note the following instructions and the accompanying cuts. Fig. 76 shows a plain round die for heavy duty. The method shown for holding the die in the block presents some advantages. It will hold the die firmly, there are no projecting parts to catch the work, and it is cheap to make. In boring the hole through the die, do not make the too common mistake of tapering it a straight taper from the top or cutting edge, for if you do, you will be unable to keep the die in order. All cutting dies for whatsoever purpose must be made straight for a short distance from their cutting edge. The balance of the hole may be either tapered out or counter bored, as suits the fancy or convenience, and the tools at hand.

After hardening, polish and draw to a brown. As the hole will shrink, and even sometimes get out of round, it will be necessary to polish out the die to size again with

PLATE XXXI.

Fig. 76.



To face page 70.

a hard wood stick, emery and oil, holding the die in a speed lathe and the stick in the hand. It is best to catch the die in the chuck under side out, or you may bell or taper out the cutting edge. As a final finish, surface off the top of die on surface grinder. The work is ground by placing it on the adjustable table, and moved back and forward by the hand. It is best to have a separate plate on which to grind the work, as unless the plate be kept level you will not get good results.

The foregoing instructions should have a prominent bearing on all forms of cutting dies, especially that part which relates to the tapering or relieving out of the underside of the die. Some judgment will have to be exercised in regard to the thickness and the amount of steel around the hole. The heavier the duty the larger and stronger you must make the die.

It will be seen by the sketch that the punch has a lock nut arrangement for holding it in the head or block. The method shown will hold the punches firm and true, and give the best results. The block or piece which holds the punch should properly be made of wrought iron or machinery steel. Modern presses are provided with a punch holder having a movable block, taking in one-half the shank and acting as a clamp. Such a holder requires the punches to have straight shanks.

In finishing up a punch of any kind be very careful about the outlines, as shown at the point X, Fig. 76. Do not leave any angles, or lines, or deep scratches in the surface, for your punch will surely break off if you do. Make the outline a clean sweep and as plain and smooth as you can. Avoid all O. G.s, beads, or other fancy outlines.

When you have a universal grinder in the tool room you can grind the round punches to size after hardening. It will be necessary to vary the fit of the punch in the die according to the thickness of the stock to be cut. For thick gauges of iron or steel the punch should fit the die easy, not loose by any means, but a nice sliding fit. For such fits the punch should be hardened and somewhat softer than the die. For all kinds of thin metal work leave the punch soft. The reason for this is the necessity of keeping the punch a close fit in the die, or to be particular, the punch must be proved or sheared in, which may be done by proving or upsetting the punches slightly, and shearing in or proving in as when first made. Always make and harden all dies before you finish the punch. Do not taper the cutting or working part of any punch, keep it straight. Large punches and dies to be used on presses of medium power or size should always have shear. If you desire to save the piece cut out, put shear on the die. If you wish the hole to a finish put shear on the punch.

Irregular Shaped Cutting Dies.

Few tool makers seem to acquire the knack of making odd shaped cutting dies in a skilful manner. To be sure the work looks well and sometimes works well, but the amount of time put on the work is sometimes very surprising. The reader is asked to follow very closely the instructions and illustrations on this subject.

For small work use round dies, as being the easiest to make and most convenient to hold. For large dies, square or oblong blocks may be used with beveled edges, and for a holder you may key the die into the block as shown in the cut, Fig. 77. First provide yourself with a template or pattern the exact size and shape of the piece to be cut, which may be filed up out of any convenient thin material. Having fitted the die to the holder, file off the top smoothly and coat over with copper, which you may accomplish by rubbing over the metal with a solution of sulphate of copper in water. The copper surface makes a nice material to show the "scratch." Next lay on the template and carefully mark around the edge with a fine sharp scratch awl. Next lay out a circle of holes just inside the line, and such a distance apart that the holes, when drilled, will not quite meet. Keep just inside the line in drilling, but the nearer you get to the line, and not go outside of it, the less labor will be required to finish the work. In drilling all kinds of cast steel be careful and not run too fast; and, strange as it may seem, if you have never tried it, a twist drill will work best dry. Grind the drill a little flatter than for iron, or as the drills are made and just a little one-sided. If you prefer to use oil, use only the very best lard oil, and use lots of it.

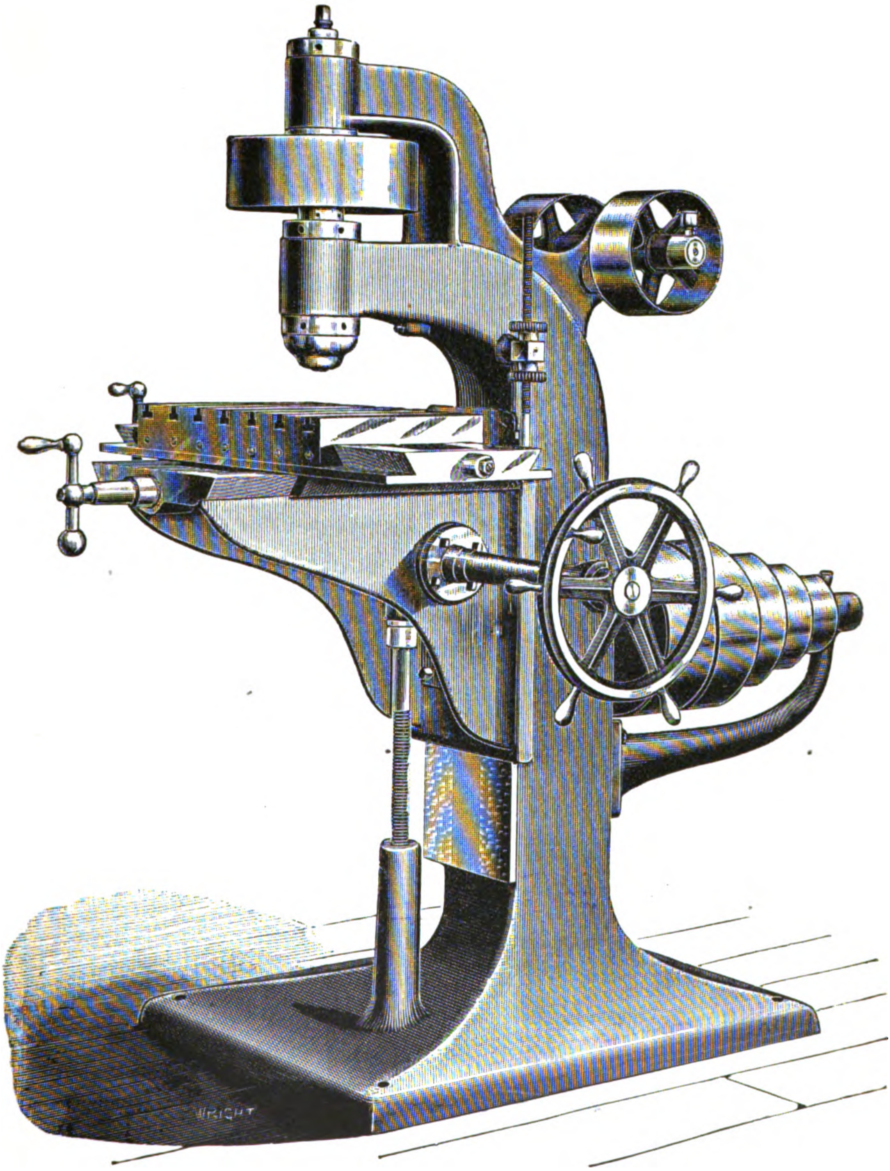
As soon as you have your row of holes drilled around the inside of the die, or rather the line which marks where the die is to be, drive a drift, part way through from each side, cutting out the remaining space left between the holes. Such a drift may be of such thickness as will be in proportion to the work, usually about $\frac{1}{16}$ inch. In tempering such drifts, temper by first hardening and afterwards drawing to a purple. When tempered, the same as you would a cold chisel, they will not stand, but will bend up and break off. Fig. 78 shows side and edge views of drift. As soon as you have drifted away the stock between the holes, the waste piece will drop out, when you may proceed, after chipping off the remaining projections, to the next operation, which is called *out-lining*,, and is accomplished as follows:

Carefully bevel off the inside of the hole back to line, following the line as perfectly as you can. If properly done you will now have a line to file your die to, which you can follow with very little trouble. If you have never tried this before it will be a surprise to you. In filing to a beveled outline fasten the die in the vise with the face side and beveled edge away from you or towards the light.

In backing off irregular dies you can, if you have them, make use of either an upright or universal milling machine, using a short taper end mill with rounded-off corners. Also be cautious about keeping the die straight for one-sixteenth or three thirty-seconds from the cutting edge. Straight parts of the die may be shaped with a bent tool in the shaper, or milled off with

PLATE XXXII.

FIG. 79.



To face page 74.

a small mill, thereby saving much filing. A very convenient tool for such purpose is the upright die sinking machine, shown in Fig. 79. Should you wish to tap any holes in the die for holding stripers or gauges, it is best to counter-bore the holes from the under side, leaving only a short distance to be tapped. Also bevel out or counter-sink the holes on the face side of the die. In hardening fill all such small holes with clay (any kind will do) before putting in the fire, or you may crack or chip off some of it. Having hardened and properly drawn your die, you are now ready to make the punch.

The fastening of irregular punches to the gate block or upper part of the press admits of such wide variations that no set rule or plan will meet all cases, and it is best to draw upon your inventive faculties to meet each special case, being guided by the style of press you must use. A suggestion is to fit most small punches with taper shanks in carefully reamed holes.

In laying out the punch, you can either mark the outline by scratching around the inside of the die, or make use of the template, being careful to reverse the pattern, that is, mark around its edge from the opposite side from which you scratched the die. Do not forget to copper the face of your punch.

In roughing out the punch, drill, shape or mill every part of the work which you can get at in that way. Your work will look neater and you will be able to save time. *Do not attempt to file the punch so that it will fit the die,* but proceed in the following manner:

As soon as you have the punch roughed out, outline by beveling the edge the same as in the case of the die, only bevel off just a trifle inside of the line, just sufficient so that the punch will enter into the die. Now to get an exact outline, it is only necessary to squeeze the punch slightly into the die. If the die is small you may do this in the vise, or if too large for the vise use the press itself, or you may provide yourself with a screw press, which is by far the best method. The distance which you may force the punch into the die will depend on the close way in which you have worked in roughing out the punch. Use plenty of good lard oil in "proving" all work, this being the term applied to this operation.

After carefully driving the punch out of the die, you may with suitably-ground cold chisels chip the stock away in advance of the cut which the die has made, re-proving the work from time to time, and the result will be a punch and die which will be an absolute fit, and will cut any material whatever without so much as the semblance of a burr. To bring the punch up to a cutting edge, it will be necessary to face or grind it off on the end as a last operation.

The previous instructions in relation to hardening will hold good in these kinds of dies. Do not temper the punch if you can make it keep its edge without it. For very thick stock in steel or iron the shrink and consequent loose fit of the punch will do no harm. Also bear in mind the shear when needed.

There is one fixture which is used and known by very few makers of presses. That is "the check or stop finger," which will enable you to utilize every stroke of the press, no matter how fast it runs. This attachment consists of a steel finger attached to a rock shaft across the back of the press, and arranged to be lifted up slightly just as the gate or head finishes its stroke. In operation the end of the finger is adjusted to catch in the edge of the hole made by the last cut in such a manner as to allow for just the right amount of waste between the cuts. As the punch rises the metal is fed forward, and the finger "checks" or stops the metal at the right point for the next stroke. A single trial will demonstrate the great usefulness of this handy fixture. Even with the roller feed this feature is indispensable in producing good work.

As all work buckles or dishes somewhat in cutting, if you desire the pieces flat, they may be flattened by means of a flatter tool, which is nothing but two pieces of steel of suitable size worked together in any kind of press. For small or thin work you may use a foot press, for medium thick pieces a crank press, and for heavy work the drop, or its more modern substitute, the toggle coining or embossing press.

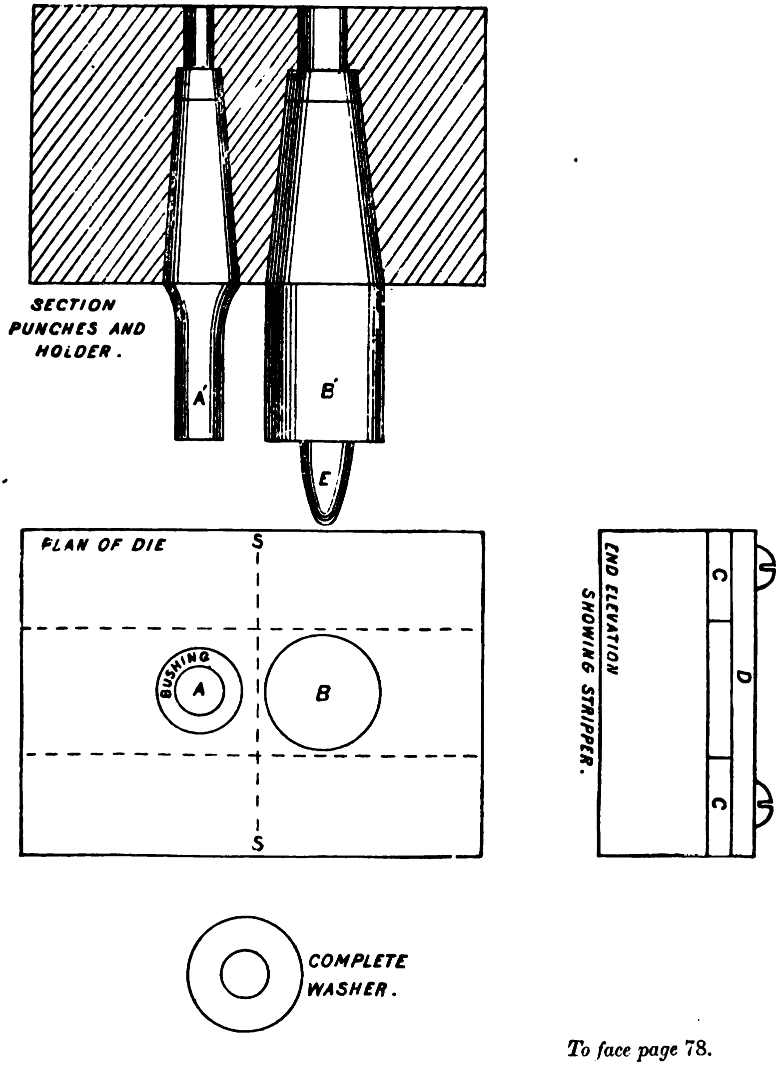
Up to the present part of this subject only plain pieces, having no holes, bends, or other variations, have been described. Some work must have holes punched in it, or as it is called, be *pierced.* It may also be bent to various forms, or have some portion drawn out to special shapes. Of course all this work may be executed one feature at a time, which for small quantities would be all right, but for any great quantity of work, where the cost price must necessarily be close, it becomes necessary to perform all the work possible at one stroke of the press. Three methods are employed to accomplish this, and they may be used either singly or in combination. They consist of the progressive die, the compound die, and the combination die. The most simple form of progressive die is used for making washers, and may be arranged to cut a single row, or be compounded to as many rows as the machine will carry. Except for the purpose above stated, this form of tool is but little known outside of a few shops, and is one of the tools which originated and was borrowed from the old Swiss watch makers.

In order to thoroughly explain the modifications of this tool, it will be necessary to begin with the washer die, and finish up with a die which will make several pieces, some of them having several holes, bends or other work, all executed at one single stroke of the machine.

In the illustration, Fig. 80, note that the small hole, *A*, in the die is bushed, and for large washers it would be well to bush the large hole, *B*, also. Such dies should be fitted with stripper plate as shown, so that the strip of metal or stock will travel squarely over the die. The punch, *B′*, must have a finder pin or guide, *E*, and in making the die always fit the large punch first and prove in, or shear the small punch afterwards. A hole, *x*, in the stripper plate for the reception of the check or stop finger, will enable the press to run continuously.

PLATE XXXIII.

FIG. 80



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In operation the die is used as follows: Push the strip of stock in as shown by the arrow, or from left to right in this instance, till the end of it reaches the line *s s*. Allow the press to make one stroke, when you will have a hole the size of the small punch. Next push the strip still farther forward till it reaches the stop or check finger, when, on making another stroke of the machine, you will punch out a complete washer, and at the same time punch another hole for the next washer. By drawing the stock along and running the press continuously, you may continue to make washers as long as the strip of stock lasts, when you may begin as before. By means of the check finger and finder pin on the end of the large punch, your stock will be fed the right length and the hole will come central. By making the finder pin long and tapering it will work the best, but if too tight in the hole it will cause the pieces to dish. It will be plainly understood that it is not necessary to confine yourself to round pieces, nor does the hole necessarily have to be in the center of the work. Also you may pierce or punch more than one hole, and in the next instructions will be shown a die which performs several different operations, all of which are based on the simple die just described.

For the manufacture of washers of large size in quantity, horizontal presses of special design, with automatic feed, knock out, and stripping head, are very economical in the cost of the work produced, as one operator attends to several presses.

For lubricating all kinds of cutting dies use the following rule: For iron, copper, steel and German silver use a thin film of lard or sperm oil. For brass or other soft metals, soap water, which can be applied by means of a reel running in a box or tank containing the fluid mixture, winding the scrap or refuse piece on another reel upon the opposite side of the machine. Where the roller feed is used it is also best to use the check finger, also setting the rolls so that they will slip when the check catches the edge of the hole. In laying out all kinds of progressive dies do not forget to allow for scrap between the cuts. This necessitates having the center of holes, *A B*, Fig. 80, in the washer die a little more than the diameter of the hole, *B*, apart.

In the accompanying illustration, Fig. 81, of a progressive die, use has been made of a very complicated piece so that the possibilities of this tool may be thoroughly understood. In the drawing of the sample to be made, several difficult features present themselves. First, the edge of the piece at *A* is turned or bent at right angles to the rest of the plate, and there is also at *E* a conical projection or flanged out hole.

By the ordinary methods not less than four, and possibly six, operations would be required to finish such pieces. We shall, however, show how it may be accomplished at one operation.

As the tool-maker has already received instructions covering the machine work on such dies, only the method need be explained, taking for the purpose a plan of the die and a side view of the punch head, with the

PLATE XXXIV.

FIG. 81.

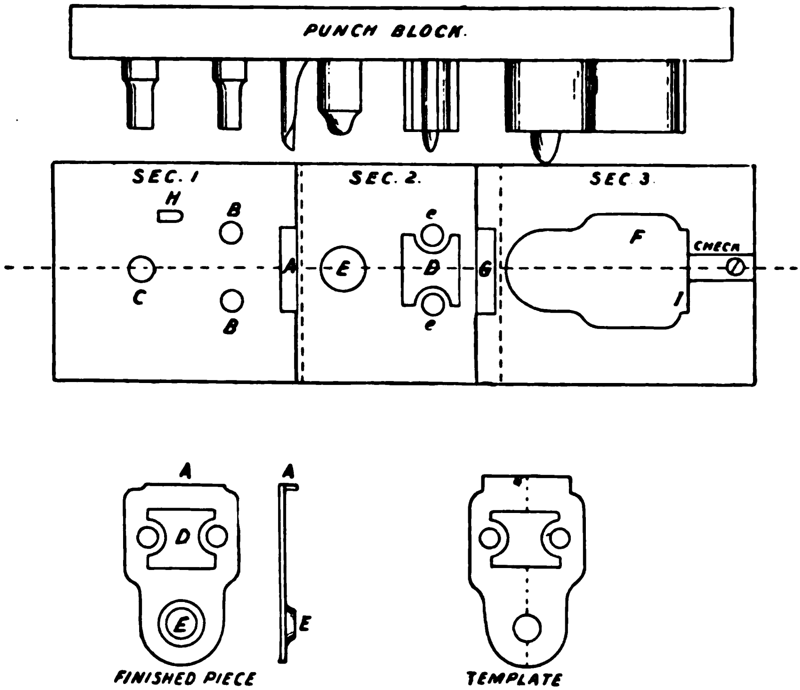
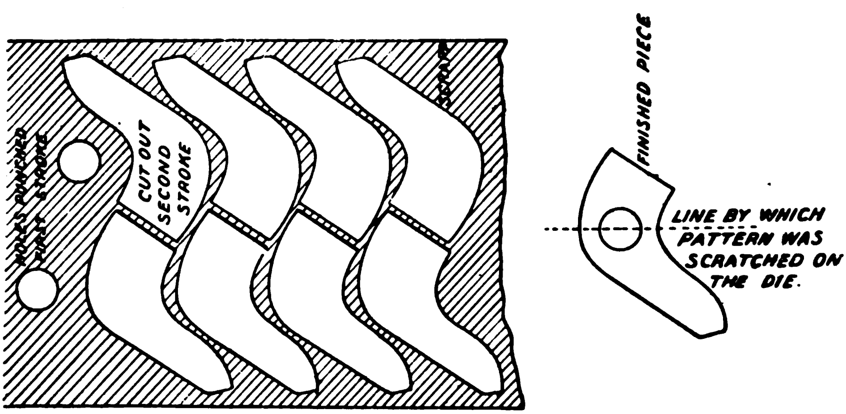


FIG. 82.



To face page 80.

various punches and tools in relative position. In making a pattern for such a die, it will always be necessary, when there are bent or formed up parts, to make two templates or patterns, one plain or flat and one with the bends or other work all finished.

For convenience in describing the face of the die, it has been divided into three sections by two dotted lines.

The tool is operated in the following manner: Push the stock from left to right till it reaches the first line between sections 1 and 2. Allow the press to make one stroke. The result will be that the holes, *B*, *B*, *C*, will be punched out, and the part with one rounded edge which works in the slot, *A*, will cut and bend the flange or bent part of the pattern at *A*. Next push the stock along till it reaches the next line, between the sections 2 and 3, when, on allowing the press to make another stroke, the large hole in the pattern at *D* will be punched or pierced out, and the flanging punch, *E'*, will turn down the flange into the hole *E*. In order that all this part of the operation may be central and true, there are provided two finder or guide pins which work down into the die at *C C*, and through the holes previously punched by the punches and dies, *B B*. During the second operation all the work which was accomplished by the first stroke of the press will be repeated on a new portion of the strip of stock, brought in position by advancing the strip over the second section of the die. On moving the strip forward for the third time, the first two operations will be repeated and the

6

finished piece will be blanked out through the die, *F*. Note that the stop is here placed after the die, *F*, but may be placed to good advantage between sections one and three, punching for the purpose an index hole shown at *H*, which is punched or pierced in waste material. Considerable space must be allowed between the top of the die and the under side of the stripper plate, to enable the flange, *A*, and conical projection, *E*, to be lifted out of their dies as the piece is fed forward. No springs will be needed for the purpose, as the punches, *B*, *B*, *C*, will pull up strong enough for the successful operation of the die. It is also well if possible to make each section of such dies a separate piece of steel, and to bush all the small holes. Bear in mind the necessity of fitting the large punch first and the small ones afterwards. It is also well on such long strings of tools to fit the two end punches first and afterwards shear or prove in the center ones, working from each end alternately towards the center. There should be a hole in the die at *G*, and the blanking out die should be relieved away at *I*, that the turned down or flanged piece may slip easily into place. It would also be well to have a finder pin in the large punch, where it will center the piece by fitting into the flanged hole, *E*.

Special presses are constructed for this class of work, having long openings in the bed, and four, or even five, sets of tools may be arranged to act progressively on one piece. In laying out the above die, use must be made of the flat template. First scratch a line across the center of the pattern in a direction which would correspond with the long way of the strip of stock, or on a line with its movement from section 1 to section 3 of the die. Next scratch a line over the center of the dies while they are keyed in position in the block or holder. Next place the template on section one, being careful to have the line on the pattern coincide with the line on the face of the dies, and taking care to make the outside lines one-half of the width of the scrap between each cut, inside of the line or division, between sections 1 and 2. For the purpose of properly laying out the work, it is necessary to mark around the outside of the template, whenever you lay out any of the work, or you may have trouble in spacing off the proper distance for laying out the dies in section 2. In moving forward the template to scratch the lines of the dies in section 2, move the pattern forward the width of the pattern at the point and in the direction of the line across its face, and enough more to allow for the scrap between the cuts. Note the foregoing carefully, or your die may not jibe when you come to use it. Proceed in scratching the second section just the same as in the first instance, being cautious to keep the lines on the pattern and on the die exactly opposite, and to scratch outside the template as before. Proceed with the third as in both of the first two instances, extra pains being taken to space or move the template exactly the same distance forward as you did between 1 and 2. Note in this die, or any other having a bending or forming tool, that the punch *A* is rounded off on the left side, and that room for stock must be allowed between the rounded corner and left side of corresponding die. This form of cutting and bending punch should be of good length to form the bend good and square. You may also have to make a test piece to get the hole *C* the proper size to flange out the projection *E* to the correct height. In order to save stock, irregular pieces may be turned at an angle, or may be even cut from both edges of the strip, the accompanying cut, Fig. 82, showing such a piece and its position as cut out of the strip of metal or other material. By the use of progressive dies you will, from the above description, be able to make many very difficult pieces, and you are not confined to two or three sets of tools, but, if required, may make four, five, or even more sets as desired. By a little thought, you will perceive the possibility of making several different shaped and sized pieces, bending, piercing, or embossing any or all of the pieces as desired. The author once made all the parts of a small clock frame, with wheels, lever, etc., at one single operation. This latter suggestion will enable you to work your stock very close, and also very fast. In laying out such dies, pierce all the small holes first, then the next larger holes or pierced pieces, and so on till you have them all completed, stringing out your sets of tools in as many sections as desired.

Another form of progressive die is called a parting die, and may be used for such work as shown in the illustration, Fig. 83, piercing a hole in each end of the piece and making the bend and side cuts as shown.

Fig. 83.

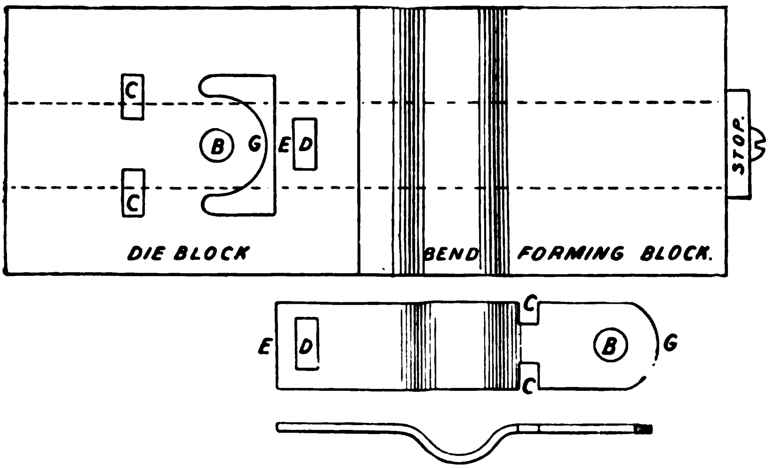
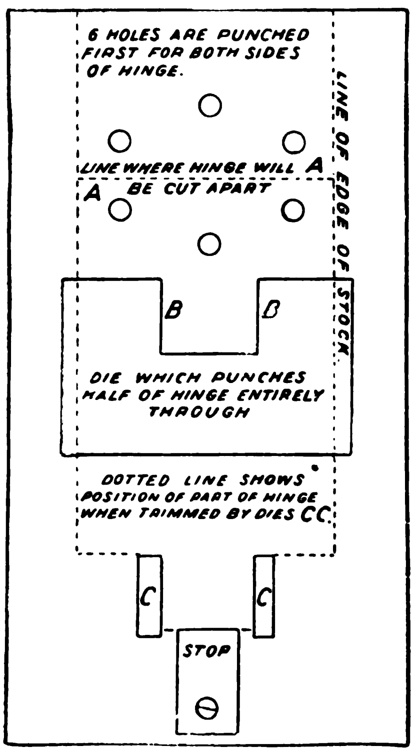


Fig. 84.



To face page 84.

The object of such a die is to make such pieces as can be easily cut up from stock which has been previously stripped up to the proper width. The two dotted lines show the position of the stock when over the die. The novel feature of this die consists in the fact that the piece is not cut out entire, but is parted or cut in two by a die having the outlines of the two ends of the piece, punching the two holes, *B D*, and cutting the notches, *C C*, at the same stroke.

The operation of the tool is as follows: Supposing the stock to be fed from left to right, the first cut would cut off the end *G*, punch the hole *B*, and the notches *C C*. The next operation will consist in pushing the piece against the stop, when on making a second stroke with the press you will cut off, or rather cut the strip in two, punching the holes, *B D*, cutting the notches, *C C*, and forming the bend, *F*, thus after the first stroke making a complete piece, bend and all, at each revolution of the press. This style of die can be applied to many uses for cutting up strips of any material, one of its best features being its cheapness and also its comparatively small size in proportion to the length of the pieces it will produce. Such dies may be kept in stock for rounding the ends of bars, or bands, and punching holes in one or both ends at the same time, setting the gauge to the length of piece desired. For making hinges or butts the parting die should always be used, as there will be no waste of stock except the holes and the butt ends at each end of the strip of stock. As the fit would be too tight if the hinge were put together as left by the cutting of the tool at *B*, a re-trimming die, Fig. 84, will have to be added to broach or trim out the end at *C.* Note that all the holes are punched out at the first operation and that the parting of the piece at *A* makes both sides of the hinge at one stroke, without waste of stock.

The author is aware that many who read this part of the work relative to cutting dies of various forms, will not be able to comprehend all the details at the first attempt. A proper solution of such trouble would be to sketch each separate example, and then arrange some modification from plans of your own. It has been the aim to show the method rather than the detail, as most tool makers have the skill to execute if they have the plan to work from, only lacking, in most instances, experience, and an opportunity to try.

Compound Dies.—Compound dies are so constructed as to make several pieces at one operation, usually all alike. A simple form of such a tool would consist of making the washer die, previously described, to cut several rows of washers at one time or out of one strip of metal. This method not only cheapens the labor cost, but also lessens the amount of scrap, and serves to produce a great number of pieces from one machine.

Combination dies are designed for the purpose of producing work of various forms at one motion—the object being reached by having parts of the die provided with springs that they may slide in and out, or follow the stock while being formed up, flanged out, or pierced.

In the accompanying illustration, Fig. 85, the sample shows a top to a patent dredge box, and the die shown will cut out the blank, make the triangular holes, the small hole in the center, and emboss or stamp the name around the edge and center as shown.

The operation consists in cutting the circle out where the punch and die come together at *J J.* As the punch comes down, the ring, *I, I,* held up by the springs, *H, H,* will hold the piece flat, while the inner part, or die block of the lower die, will push or draw the cup or top up into the upper part turning or drawing the rim. As soon as the piece is completely formed, the punches, *E, D, E,* will pierce the holes, and afterwards the steel embossing stamps will emboss or strike up the letters as shown. The piece after being finished will be forced out of the upper die by the stripper *F,* which should be provided with springs for the purpose. Some makes of presses have a knock-out working in the gate or ram of the press, and intended for special use in working combination dies.

The details of making such a die are similar to the work previously described. Harden and grind every part of this die to size, being careful not to have the punches and dies too hard. Make up out of as many pieces as convenient, which will enable you to repair any broken part at small expense.

You will not be limited to round work with this form of die but may adapt the tool to many similar uses, especially in hollow ware work of tin or copper. If you have much of this kind of work to do, provide yourself with a press that can be inclined backwards, Fig. 86, which will cause the finished piece to drop out of the way and slide into a box placed back of the press. Extra care should be taken to set the die in the machine, working the press around carefully by hand a few times till everything is all right.

Where there is much work of this kind to do, it can be executed cheaper, both as to cost of tools and product, by means of a special double-acting press, Fig. 87, which permits of a wide range of production, both as to form and quantity. The dies for such a press require few springs, from the fact that there are two heads operated by separate crank and cams.

In setting all kinds of dies, always fasten the upper tool or punch first, then enter the punch into the die by hand, and bring the punch down carefully and while the lower part or die is loose, taking due precaution that the punch remains in the die during the whole operation. The last thing is to bolt or fasten the die block down firmly, taking care that it does not spring in the operation. When cutting dies get dull or chip off, and make bad work, they may be sharpened—the tempered dies and punches by grinding off the face of the die and punch, and where the punch is soft and the die hard, you may upset and shear, or prove in as previously described. For large dies with soft punches, a special upsetting L-shaped drift or swageing bar may be put up through the die from below, and the bad spots touched

PLATE XXXVI.

Fig. 85.

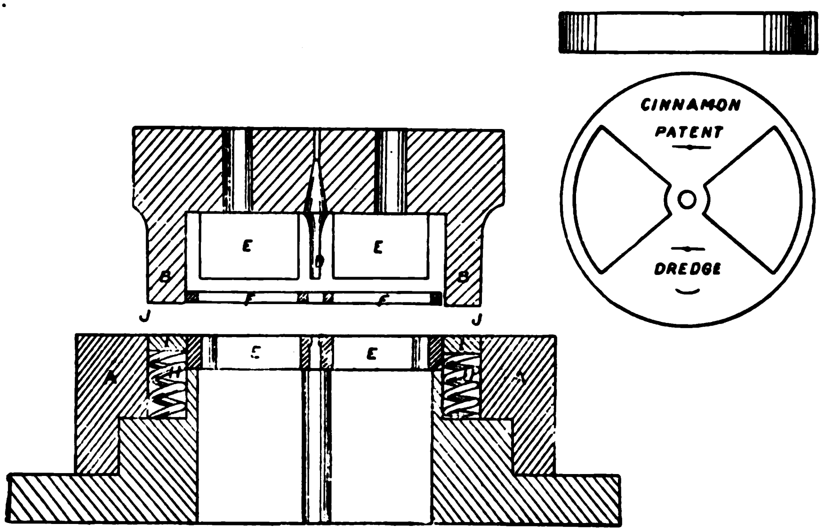
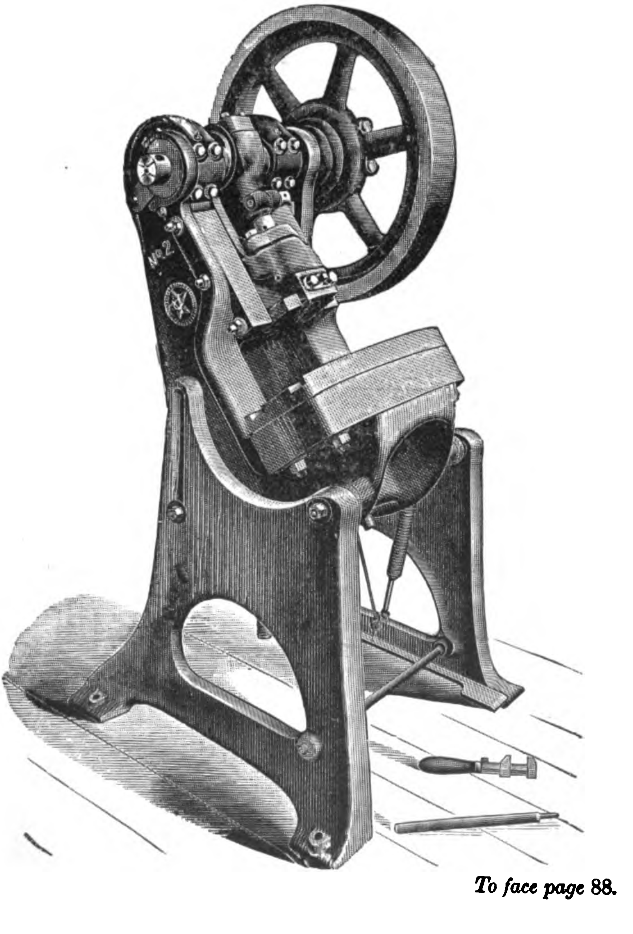


Fig. 86.



To face page 88.

up and sheared in without removing the punch from the press.

All that has been said in the foregoing pages is plainly applicable to the drop press, especially such dies as are intended for heavy bending or embossed work. It is an excellent plan to fasten a spring stripper on the drop head, to strip the work from the punch, and also to act as a cushion to take the shock of the drop. All embossed work such as medals, coins, badges, etc., have been heretofore produced by the drop hammer, but a better way is to follow the plan used in the mints, and use presses arranged like a rivet header with crank and toggle joint (see Embossing and Metal Work). The advantages of this plan are the longer life of the die and consequent uniformity of the production. Parting dies which are in combination with bending, forming or swaging tools, can be handled nicely in the drop hammer, care being taken to see that the head fits tightly between the ways. It may happen that the head will not fit snugly without lifting too hard. This trouble may be overcome by packing up the foot of the uprights so that they will be a trifle open at the upper end, causing the drop head to fit tight just as it strikes the die. Extra caution must always be exercised in seeing that the ram or gate of all presses fit snugly, and are positively without side motion. On fine work, where the dies fit the punches very close, the slightest movement out of true will shear the punch or die, and ruin it for nice work. Some presses have altogether too short bearing surfaces, and in selecting such tools look well to this feature, and see that the sliding surfaces are long and true, and that all other bearings are ample in size and provided with removable bearings perfectly adjustable for wear. The clutch movement should be carefully considered, and should in all cases be easily removable without taking off the wheel. Reject any cutting or punch press intended for quick work which does not have a brake on the shaft, as checking the head by keeping the slide tight will cause the latter to heat up and become destroyed, ruining the press for accurate work.

PLATE XXXVII.

FIG. 87

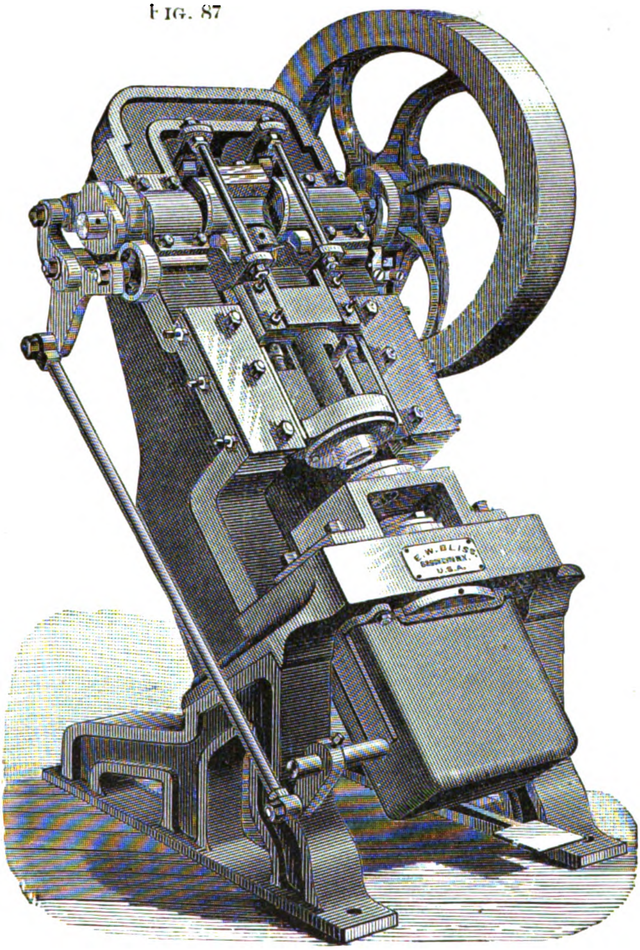


FIG. 88.

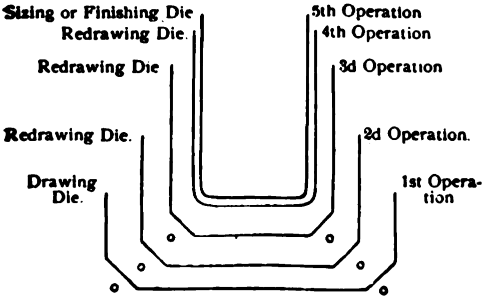


FIG. 88

To face page 90.

CHAPTER IX.

TOOLS FOR HOLLOW-WARE.

SUCH a wide variation of work comes under this head, that to handle the question exhaustively would alone require several volumes. Some general instructions, however, will enable the tool-maker to make the tools and fixtures on general principles established by a few examples taken from the average of work coming under this head.

Round cylindrical articles. Drawn at several operations. The first operation shell is drawn with "outside" blank-holders, but all the others with "inside" blank-holders, which hold the partly finished article at its lower beveled edge "0," Fig. 88, while the punch draws it into a deeper shape of less diameter. These drawing and redrawing dies are mostly made of a special grade of cast iron treated in such a manner as to give a very dense and uniform texture to the metal at the working surfaces. Sometimes, however, steel rings are set into the dies, and the blank-holders made of steel castings, which adds considerably to the durability of the tools. For articles which have to be very accurate in diameter, a hard steel "sizing" punch and die are sometimes used after the last drawing operation.

For leveling up rings, flat dies, and any hardened piece which must be parallel, note the small and convenient grinder illustrated in Fig. 89. Mention has been made several times of this tool, which is almost a necessity where presses and dies are in use.

For straight or slightly tapered bodies of all kinds of utensils, such as tea kettles, pans, skillets, cups, etc., the work may be pulled up on the special toggle presses designed to meet such demands. Two-thirds of the diameter of the work may be turned or drawn up at the side. The parts to a cooker designed to boil farinaceous foods without burning, Figs. 90 and 91, cover nearly the entire range of work, and a full description of each piece, and of the various operations and tools required to produce them, will no doubt enable the workman to get at anything of a similar nature, or even when considerable modification of form may occur.

The utensil is made up of three main parts, water bath, *A*, cooker, *B*, and the cover, *C*. The water bath may be drawn up in the double acting press in one operation, trimmed, and then crimped in at the top with the roller dies, Fig. 92, which will form a supporting rim for the cooker; the corrugations or crimps providing a means for the escape of the steam. It is necessary to crimp this support, because metal which has been drawn, and not afterwards annealed, will not flange either inwards or outwards without splitting in the direction of the draw. In making the corrugations in the die, allow plenty of room for the surplus metal to rise upwards,

PLATE XXXVIII.

FIG. 89.

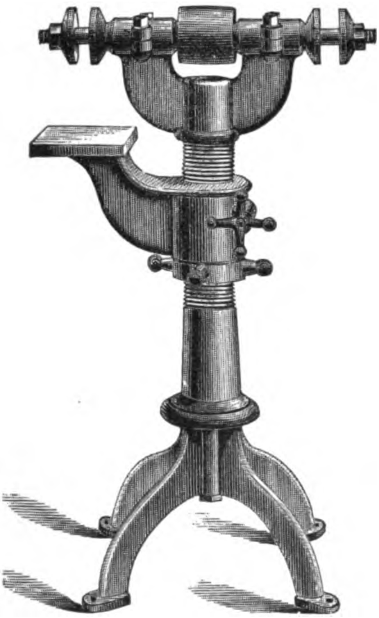


FIG. 90.

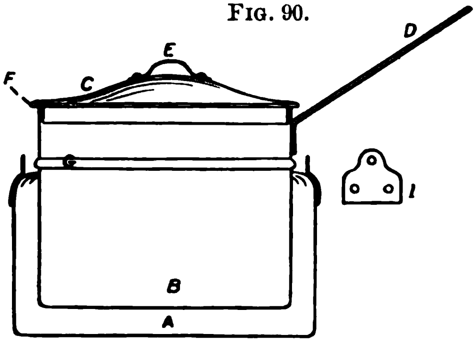


FIG. 91.

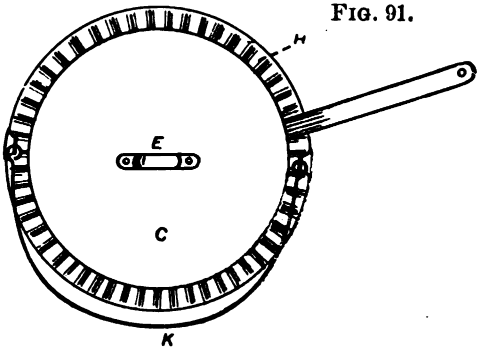
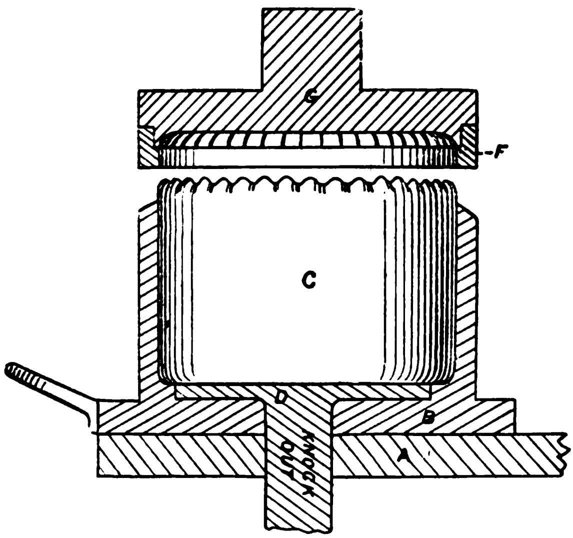


FIG. 92.



To face page 92.

which will prevent the rolling down of the corrugations and the bulging out of the top. As will be noticed, the die is composed of a corrugated head, *G*, with a retaining ring, *F*, shrunk or driven on after the machine work and milling of the corrugations has been finished.

The knee press, Fig. 93, with sliding table and elevating movement to the knee, is specially adapted to this class of work, though the piece may be set direct under the tool in this particular case.

In forming up the part *B*, two draws will be required, first, drawing up the metal as far as it will work at one draw, and further reducing it by a second draw, using a blank holder or hold down. The blank holder is attached to the outer head of the press and operates in the same manner as in drawing from the flat circle of metal, holding the metal flat against the die to prevent it from wrinkling. After trimming the rough edge, the imitation wire or bead may be rolled out with a set of three rolls arranged to swing around a common center, as shown in Fig. 94, the shape of the rolls being also shown in the same drawing. The bead around the center which stops the cooker against the corrugated top of the bath, *A*, may be rolled or spun out with a beading roller from the inside.

A more modern way of wiring is to use a press fitted with dies.

Wiring dies.—The use of dies for wiring pieced tinware has almost entirely superseded the old methods; their work being more uniform and the saving of time and labor great. Dies can be made for either genuine or imitation wires. These dies require to be operated in presses especially adapted to the purpose. From 2,000 to 8,000 pieces can be wired per day, according to size of work and skill of operator, and the work will be more satisfactory than that of a skilled operator with rollers.

In straight-sided work and work but slightly flared, the tin will be turned around and under the wire quite perfectly. In work which is considerably flared, the tin will show a slight wave on the under side of the wire. If this is objectionable, it may be remedied by a turn in the wiring roll, a simple operation which can be performed by a boy or an unskilled workman. An attachment may also be put on the Double Seaming Machine, that will smooth the wire after the bottom has been secured to the body, without extra handling.

There are usually two, and sometimes three, operations in both genuine and imitation wiring, Fig. 94. After trimming, the piece is placed in a die and turned, thus ρ, and with a second die closed up to a complete circle, thus q.

Fig. 95 shows a power wiring and horning press.

To pierce the holes in for the reception of the rivets which hold on the bail luggs, remove the table from the knee press and insert the horn or mandrel upon which dies may be fastened to pierce both holes at one stroke. A similar die will be needed to punch the holes in the side of the cooker for riveting on the handle *D*, Fig. 90. The cover *C* may be either drawn up as a shallow cup

FIG. 93.

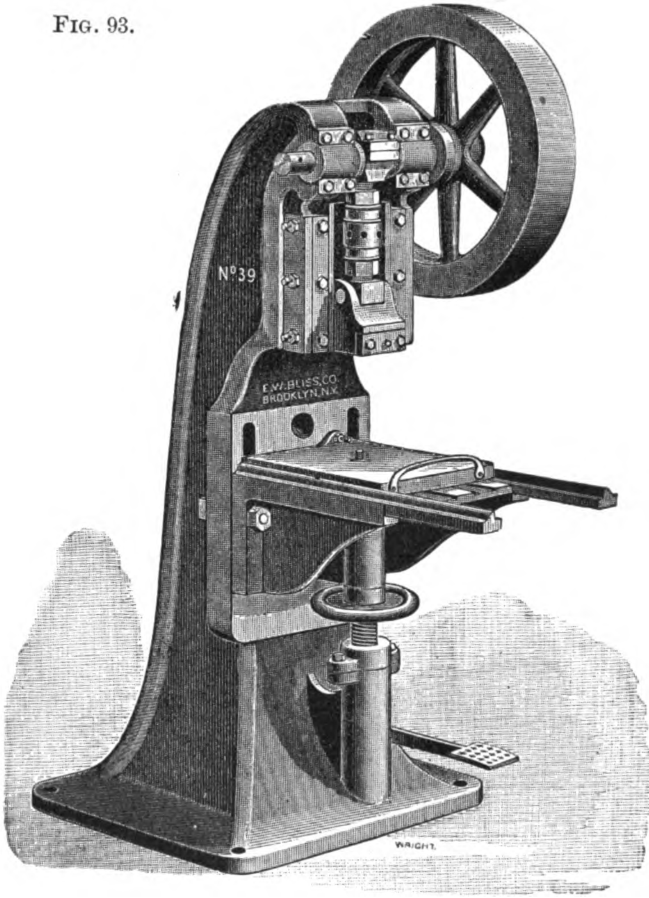
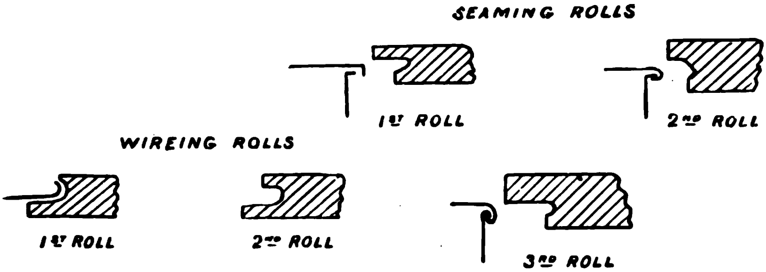


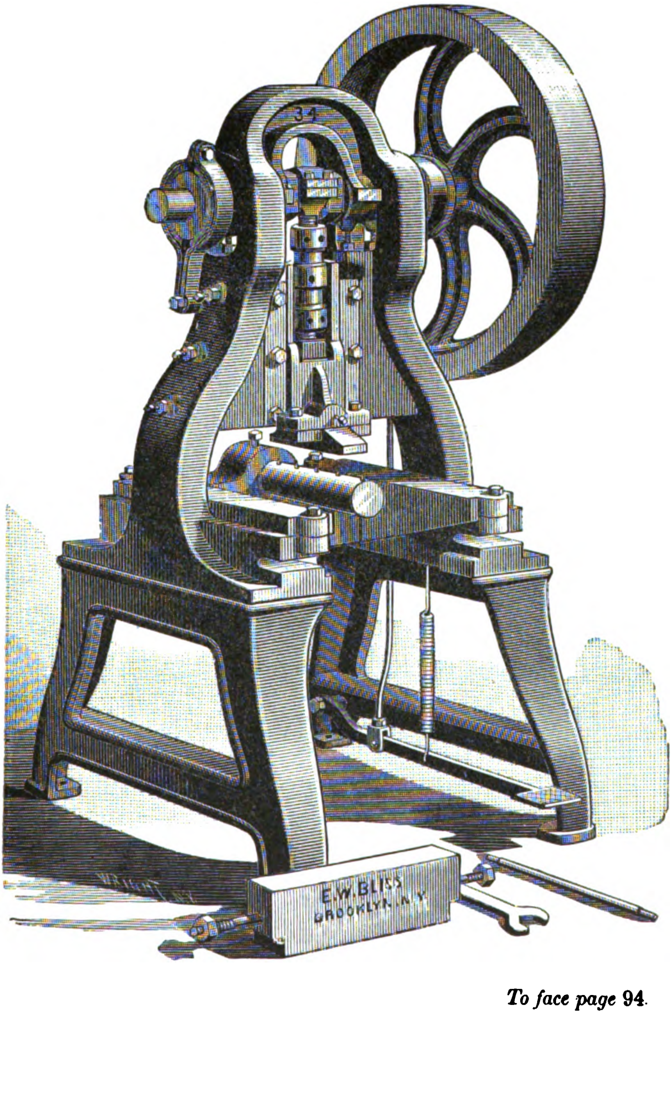
FIG. 94.



To face page **94.**

PLATE XL.

FIG. 95.



To face page **94**.

and afterwards headed to form the flange *F*, or can be drawn, flange and all, in either a single acting press with spring hold down, or in a double acting press.

For forming the cover in one operation, see Fig. 96, the tool works as follows, the cut showing a double acting set of tools: The part *L* is the ordinary cutting and hold down die, as already described. The drawing mandrel *B* has fitted in its end a cap or head held down, or rather pushed out, with a stiff spring inside of the mandrel. A pin passes through at *M* both to keep the head in and prevent it from turning around. The die *A*, Fig. 96, is made sufficiently high to allow of being cut out on the under side, with an opening wide enough to allow the finished cover to fall or be pushed out from between the table, or holder, and the drawing part of the die. A portion of the die *J*, just equal to the width of the rim of the cover, is counter bored just a trifle larger, .008 or .0010, than the drawing part of the die, taking care to have the slight edge between the two diameters square and sharp.

In the lower part of the holder is fitted a knock-out, used in this instance as an up-set. In the outer part of this piece are three or four thin stationary wings, *F*, working in corresponding grooves in *D*. The top or end of *D* at C corresponds to the shape of the top of the cover, and fits the bottom of the drawing mandrel to form the top of the cover.

In operation this die works as follows: After cutting the blank, the punch or mandrel will draw the piece down to a point just beyond *J*. The knock-out should be timed to come against the end of *B* just as it begins to ascend, or rather as *O* begins to ascend, as the spring will hold *B* down till the pin, *M*, strikes and draws it up and out of the cover. The edge of the rim striking against the under side of the die at *J*, will cause *O* to compress *B* and upset the flange tightly into a circular depression, *H*, and when the knock-out, *B*, drops down the tight fit of the flange at *H* will draw the cover out of the die to be ejected by the wings, *F*, and finally, if the press be inclined, fall out at the back. If desired, small punches and dies, *N*, *N*, *O*, *O*, can be inserted to punch the holes for the handle, *E*, the puncheons or pieces falling down through the holes, *P*, *P*, *P*, or a separate die may be made to punch the holes as a separate operation. If the above tool be kept sharp and in order the rim will need no trimming. The handle on the top of the cover, and the handle riveted to the side of the cooker, are examples of parting die work. The dies cutting off the stock, piercing the holes, and making the bends at one operation. The bail lugs on the water bath should be punched out with a progressive die, rounding the end of the blanking punch to correspond to the circular side of the bath.

It should be understood that the cooker and water bath are retinned after being drawn up.

Special bail machines, Fig. 97, are made for forming up the wire bails used, and though expensive, pay for themselves in a short time.

PLATE XLI.

Fig. 96.

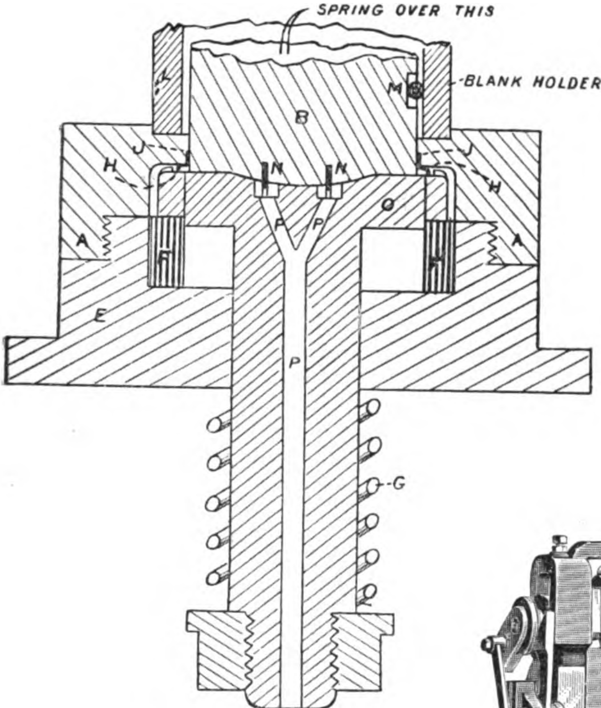
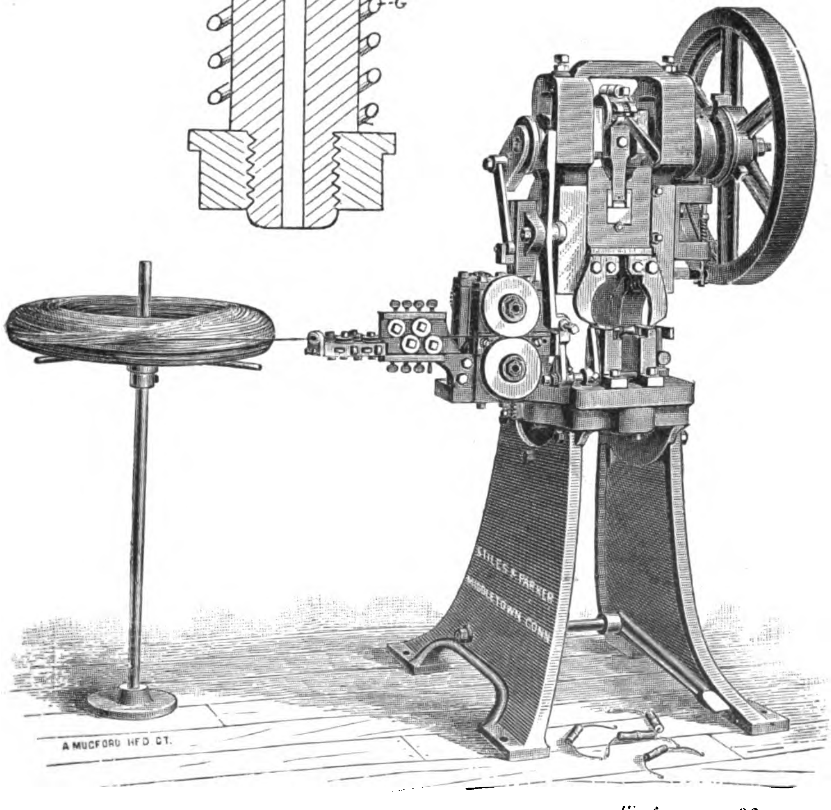


Fig. 96.

Fig. 97.



To face page 96.

Too much care cannot be exercised in the construction of dies for tapered work, such as milk and dish pans, pie and cake tins, skillets, etc. It is usual for a majority of shops to draw such work, tapering as a first operation, and the wrinkled, crimped and awful work produced is something to behold. Drawing in such places is only a misnomer, as the presses only shape up the stuff for the spinner to finish. Even pie tins one inch high are spun, which is an unnecessary waste of time. Drawing consists in pulling a sheet of metal between surfaces equally distant from each other. To form up a piece as large as a dish pan with a taper punch is not drawing. As will be explained, under the head of solid drawn shells, all taper pieces, if desired smooth, must first be drawn straight, and then tapered as a separate operation, being careful to round the end of the drawing punch only to the size of the small part of the taper. If the work is not too tapering, no spinning will be required. Fig. 98 shows a large toggle press, and Fig. 99 a toggle-drawing press.

Large drawn pieces having to be rolled or wired around the top, if made of tin plate, should stop at the point where the wire is inserted, thus leaving the work partly turned or wired. In a double-acting press, the piece will not only be drawn up out of the die, but the flange will cause it to strip off from the punch. It has before been noted that the edges of unannealed pieces are apt to split if bent at any great angle, hence the necessity of flanging pieces of large size which are to be wired.

Combination Dies (Fig. 100) are used in single-action foot or power presses. They cut a blank, and at the same operation turn down its edge and form the article into shape. In most cases the articles thus made are of shallow shapes, their edges ordinarily not over $\frac{3}{16}$ inch deep, as, for instance, can tops and bottoms, pail, bucket and cup bottoms, etc., etc. Quite frequently, however, dies of this class are used for making deeper articles, such as blacking, lard, salve, and other covers up to $\frac{5}{8}$ inch deep, or for cutting and forming burner and gas-fixture parts, toys, etc., up to 1 inch deep or more. Suggestions concerning a large variety of shapes and styles of work such as can be done in combination dies, will be found on the following pages. Most combination dies are so arranged that the finished article is automatically pushed out from the dies by the action of springs. With a press set on an incline, the finished work will therefore slide back by gravity, effecting a considerable saving in labor and greatly increasing the speed of production. An expert operator, with a medium size combination die in a power press, will produce from 15,000 to 17,000 pieces per day of ten hours.

The cutting and working parts should be of the best cast steel, welded to wrought iron, thus making them solid, and consequently more durable than dies made partly of cast iron and in separate pieces.

The Fruit Can Combination Die, with removable centre punch, is now quite generally used, and with the most satisfactory results. It is simple, saves expense and

PLATE XLII.

Fig. 98.

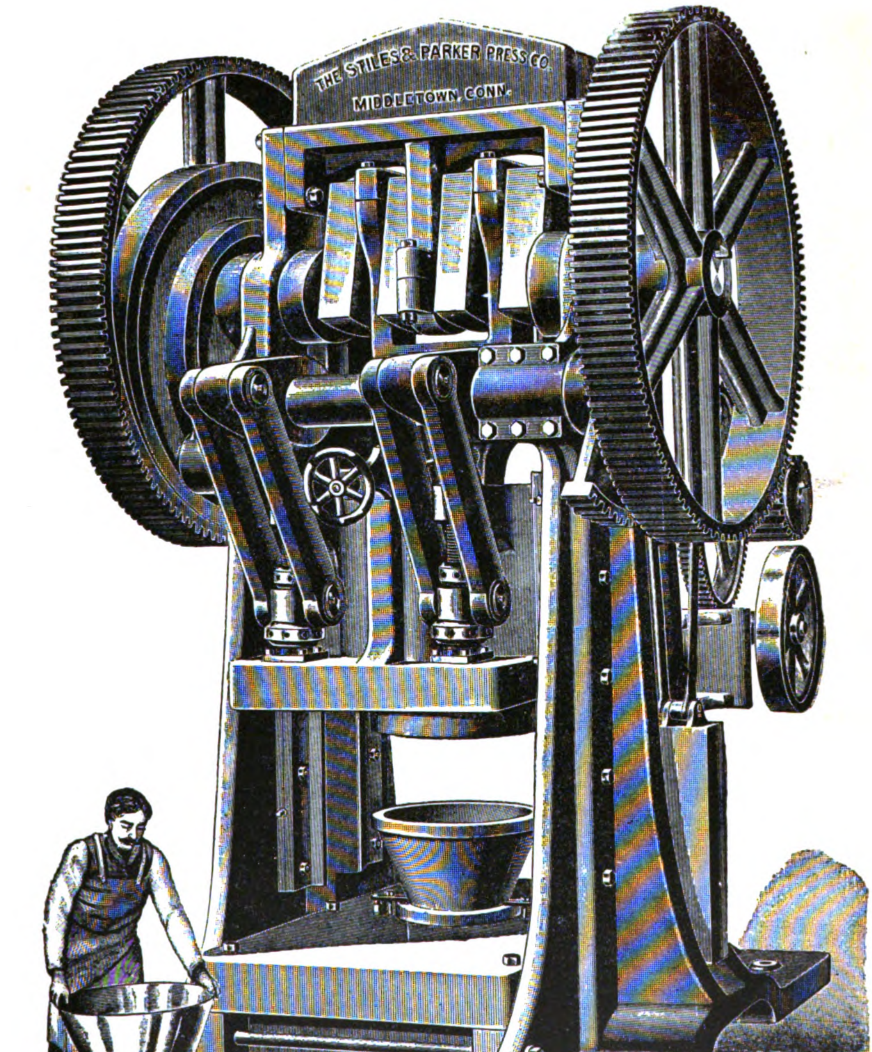


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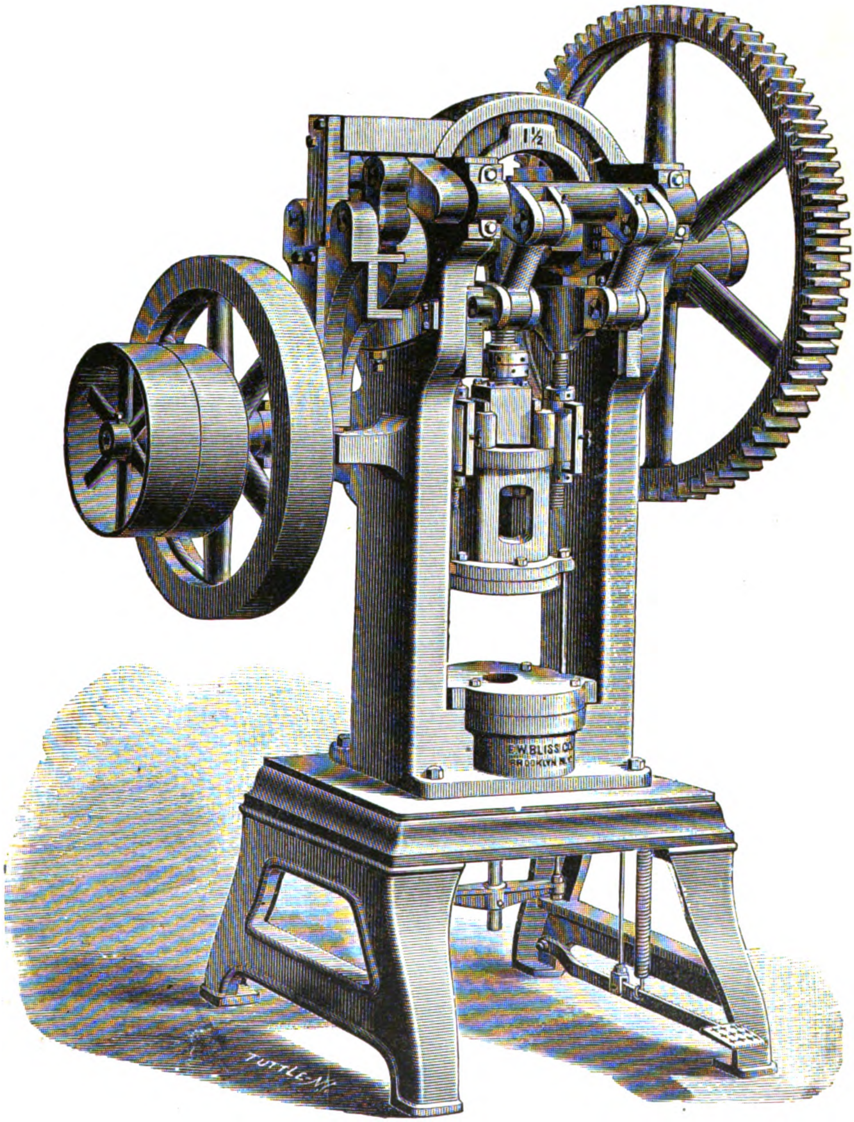
PLATE XLIII.

Fig. 99.



To face page 98.

the inconvenience of changing dies, as by this arrangement both tops and bottoms can be made with the same die, finishing the tops by one operation, and by simply removing the centre punch (while the die and punch are still in the press) make the bottoms.

The vent punches in the cap dies can be easily removed for sharpening, and are adjustable, so that the vent holes can be made of any desired size.

These dies are generally made entirely without springs when fitted to presses having knock-out attachment in the mandrel of the press which discharges the work from the upper die, and an attachment on the under side of the bed plate which throws it out of the lower die.

Double-action Cutting and Drawing Die. Fig. 101, shows a "Solid bottom" cutting and drawing die. These dies are used in double-action presses. They cut a blank, and at the same stroke of the press "draw" it into shape, the kind and thickness of the metal used determining whether one or several operations are required to obtain the desired depth and shape. The nature of the shaping process, which is known as "drawing," will be understood from the annexed sectional views of cutting and drawing dies.

The lower die *A* is fastened to the bed of the press, while the combined cutting punch and blank-holder *B* is worked by the outer slide, and moves slightly in advance of the drawing-punch *C*, which is actuated by the inner slide. The outer slide of double-action presses is so arranged that, after making its stroke, it stops during about one-quarter of the revolution of the crank shaft. The blank having been cut from the sheet by the cutting edges of *A* and *B*, drops into the lower dies, and is there held between the annular pressure surfaces *O* and *P* during the down "dwell" of the outer slide. While the blank is thus held under a pressure which can be regulated to suit the special requirements of each case, the drawing-punch *C* continues its downward movement, thus drawing the metals from between the pressing surfaces into the shape required. In this manner the metal is prevented from "wrinkling." Where a counter pressure in the lower die is required, dies of the kind shown in Fig. 101 are used. These have, in addition to the lower die, blank-holder, and drawing-punch, what is known as a "push-out plate," *D*. This plate rises at the same time as the blank-holder, *B*, thus lifting the finished article from out the lower die.

Forcing dies are commonly employed under the drop-hammer to shape up such pieces as have raised ornamentations, and consist of a cast iron or brass die with a lead force cast into it by filling the die with melted metal of various compositions. The lower die or mould is first either carved or modeled as to the pattern, and after casting is fitted to the drop and the mould or die carefully scraped smooth. A head provided with a wrought-iron dove-tail or key being fastened into the drop, the mould is filled with the melted metal and the head let down into it. Giving the die light taps with a hammer will have a tendency to work the air out of the force and

PLATE XLIV.

FIG. 100.

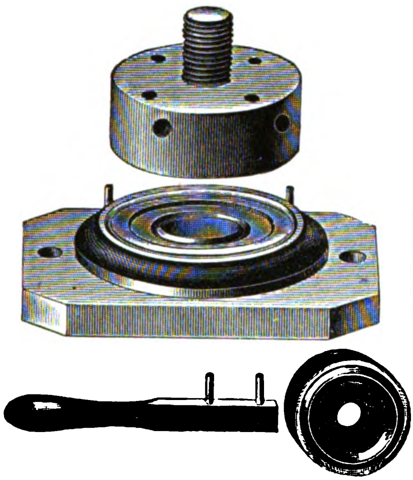


FIG. 100.

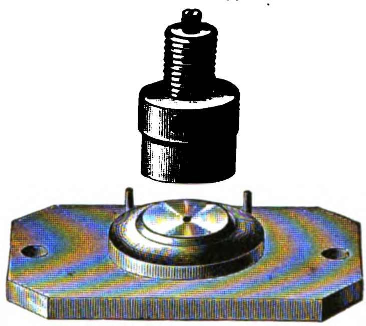


FIG. 101.

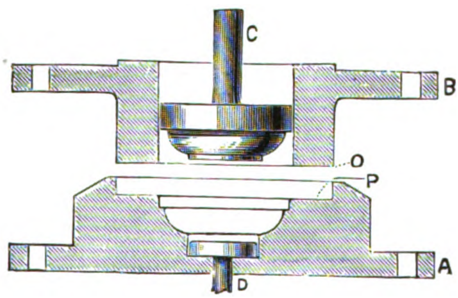
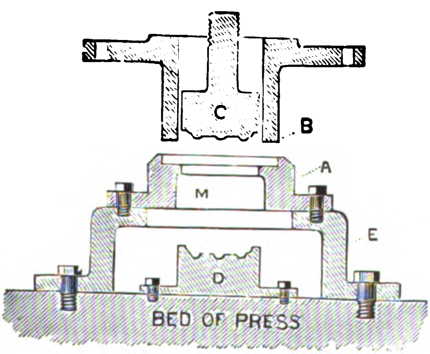


FIG. 102.



To face page 100.

make a smoother job. Smoking the die with a little burning rosin will also make the metal run into all the openings.

As soon as the metal has "set," raise the head and allow to cool. After the metal has cooled, work in your force by allowing it to make a few hard blows in the empty mold, and then draw or drop a piece of metal somewhat thinner than the stock to be used. Repeat this operation several times, and then substitute the regular stock, and the force is ready to use. The composition of force metal for drop work consists of three parts tin, 3 parts lead, 1 of antimony and 2 of zinc.

Cutting dies consist of a "male" die or "punch," and the lower, or "female" die. They can be made in almost any size and shape for cutting out flat blanks in tin, brass, copper, zinc, silver, paper, leather, cloth, etc. Ordinarily, the lower die is hardened and tempered to a degree best suited for the work, while the punch is left comparatively soft, so that it can be "hammered" up, when worn. Sometimes, as in the case of playing-card dies, it is preferable to reverse this and make the punch hard, leaving the die soft. Circumstances determine whether any, or how much shear shall be given to the cutting edge. For ordinary work in tin, brass, etc., a moderate amount of shear is desirable. Ordinarily, the steel cutting rings are welded to wrought-iron plates, after which they are hardened, carefully tempered, and ground on special machinery. In some cases it is preferable to fasten the steel dies in cast-iron chucks or die-beds by means of keys or screws. This applies more particularly to small dies. For cutting thick iron, steel, brass, and other heavy metals, both the die and punch should be hard, and provided with strippers.

Triple-Action Drawing Dies.—These dies, Fig. 102, are used in presses intended as cutting, drawing and stamping presses. They are frequenly used instead of the solid bottom double-action dies. Like these, they cut, draw and stamp at one operation, but they deliver the finished article below the die, instead of pushing it up, enabling the operator to feed continuously, instead of waiting for each piece to come up, before the next one can be cut. Their construction will be understood from the sectional view, Fig. 102, in which *A* (set on a raised bolster, *E*,) represents the cutting and drawing die; *B*, the blank-holder and cutting punch; *C*, the drawing and embossing punch, and *D*, the embossing die, which corresponds in its action to the solid bottom in double-action dies. After the article is cut and drawn by the action of *A*, *B*, *C*, the punch, *C*, continues to advance and carries the drawn article down until its lower surface meets the embossing die, *D*, where it receives the required impression of beads, fancy designs, or lettering, etc. On the up-stroke of the punch the finished article is stripped from it by the edge, *M*, and the press being set on an incline, the work slides back by gravity beneath the raised bolster, *E*, into a box placed behind the press. In this manner, embossed drawn articles can be produced as rapidly as ordinary plain covers in push-through dies. Triple-action dies are especially adapted for blacking-box, lard-pail, baking-powder, biscuit-tin and other covers, as also for seamless sardine boxes, some burner work, etc.

CHAPTER X.

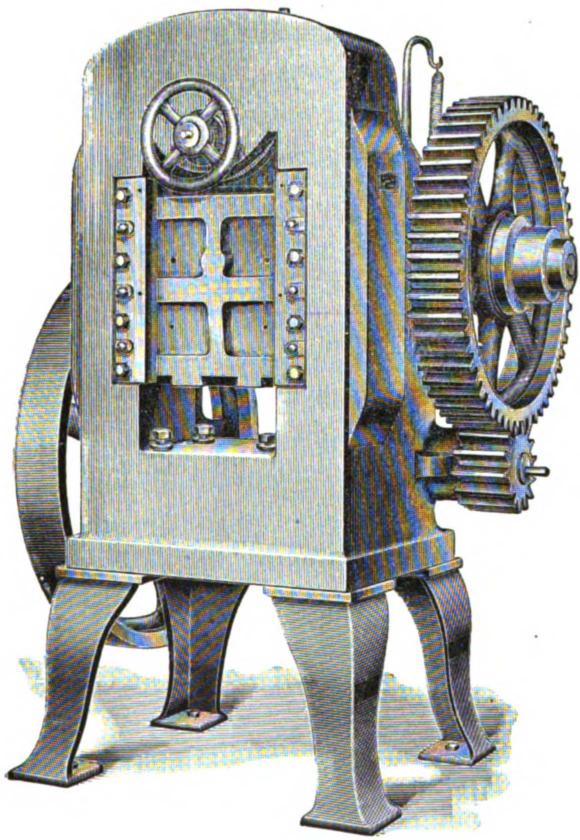
EMBOSSING: MEDAL, COIN AND STAMPED SHEET METAL ORNAMENTS.

To cut or engrave steel dies for raising or sinking the steel dies required for embossing is a separate art or trade by itself, requiring a natural adaptability, to say nothing of the artistic features. The ornamental bands around circular medals, badges, or coins are usually knurled, a raised or depressed ring being turned for the purpose. The medallion portion is first sketched or drawn on the leveled surface, which has previously been either coppered, or coated with a thin coat of zinc white thoroughly dried. Next cut away all the outer part to the depth required, exposing a silhouette of the figure, then cut in with small chisels, engravers' and die sinkers' files the coarser details, boldly rounding all such parts as are to appear rounded. The fine details are engraved and chased in as a last operation. Much practice and patience will be required to execute even a creditable looking job, but the two combined will eventually succeed in overcoming the mechanical difficulties, the artistic features being a matter of taste and individual adaptability.

The presses, Fig. 103, constructed for such purposes

PLATE XLV.

FIG. 103



To face page 104

are very heavy and powerful, and are operated by means of a toggle, which arrangement gives a very powerful pressure, without shock or unnecessary strain on the dies. The objection to the use of the drop hammer exists in the tendency to wear off the fine details of the dies, and in the impracticability of getting every stroke exactly of the same force. With the toggle machine very delicate impressions can be obtained, and the adjustment for pressure and effect can be brought to a nicety. Perhaps, as an illustration, the method employed in making coin dies will be an interesting example of how the dies for such work are produced.

In executing or engraving the dies for striking gold, silver, and other coins, the first operation consists in cutting or engraving on the face of a carefully annealed piece of steel an exact reproduction of one side of the coin. Understand, this die is precisely like the work is to look when finished, with the exception of the date, which space is left blank. This piece is then fitted into the press carefully, hardened and drawn to a deep straw color. In the meantime another piece of thoroughly annealed special steel has been fitted into the opposite side of the press, and the end carefully leveled and polished. The next operation consists in putting the two pieces in the press and forcing the hardened die into the end of the soft steel till a perfect impression of every single line and detail appears. This reverse die or mould can now be trimmed up and hardened ready for use. The die for embossing the opposite side of the coin having been made in the same manner, the two dies are inserted in the press and both sides of the coin "struck" at the same time. The date which changes from year to year is stamped in by hand after the impression of the "master" or hand cut die has been made. In making the impression from the master die the press is turned very slowly by hand, and the surfaces kept carefully oiled. This method of making the working dies permits of exact duplication of the worn-out ones, which would be possible in no other way, no workman being skillful enough to cut two dies exactly alike. Nearly all medals or medallions are finished in the same manner, to avoid accidental risks when working the dies.

Spoons, forks, and similar articles are usually embossed under the drop, though there is a growing tendency to use heavy automatic presses, the dies lasting longer and the work being much more uniform.

It is not customary to coin or emboss the dies for such uses, though the method could be employed to advantage.

The automatic features of such presses are very simple and easily kept in order.

Stamped or raised sheet metal work must first be drawn or stamped up, and then trimmed up afterwards. The two operations may, however, be combined into a progressive die, which will stamp and trim at one operation. In making dies for this purpose a lead force will not do good work. Several methods are employed for making these dies. Both may be made of steel, one of steel and one of copper or brass, one of hard bronze and one of soft brass, and for large work, one of cast iron and one of brass.

The making of the steel dies has already been explained. The engraved die and mold forming the thin metal between their surfaces. Some trouble will occur in the tendency of the metal to cut apart wherever perpendicular lines or surfaces occur. Careful engraving and scraping away of the metal where the breaks occur is the only way to avoid such defects.

For very large dies made of steel, it will be found necessary to drop the mould hot, carefully anneal, remove the scale and then re-drop cold. The substitution of a copper or brass mould in the place of the soft steel one will be suitable for thin metal. Bronze or brass dies are first cast from wooden or modeled patterns, and the mould or matrix from a plaster cast of the die, scraped and polished, and then dropped or forced till a clean impression appears. The die should be of hard brass or bronze, and the mould of much softer metal. One feature of importance in all stamping dies is the necessity of routing out or cutting deeper all the depressions of the mould, leaving all the high parts to be carefully smoothed up and polished. This is necessary to prevent marking or injuring the face or right side of the sheet metal. For tin ware and articles with plain or coarse ornamentation and large size, cast iron dies with brass or hard babbitt moulds will answer. When taking the plaster cast from the pattern for the die, you can relieve the plaster mould in the deep places, thus saving much time in routing out the brass mould itself.

When the stamped piece is very deep, or the figures much raised, it will be necessary to provide a hold down and two moulds, one for roughing out and having only a rough outline of the die, and one for finishing, annealing the work between the operations. Excessively deep pieces may require three or even four draws to prevent pulling in two on the high lines. Circular pieces having ornamental borders not too close to the edge, or raised designs in the center, can be blanked out and stamped up in single acting presses with spring hold down, or in double-acting presses in the regular way. It is always best where possible to incline the press for such work, as the finished pieces will fall out naturally. In turning up the shanks of such dies, clamp the die and mould together, and turn or fit as one piece. This method will ensure the faces of the dies coming parallel with each other.

The small indentations on the end of a thimble, cane, whip, and umbrella mountings, are embossed with knurl wheels where the design will permit. Very fine work is hand chased, which is performed by filling the articles with lead and afterwards driving the thin metal into the lead with chasing tools, the latter being small blunt chisels of proper shape to fit the designs or ornaments wanted.

Exact reproductions of chased work can be produced with the water die, a fixture composed of a hinged mould having the decorations cut on the inside, and enclosing the piece to be decorated filled full of water. The mould is placed under a press, and a plunger fitted to the gate or ram, and made to slide closely into the opening, when the confined water will force the metal against the sides of the mould, reproducing an exact copy of the design. Lamp bodies, all kinds of hollow ware, silver and britannia work, are now produced very cheaply in this manner. Very plain figures, swells, etc., can be made by substituting a piece of soft rubber for the water, having the plunger to strike the rubber and force it sideways against the mould.

The press with a sliding table and adjustable knee is best adapted for this work. The patterns for casting the dies from can be either carved in wood, or moulded in plaster or wax. The wood carving is so common as to need no description. Plaster of paris castings when kept wet may be cut almost as easily as cheese, and the method of modeling in plaster consists in forming a rough outline of the work with freshly mixed plaster, which after setting may be cut or carved into the form desired by keeping it wet. Wood and brass tools should be used, as the plaster rusts iron or steel quickly. Some moulders make the first model of clay, from which a plaster or gelatin mould is cast, and then a reproduction of the original model cast from this. The gelatine used is glue dissolved in sufficient hot water to be when cold about the consistency of soft rubber. For preventing the plaster from sticking together, use lard oil thickened with white soap to a stiff paste. Decorations having many fine lines can be best modeled with modelers' wax, composed of two parts bee's wax and one part bayberry wax, colored with dry paint or pigments to suit the fancy. When modeling wax, keep the tools moist with strong soap water to prevent sticking. In finishing up dies for stamping, whether of steel or other metal, do not forget to make liberal use of chasing tools. You can hammer in a chasing chisel where a file or graver will not go.

In making the plaster casts proceed in the following manner: First, as to the plaster. The kind used by masons for plastering walls will not do. Get that which is specially prepared for dentists' use. In mixing, stir the plaster into the water slowly to about the consistency of syrup or molasses. Be careful not to get it too thick. Second, work fast. Pour the plaster over the piece of which you wish to take a cast, from one side, flowing the plaster along the surface from one side to the other. This is for the purpose of preventing small bubbles of air getting locked into the depressions, which would result in small holes when dry. You can also still further ensure the removal of the air by churning the plaster with a small paddle or stick. In a few moments the plaster will set, and immediately afterwards heat. As soon as it is hard enough to resist the pressure of the finger nail, which will be from ten to twenty minutes, according to the grade of plaster, gently rap around the edges between the mould and pattern till they split or separate. Plaster shrinks considerably in drying, and if any length of time ensues between the hardening and separating of the cast and pattern, it will not only stick, but may split apart, or destroy some of the prominent parts of the mould in parting. In patching any defects which occur, wait till the cast has cooled, as the freshly mixed plaster will stick better. In patching, carefully scrape the surface, as the soap and oil mixture used to prevent the sticking of the mould may also prevent the patch from sticking. In making large casts, iron dies for bending, etc., both die and mould can be cast from a carefully prepared fac-simile of the piece to be made, using it as a pattern, and working out the parting between the two dies in just the same manner as a moulder would mould a pattern in sand. For drop dies, you can model a pair of cast iron dies in this way, and drop out the steel ones to the nearly perfect shape required. Much hard chipping, filing and time can be saved in this manner.

CHAPTER XI.

DROP FORGING.

THE drop forging of iron, steel and copper pieces as a more rapid method than hand forging will not only produce large quantities of work, but makes possible shapes which are next to impossible by hand forging. The facilities necessary consist of a blanking and trimming press, suitable furnaces and a drop hammer.

There are two methods of dropping, to blank out, drop and trim, either with combination drop dies having flash edges, or with separate trimming dies, as the nature of the piece will permit. In blanking pieces which are to be dropped afterwards, make a careful study of the piece, and, if you have time, cut the drop die first, hardening and finishing ready for use. Make a wooden pattern just as you think the blank should be, and from it make a lead casting in sand, which you may try as a test piece in the drop hammer. The result will show you if you have made any errors, which you can correct and try again. Once you have one right, cast one for taking the measurements if the die is large, as the lead shrinks some in cooling. For small pieces, however, the wood pattern will answer. For nearly all drop dies, it will be found necessary to "flash" the edges, that is, to provide a narrow edge around the mould of the die. The purpose of this is to cut off the surplus metal which flashes or squeezes out, as well as to reduce the pressure which would occur should this surplus, in the form of a thin flat plate or rim, come between two flat surfaces. It depends much on the shape of the piece as to the form of flash edge. When the die will not be weakened too much, Figs. 104 and 105 show the proper method, which is a combination drop and trimming die. The edge *C* of the upper die, Fig. 104, fits over *C* of the lower die, forming a cut-off for the surplus metal. The upper cutting edge should pass the lower one only far enough to cut off the fin, and where great uniformity of thickness is required, a stop or bunt, the same as at *D*, Fig. 105, will be necessary. This form of die is particularly adapted to dropping pieces which have previously been blanked out, but may also be used on plain work as a tool to blank out and drop at one heat, sometimes using several strokes of the hammer to get a perfect piece. To keep the dies both cool and free from scales, conduct a pipe from the forge blower, and arrange it to blow against the face of the lower die. A very powerful blast will sometimes be needed to keep the die free from small scraps of iron or steel. Much hard werk can be avoided in cutting drop dies by getting out a steel pattern piece, and after fitting the dove tails, heating the dies, and dropping the cold steel pattern between them, thus forming a perfect mould of the piece. In doing this, care must be taken to see that the pattern rests properly be-

8

tween the two dies to prevent bending of the piece. It is generally necessary to partly rough out the dies, and give them a final shaping by the hot method. Some allowance for shrink must be made in dies intended for long or very accurate pieces—the two shrinks, that of the die and of the piece of work when dropped, combined together amounting to about $\frac{1}{16}$ inch per foot. Fig. 105 shows a form of die generally employed in dropping circular pieces that do not have too much relief or projecting parts, the hot steel or iron being dropped first and trimmed afterwards. Sometimes the piece is given a final drop after trimming while still hot. Difficult pieces with several projecting parts are sometimes roughed out under a hammer and dropped to a finish afterwards, but may, where large numbers of one piece are made, be trimmed or cut out from a rolled bar, leaving the projections of the forging represented by continuous flanges along the bar. By cutting away part of these flanges, the outline of the forging will appear, which in one or more dies can be shaped up to the proper form. The crank hanger, or bearing of a bicycle, is an extreme example of this kind of forging. Fig. 106 at *A* shows a section of the steel as rolled; at *B* is illustrated the manner in which 2 and 3, 3 are trimmed out; and at *C* how 1 is cut away by the same die which trims 2. The cutting off of the stock and trimming away of the surplus may be accomplished cold with a sufficiently powerful press, but lacking a large press, can be done, if heated, with a moderate sized one. When doing the

PLATE XLVI.

FIG. 104.

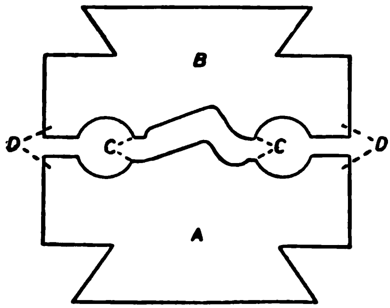


FIG. 105.

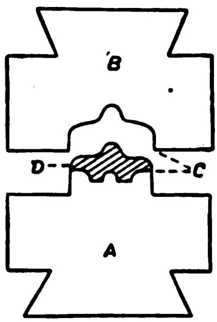
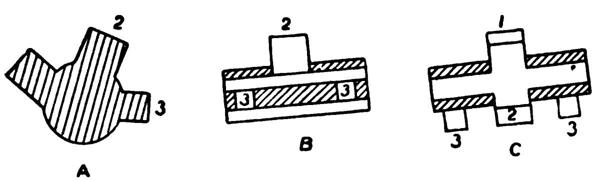


FIG. 106.



To face page 114.

work hot, it is best to have the trimming dies both placed in the trimming press, Fig. 107, at once, together with a cut-off die, three dies in all. Arrange one of the trimmers at the right, the other at the left, with the cut off in the center. Thus the heated bar can be trimmed up and cut off in one machine, and at one heat.

A very recent adaptation of the principles of the tapering rolls to forging taper and other plain pins presents a very rapid method of forging. By this process, instead of cutting a mould upon the surface of a flat die, it is cut on the circumference of a roll, or pair of rolls, all the features of trimming edges, etc., being carried out in circular form. Whole bars of steel are in this manner converted into forgings in a few seconds. All the housings and framing of such rolls should be very heavy, and the rolls as short as possible. For moderate sized forgings, the neck or bearings of the rolls should not be less than 6 inches, and the rolls more than 10 inches. To keep these sizes it will be found necessary to cut several dies in rotation around the circumference of the rolls, adapting the diameter of the rolls to the pattern.

In hardening all kinds of drop dies, especially those of large size, on no account plunge the whole die into the water, but as soon as properly heated set in a convenient place, and direct a stream of cold water from a hose onto the face of the die. The stream of water should be ample to cover nearly the whole face of the die, the water being kept flowing till about the temperature of boiling water is reached, and then allow to gradually cool. In arranging the die for cooling, place it on a slight elevation in a manner that will prevent the surplus water from cooling off the lower part of the die at the same time with the top. This method is intended to shell-harden only the top of the die, thereby preventing fire cracks and undue strain. The block can be drawn, if desired, while chilling by back drawing, while the lower part is still hot, and as soon as the proper color is reached, again turning the hose on the die.

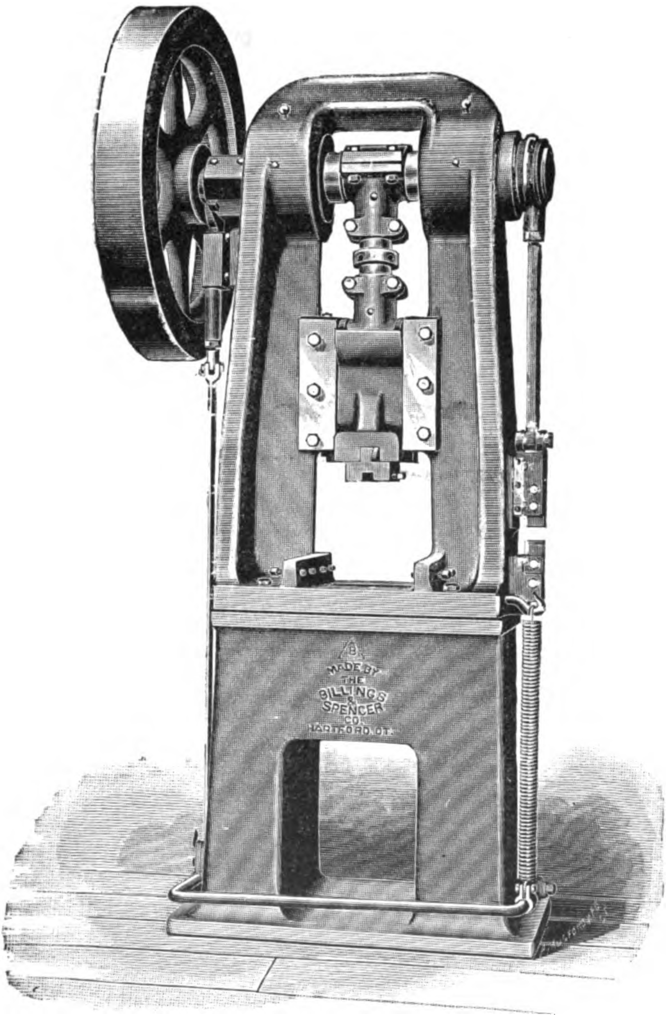
For nearly all kinds of die sinking or cutting, a vertical milling machine will be found almost indispensable. While it is possible to drill and chip out the metal, far better and more rapid work can be executed with the machine.

All heavy drops for forging must be provided with a lifter. The ease with which a hammer is operated, and the stopping of the head above the die by this method, are very essential for quick work. The trimming press, if one be used, needs to be placed at right angles to the drop, a position which permits of the handling of the two machines with very slight turning of the body, it being always more or less necessary to drop and trim the piece from the same heat.

To reproduce dies which are to be used on one piece of work right along, and must be constantly renewed, master dies can be made from which to coin or drop new dies at any time. Should the dies be very deep, proceed as follows: First heat the die block and drop the master die into it, giving a sufficient number of strokes to ensure

PLATE XLVII.

FIG. 107.



To face page 116.

a perfect mould. Carefully anneal the die, and remove the scale by immersing in muriatic acid.

Wash in warm water, dry off, and oil all over. Set master die in mould and examine for tight places resulting from shrinking. Lower down all flat surfaces outside of the die, trimming up all the edges and surfaces as when finished. Place under master die, and drop lightly with oil between the surfaces, producing a finish by a number of light blows rather than a few heavy ones. Take die from drop and give the final finishing touches, and harden as already described. By this method dies which would cost, if cut by hand, several hundred dollars, can be easily produced in a day at a few dollars expense. Coupled to this is the certainty of every die being a duplicate, a feature very difficult to reach by hand work, if the details of the die be very intricate.

CHAPTER XII.

SOLID DRAWN SHELLS OR FERRULES.

Cupping, or Cutting, and Drawing.

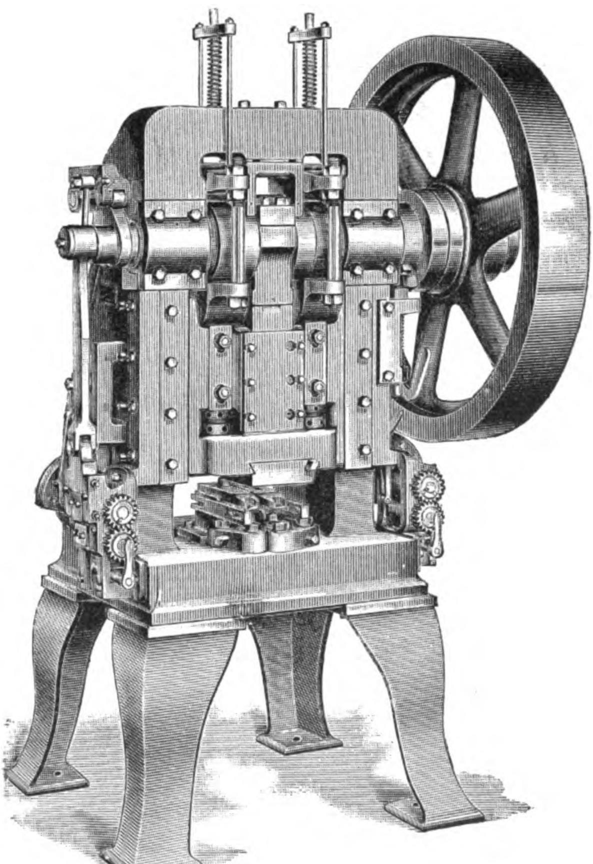
CUPPING is the first operation of making solid drawn shells. There are two forms of dies used. One kind for the single-acting press, and one for the double-acting, cam or cupping and drawing press. Where there is much of the work to do, either a double-acting or cam press will turn out the best and largest quantity of work.

The double-acting press, Fig. 108, having two cranks placed on the quarter will require very nice adjustment to produce good work. Special attention is called to the timing of each part, as both the cutting punch and the drawing mandrel should strike the metal at the same time. To the outer or short stroke crank is attached the cutting punch which blanks out or cuts the circle to be drawn, and to the inner or longer-stroked crank is keyed the drawing mandrel which forces the metal through the die and forms the cup. It is very essential that every part of a cutting and drawing die should be true. One-sided cups will result if the tools are carelessly made. From the illustrations, Figs. 109 to 111, may be constructed the three best forms of dies in common use.

Referring to Fig. 109 it will be noted that there are

PLATE XLVIII.

FIG. 108.



To face page 118.

four principal parts to this set of tools—the cutting punch, *A*, the drawing mandrel, *B*, the cutting die, *C*, and drawing die, *D*. No dimensions are given, as this set of tools is subject to very wide variations in size. Considering the two punches first, have the hole through *A* the same diameter as the hole, *H*, in the drawing die. This feature will make it possible to draw cups of different gauges of stock by simply varying the size of the drawing mandrel. The top of the mandrel, *B*, fastens in most presses by means of a horseshoe-shaped key, and the head shown in Fig. 109 is for that purpose. The best results can be had by fitting *A* into the block with a taper and key, *J*. Have the key force the punch upward and not sideways. Never use a set screw if it can be possibly avoided. The cutting die, *C*, can in all cases be about $\frac{1}{4}$ inch thick, and is beveled on its outer edge. The drawing die, *D*, can be varied in thickness to suit the size of the machine at hand, but the hole must be central and true. Be careful and not make the edge of the die where the metal is drawn over too rounded, as bad crimps will form when the last edge of the cup goes down into the die. The proportions of the cutting die, *C*, and the drawing die, *D*, should be such that the hole, *H*, should be about $\frac{55}{100}$ of the diameter of the hole in the cutting die at *E*. The end of the cutting punch at *G* should be a very perfect fit in the hole, *E*, and should be kept perfectly sharp, as well as the cutting edge of the die. Any burr or rough edge around the blank or circle will surely make the cups come crooked. It will be readily understood that the size of the drawing mandrel where it passes through the die at *L* must be of such diameter as will draw the cup the same gauge as the stock from which the circle is cut, though, in some instances, the sides of the cup may be somewhat thinner than the original stock. As all the working parts must first be hardened and then ground to size, in turning up the piece considerable stock must be left for grinding, and the springing of the work in hardening which will be found unavoidable. The drawing mandrel and die should be very hard, to prevent wear. Only draw sufficient to take off the strain produced in hardening.

The cutting punch will work well if drawn to a light straw color. Do not chill in water, but in the pickle or chill described as "standard." Cut a spiral groove, *K*, in the side of the drawing mandrel, where it works up and down through the cutting punch, as unless this part of the tool is kept well oiled, it will cut and cause trouble. Make the end of the drawing mandrel and the hole through the drawing die perfectly straight, and see that all the surfaces, when the metal passes over, are free from scratches, and have a very nice polish. The last operation before putting the tools into the machine should be to grind sharp the lower edge of the drawing die at *F*. This is usually accomplished with a small emery wheel, and is very necessary to prevent the cups from pulling back into the die as the drawing mandrel returns upward.

In the next sketch, Fig. 110, the working parts of the

PLATE XLIX.

FIG. 109.

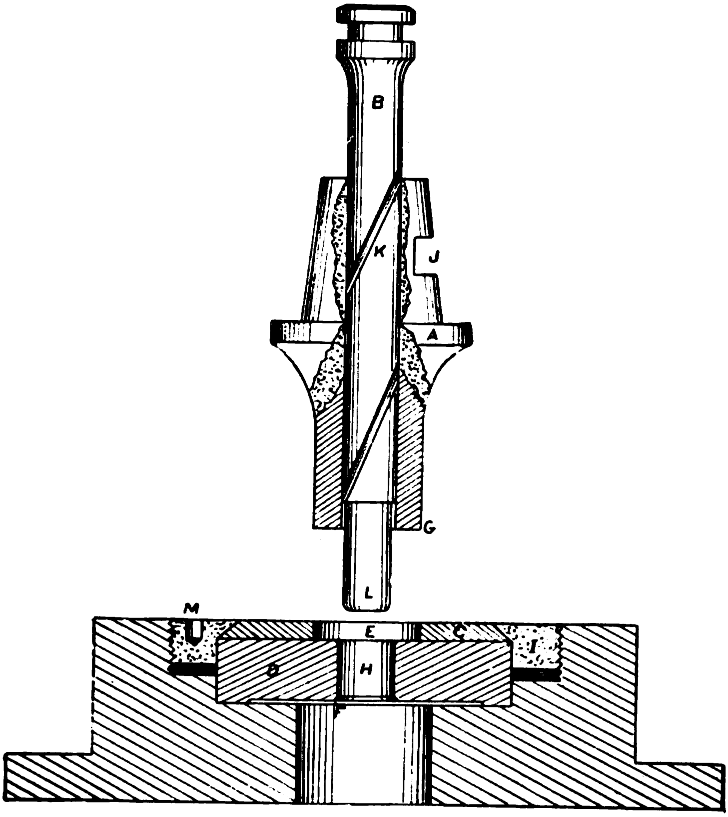
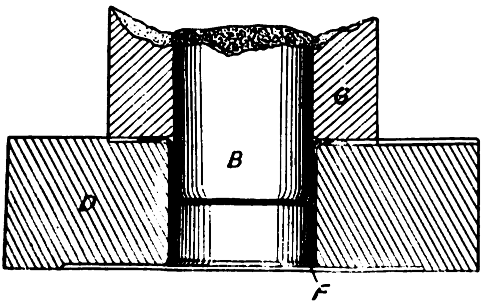


FIG. 110.



To face page 120

tools are shown with a cup partly drawn, and it will be noted that the part *G* holds the metal perfectly flat, while the mandrel, *B*, forces it through the die. Be careful and have the surfaces between *G* and *D* parallel with each other. Bevel back the lower edge of the die at *F* to prevent the strain from chipping off the edge of the die.

Some experience will be required to get just the right pressure on the blank. If there should be too much pressure, the mandrel will punch a hole through the center, and if there should be too little pressure, the metal will crimp up and pull in two. Time the presses, so that the mandrel will commence to draw just as the blank is clamped between the cutting punch and the drawing die.

In cupping and drawing it is customary to run the metal from one reel to another, using the same soap mixture and check finger as formerly described under the head of cutting or blanking dies. German silver and copper will not draw well with soap, and must be lubricated with good lard oil. Always remember that any defect in the cup will be multiplied in any future operations and cause a waste of stock, hence the importance of making as nearly perfect cups as possible.

The only suggestion as to change of construction consists in making the dies *C* and *D*, Fig. 109, all in one piece. The objections to such form consist in the fact that any injury to either the cutting edge or drawing die is more difficult to repair. Trouble is also liable to occur by the drawing die being worn faster than the cutting die, when it must be shrunk and repolished to size again, which would destroy the nice fit between the cutting punch and die. The shrinking and polishing of dies will be carefully treated under the head of "Finishing."

The most practical way to cup work with a single acting press is to first cut out the blanks with a blanking die, and afterwards draw them up into cups with the tool shown in sketch, Fig. 111. The die *A* is made with a recess the size of the blank, the same as the drawing die in Fig. 110. The blank holder *B* is arranged with a spring of sufficient tension to hold the blank flat, and yet allow of stroke enough to enable the punch to form the cup and force it through the die far enough so that it will strip. This kind of die will work all right for shallow cups, but will not do very good work if very deep pieces should be required. For work with high sides a double-acting press must be used.

Large work, such as lamp bodies, cuspidors, etc., is best cupped up in specially constructed cam presses. All the tools are but a repetition of what has already been described, only that they are made on a larger scale. For large work it is customary to use a thin film of oil on all kinds of material, care being taken to keep all the parts of the tools free from grit or small particles of metal which may cause a bad scratch at any time, and eventually injure not only the work, but the die and punch also. Circles for large work can be had already cut, from the mills, thus saving much expensive die work.

PLATE L.

Fig. 111.

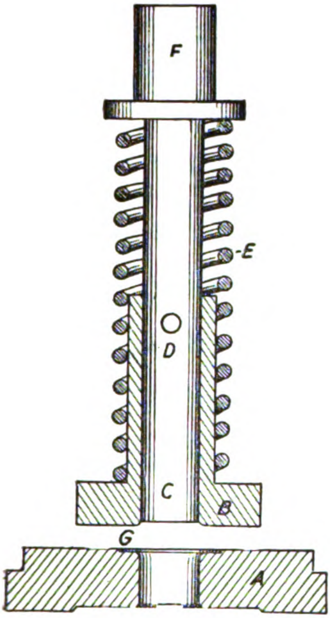


Fig. 112.

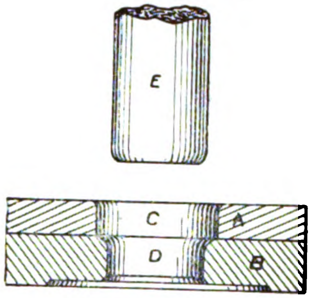
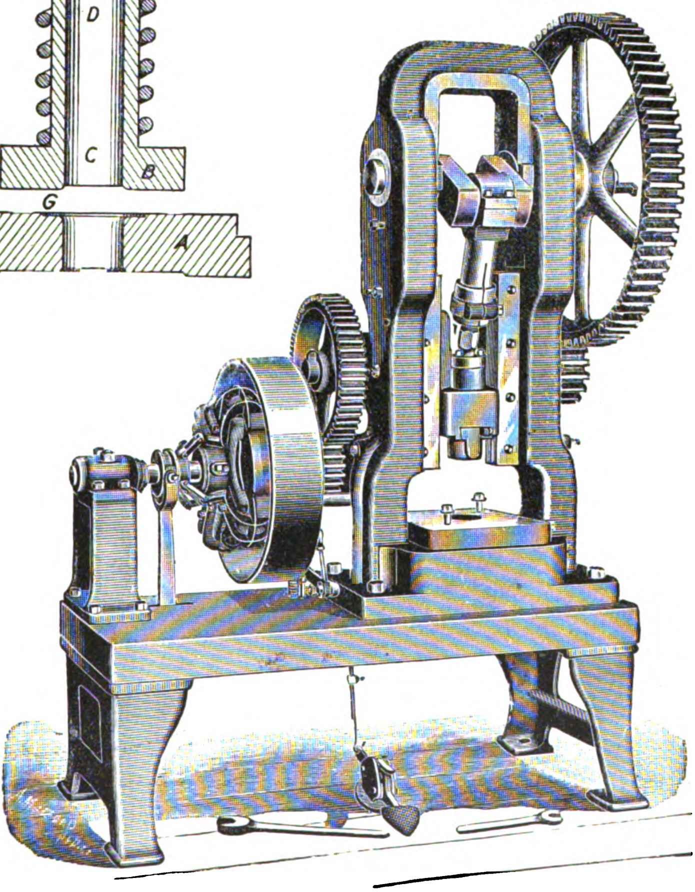


Fig. 113.



To face page 122.

The modifications of construction given in the foregoing pages only show how the work may be executed under varying conditions. Care should be taken to see that the space between the cutting punch and top of drawing die is uniform in width, and that the circles or blanks are cut without any rough edge or burr. Keep the bottom or lower edge of the drawing die sharp by grinding, in order that the cups will surely strip from punch.

After the cups are made, they must be annealed before further operations. The subject of annealing has been treated in a separate chapter, and care must be taken to note the troubles liable to arise from improper or careless handling at the muffle or the pickle tub.

Breaking Down Shells.

Break down dies are usually made with a "set edge" or centering die placed above the regular drawing die. Such a die may be made all in one piece if so desired, or may be constructed to have a cast iron or brass ring set on top as shown in the illustration, Fig. 112. The hole *C* in the set edge die should be a good easy fit for the cups, that they may be easily "set" in place. Have the hole *D* in the die *B*, with plenty of bell, but be sure and have at least one-third of the thickness of the die or rather the length of hole with a straight bearing, and perfectly smooth. In tempering have the die just as hard as it will stand. If after hardening only the strain is removed by slightly heating, the die will work satisfactorily.

The punch or drawing mandrel must be hardened and ground to size. Draw to a light straw color, polish with clamp and emery and oil, and make with a taper of about $\frac{1}{1000}$ for six inches of length.

When such a die is fed by hand, the operation will be readily understood as placing the cups in the space *C*, as shown, and pushing them down through the hole *D* with the punch *E*. Strong soap suds, or rather weak soft soap made from white curd or neutral soap, should be freely used during the operation, keeping the shells in a pan partly filled with the luke warm solution.

Some experience will be needed to get the kink of shrinking and polishing out a die to the proper size, always remembering to grind off the bottom edge of the die the last thing before using.

Fig. 113 shows a geared drawing press.

Each draw should reduce the cup or shell about one-eighth its diameter, though this proportion will be subject to variations. Very thick stock will stand more folding in than thin material. If good work is expected it will be necessary to reduce the thickness of the metal as well as the diameter of the cup, hence the importance of commencing with material somewhat thicker than is required for the finished product.

The majority of this kind of work is properly done on dial presses, which have two forms—the index machine and a more modern kind called the friction dial press.

The index dial is simply a machine having a revolving dial worked with a ratchet, and provided with a circle of set edges revolving over the drawing die at each stroke of the press. The cups are set in the dial, and revolve over the die in turn, and are pushed through the die as in hand drawing. The great objection to this form of machine is the difficulty of getting the scrap out of the die, as the whole plate must come off in order to do so.

These machines will handle the work as fast as the metal will stand, there being no limit to its capacity, except the strength of the metal.

Dies for this kind of machine must be made of uniform thickness, and be belled out just the outside diameter of the cup. An improvement on the machine is to set it somewhat on the incline, having it highest in front. Cups may be drawn on this type of press as long as they will stand readily on end.

In breaking down, one of the principal things in view is to get the shells or cups ready for the finish draw. For a nice finish, draw the shells down just a little thicker than is required for the last time. Allow as little fold in as will enable the shell to be slipped up on the punch.

Between every operation of drawing there must be an anneal, and the more carefully this is done the better the results will be.

Between cupping and finishing there will be several operations on either the dial press or other break down dies, depending of course on the length of the shell. Thick stock may be reduced in both gauge and diameter, faster than thin metal.

Having described the breaking down of the stock, we will now go into the details of the finishing process.

Finishing and Drawing Press.

If all the previous operations of cupping, annealing, pickling and breaking down to size have been properly performed, we may now proceed to finish the work.

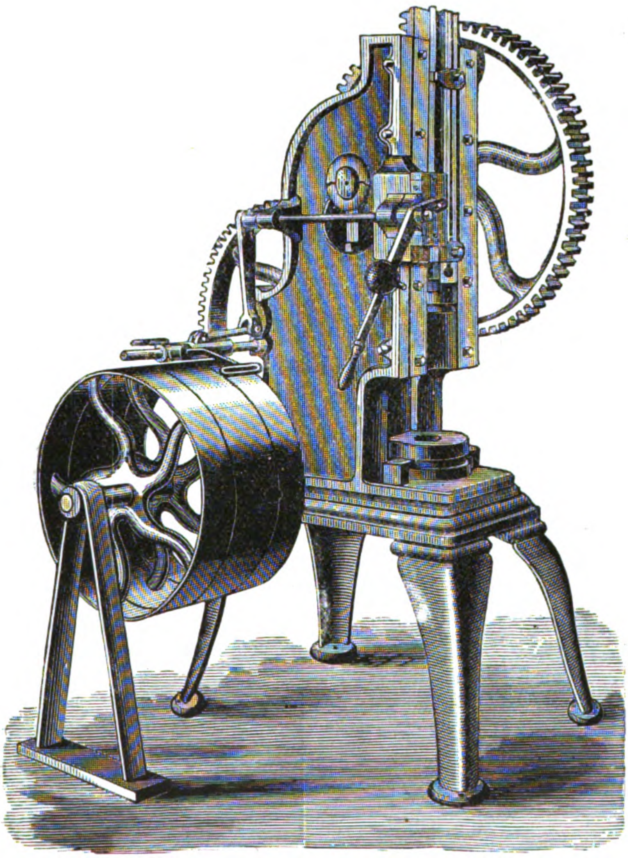
Fig. 114 shows an upright rack and pinion press, and Fig. 115 a horizontal press. For both finishing and tapering. These presses have automatic feed, knock out, etc., and are adapted for pieces that are in length several times their diameter.

Only experience will reach the highest efficiency, but a few general hints as to method will aid the tool-maker in getting the final results. As previously mentioned, always have the shells a little thicker than the gauge of finished work. If everything is all right, the work should come from the last tools, smooth, and with a fine burnished appearance.

In hand drawing, the work, if short, is placed in a set-edge die, but if long, is usually pushed up on the punch by the fingers of the operator while the machine is in motion, the shell being held in position with the first two fingers and thumb of the hand, removing them as the shell strikes the bell of the die. The die must be well belled out, and the same care in regard to polish is more important than ever. Keep the die free from the small pieces of metal which sometimes break off, and should pieces of scrap push up on the punch, they can be removed by slightly hammering with a small hammer. If the operator is new to the business, the press should be speeded about twenty per minute, and may be

PLATE LI.

FIG. 114.



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increased from time to time as the operator gets more skillful, till a speed of forty is reached, which is about as fast as it is safe to run. Care should be taken not to drop the shells, as such carelessness results in serious injury to both the die and punch. A very nice arrangement is to have the press provided with cone pulleys, so that the speed can be varied to suit the work and the skill of the operator.

When the work splits or wrinkles in drawing, you are folding in too much stock; when it pulls in two, you are reducing the thickness too fast. When the bottom punches out, it may be from both of the above causes. Too weak soap water will sometimes make lots of trouble before the cause is discovered.

Keep all the tools highly polished and free from scratches. When a die is hardened, it will shrink about $\frac{5}{1000}$ for each inch in size of the hole. In polishing out be careful not to bell out the die at the bottom side; the result would be to cause the work to stick to the punch.

Thus far only straight work has been described, but you may shoulder—taper—oval bead—corrugate—square—emboss the closed end, or produce such modifications as the nature of your job may require.

Shouldered work is made by pushing the shell only partly through the die, for the length of the smaller part, and then redrawing the top or larger end at a separate operation, see Fig. 116. In redrawing the larger part, it will be necessary to have a pin turned on the end of the punch that will fit the inside of the smaller part. It will also be necessary to have a shoulder in the die the size of the shell. In the illustration, Fig. 116, the heavy black line shows the proper arrangement of the shell and tools for this work.

The work will also come nicer if the smaller part, which is drawn first, is also drawn in a die having a shoulder, see Fig. 117, which will keep the top or larger part from being crooked.

For the first operation there will be required a stripper plate to strip the work from the punch. Such a plate will need a spring movement, as it must push down to the die, but must stop on its upward movement soon enough to pull the work from the punch.

Several shoulders may be drawn on one ferrule, and each part may be tapered or left straight, made square, corrugated, or otherwise shaped to suit.

Where particularly close fits are required, the die must from time to time be shrunk and repolished to size. Bad scratches may be removed in this way. Little trouble will occur with the punch, as it does not wear very rapidly.

To draw an extra long ferrule a special punch with a hinge, as shown in Fig. 118, is convenient. The dotted line illustrates how the punch may be brought forward so that the shell may be pushed on. Ordinarily, a ferrule only a trifle more than half the stroke of the machine can be made, but in this way nearly the entire stroke may be used. This is a valuable kink, and is sometimes of great use when extremely long shells

PLATE LII.

FIG. 115.

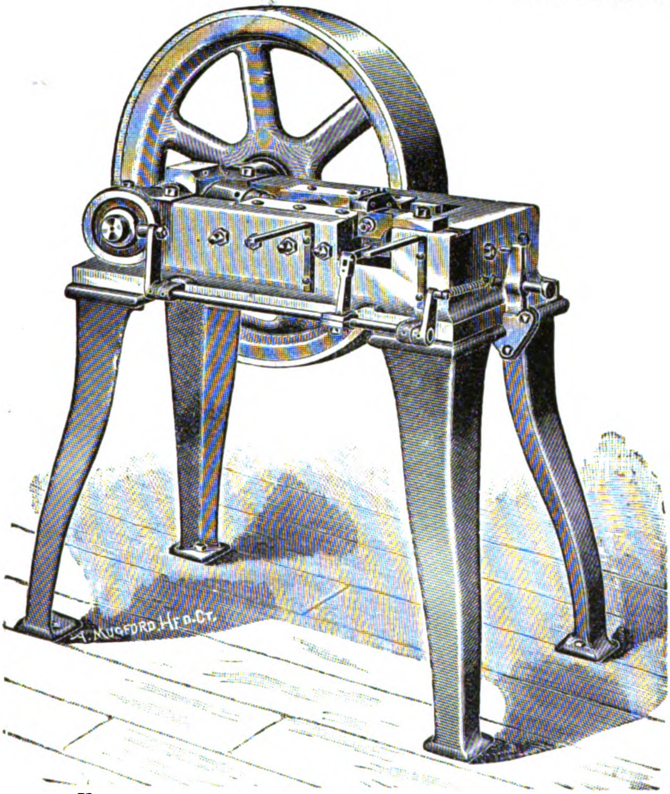


FIG. 116.

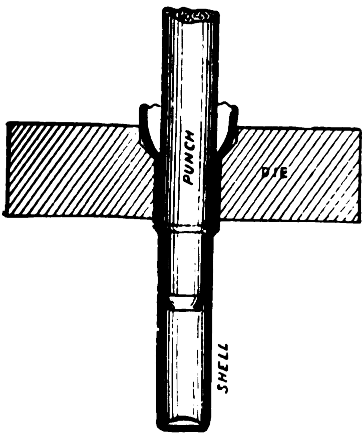
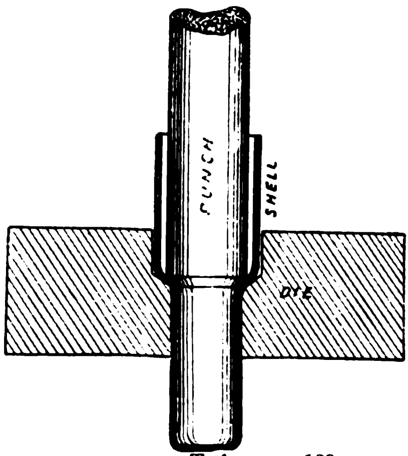


FIG. 117.



To face page 128.

are wanted, and no rack and pinion or other very long stroke press is at hand.

It sometimes becomes necessary to reduce a piece of work to such an extent that more than one draw will be required. Should it be necessary that the smaller part be of definite length, some experiments will have to be made to get just the right amount of stock to make the right length when finished.

In the drawing, Fig. 119, the solid lines show the finished piece, and the dotted lines the successive draws, there being three, not including the finishing of the larger part.

It also sometimes happens that the open end must be made smallest. This may be accomplished as described under the head of tapering. There must be an anneal between each draw or taper.

Tapering in the Draw-Press.

Tapering may occur in two ways: Smallest at the closed end of the shell, and reduced at the open end. To taper a piece of work small at the closed end, have the stock broken down to the size of the larger part of the taper, and then after annealing, push down into the die as shown in Fig. 120, care being taken that there is no soap water left inside the shell, or the end of the work may "blow" off. Have the end of the knock out where it fits against the small end a nice fit; and carefully note that the part of the die where the knock out pin works through it is straight.

As the shell sometimes sticks to the punch, a stripper plate will be needed. Should the taper be very great, it may be necessary to do the work in two operations. Fig. 115 before described, shows a horizontal drawing and tapering machine. Also used for drawing long work.

In tapering work smallest at the open end, you will find yourself limited to the extent that you cannot do very thin shells in this way. Break down same as for other tapers, and before running through the tools, trim and afterwards anneal. Referring to the cut, Fig. 121, see that the driving punch, *A*, fits the end of the shell very nicely, or bad marks may occur. If the open end should crimp or wave, it may be necessary to make the stock thicker or do the work in two operations. Where large quantities of shouldering or tapering are to be made, it is best to employ a horizontal press with automatic feed.

Striking Up, Heading and Swaging.

In striking up the closed ends of work for ornamentation, or to produce special shapes, do all the work on the last break down size, and then finish afterwards. Such work is always best done by having the tools inverted—that is, the punch stationary and the die moving up and down with the head. This is clearly shown in the Fig. 122, and needs no further explanation.

Should it be necessary to punch any holes in the head of the shell, do not do so till all other work is finished, or the holes will be distorted in size and shape.

PLATE LIII.

FIG. 118.

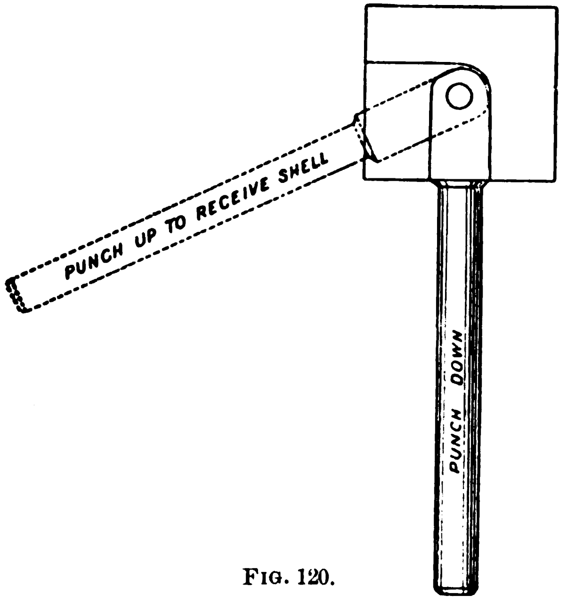


FIG. 119.

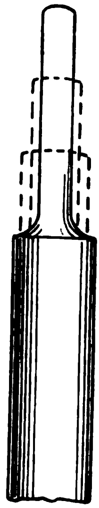
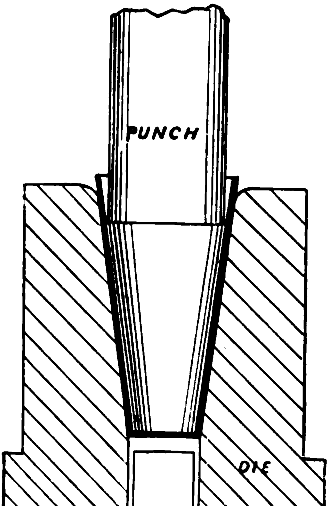


FIG. 120.



To face page 130.

In swaging ferrules into special shapes, such as oval, hexagon, square, etc., the last break down should approximate the size and shape of the finished tools. Previous to the last break down the work may be best brought forward in the round.

To give ferrules special shapes for a part of their length, it is only necessary to carry out the ideas given under the head of shouldering, substituting special shaped punches and dies for the plain ones described. Large quantities of such work may be produced rapidly and cheaply by means of the water die as elsewhere described. Work may be flanged or widened out at the open end in two ways: Either by shoulder drawing, and afterwards trimming out the part wanted, or by flanging or spreading out the open end of a straight ferrule. When the work is done by shouldering, the stock will all be of one gauge, but where it is produced by flanging or stretching, that part of the stock where the flange is turned over will be thinner than the balance of the work. Narrow flanges will work all right if spread out, but wide flanges must be broken down to shape by several operations as in making shouldered work. In trimming flanged work it is best to make use of a cutting die, punching or trimming the flange, and forcing the finished piece entirely through the die at each stroke. Do not forget the guide or finder pin on the end of the punch.

Irregular work, such as lamp burner tops, oil can bodies, and all similar shaped pieces, are best made in two or three operations, using a cup having as near the general outlines of the finished piece as can be made in the double acting press. There are some kinds of such work which can be made directly by the cupping press, but many shapes will occur which are either too deep or have too many angles to make in a single operation, without bad crimps showing in the work. From the illustration, Fig. 123, it will be seen that the angle at A could not be formed except in a die which bottomed and was provided with a knock out. The finishing of such pieces properly belongs under the class of tapered work, and with the exception of the shape of the tools is usually made in the same manner.

Trimming.

There are three ways of trimming, varying with the nature of the work. Thick work is usually best sawed. Small work will trim best with a cutting tool similar to a cut-off tool in the lathe, the work being held on a revolving mandrel by means of a tail spindle made to revolve at the same rate of speed. Such a machine is called a trimming lathe.

For ferrules which are not too thick or too small in diameter, the shearing tools shown in Fig. 124 will give the highest results attainable in hand work. Everything about these tools should run perfectly true, and the speed for brass work should be about two thousand per minute. It is not always necessary to use the tail spindle with this form of trimmer, but it may be used

PLATE LIV.

FIG. 121.

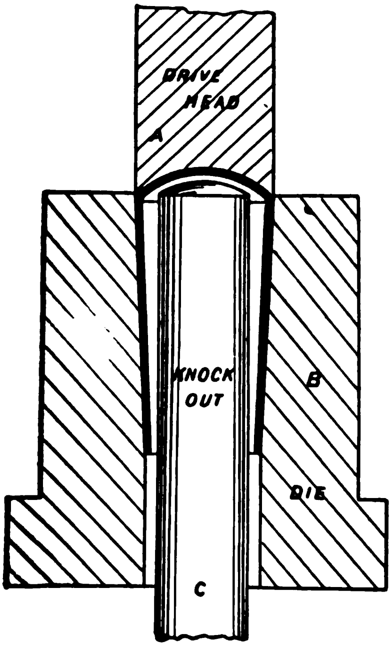


FIG. 122.

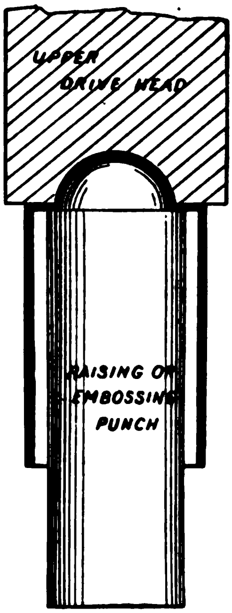
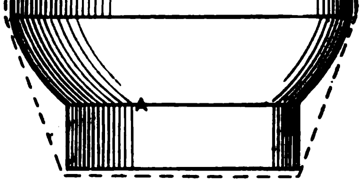


FIG. 123.



DOTTED LINE SHOWS SHAPE OF
CUP BEFORE FORMING

To face page 132.

where the work is short or has a tendency to slip. Keep the cutting edges sharp, and note that the notch in the trimming arbor is made with a very small nick or notch, which is necessary to prevent the scrap from catching when being taken off.

Always be careful to have the roller or cutter which cuts off the open end of the ferrule slightly in advance, and also arrange the slide so that the cutters will have a little pitch, that is, have a tendency to screw the ferrule onto the mandrel or arbor. Should the opposite pitch or screw occur, much trouble will be caused by the work getting badly marked and spoiled. Keep the stop screw at such a point that the rollers will just cut off and no more. Caution the operator about bringing the roller up against the work too quick on the start. Keep all the lost motion out of the spindle, and have the cutting edges work very close together.

If all the tools are properly made and run true, the ferrules will cut off without any burr or rough edge. Work should always be trimmed hard, that is before annealing.

Should the inside edge of the ferrule be required nicely finished, it will be necessary to burr or ream it with a reamer, having fine teeth unevenly pitched; the last being necessary to prevent chattering.

For sawed ferrules it will be proper to provide a hollow bell-mouthed reamer or rotary file, having a flat taper drill or reamer set in a slot cut cross-ways of the open mouth of the bell, and arranged to move outward or inward to fit various sizes of work. Such a tool, of course, will burr off both the inside and outside at the same time, and may be used in any kind of a lathe or a special head similar to an emery wheel grinder.

In the heading of cartridges or similar work, the shell after trimming is forced down into a die having a shoulder. Another feature of such a die is the sleeve and the knock-out pin, as shown in Fig. 125. This arrangement of the tools is sometimes made necessary in thin work, and also because there is a double strip, the shell requiring to be stripped from the knock-out as well as out of the die. The horizontal automatic Drawing press, Fig. 115, is the best for the purpose of tapering, heading or shouldering large quantities of ferrules.

Knurling, Chasing, Beading, etc.

The various decorations which are produced on ferrules, where the design is of regular pattern, may be made with ordinary knurling tools of special patterns. Only a suggestion can be made in this matter, as the artistic taste of the workman enters largely into the final appearance of the work.

Much of this work may be executed very rapidly by means of the water die. Fancy designs, such as for cane or whip heads, are first rolled or beaded into the general outline, and then filled with lead, afterwards chasing the design (see *Chasing*), and melting the lead out again. So-called engraved work is all produced in this way.

In beading, rolling, or chasing, do not run the tools

PLATE LV.

FIG. 124.

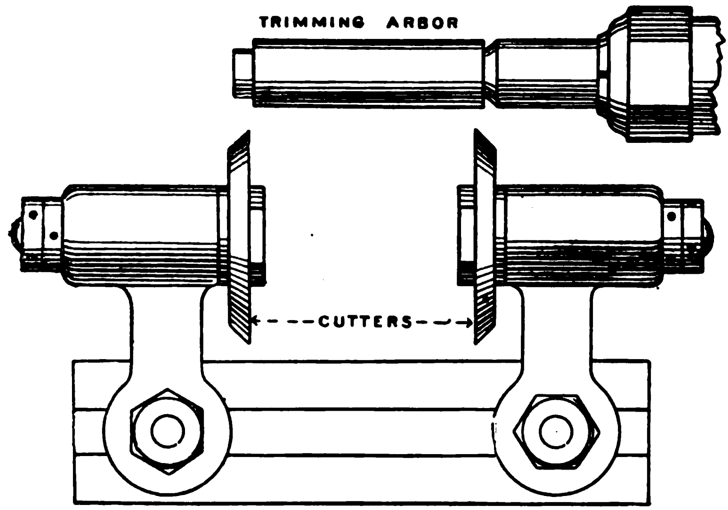
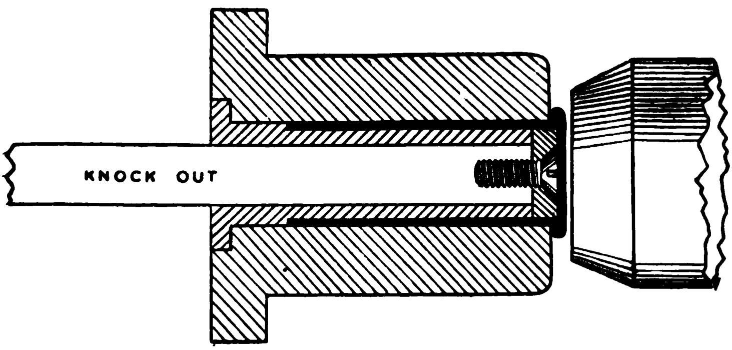


FIG. 125.



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too fast; for beading this does not matter so much, but where patterns are to be matched, only one revolution of the work is permissible, and unless the machine runs slowly it will be impossible to stop at the right moment.

Work may also be made for part or the whole of its length, square, hexagon, or other shapes, by rolling lengthwise on mandrels of proper shape, using for the purpose a machine with an adjustable crank movement and slide, with the knurl or roller attached to the slide, and a suitable cam to bring the knurl down to the work.

Annealing and Cleaning Shells.

For annealing quantities of shells, a muffle oven will be needed, and should be constructed with a detached fire. Should the fuel be wood, two fires will work better than one in large ovens. Gas or crude oil will also work nicely. Annealing, to be well done, must have time, and is always better when accomplished within muffs or pans which are arranged to exclude the air. Fig. 126 illustrates outside appearance of annealing furnace.

Where the shells or cups are annealed in open pans, a heavy oxide will form and cause waste. In closed pans that exclude the air very little scale will appear. It will be necessary to have a small hole in the cover of closed muffs or pans, to let off the moisture from the soap water or gas from the oil used in drawing. For open pan work, only wood or gas may be used.

For heavy shells, which will stand tumbling, they may be pickled and washed in large copper pans setting on an incline. The pickle may be poured over the shells as they revolve in the pan, catching the acid in a lead or copper trough or pan. After draining off the surplus pickle, a stream of water may be turned on the shells, and they may be washed and tumbled perfectly clean and free from acid. If the shells are for stock, that is, to store away for use at a future time, they should receive as a last treatment a washing with hot soda water made quite weak with common sal soda. The latter washing will prevent the cups from turning black when kept for any considerable time.

Where the nature of the work is such that the dents and other marks from tumbling can not be permitted, pickling and washing may be accomplished in large perforated wooden boxes, which should be provided with handles and be put together with brass or copper screws. A suitable lead-lined tub to hold two or more of the boxes and the pickle, and a large wooden tub for washing off the acid, will be required. It is best to have the water run in at the bottom of the wash tub, and not at the top, and it will be found necessary occasionally to give the ferrules a good shaking up to get the acid out of the inside. The pickle will be required stronger than where the shells are tumbled. As there must be an anneal and pickling between each operation of drawing, too much care cannot be exercised in arranging this part of the plant. An essential feature is to have plenty of water, which may be pumped by a special pump.

Fig. 126

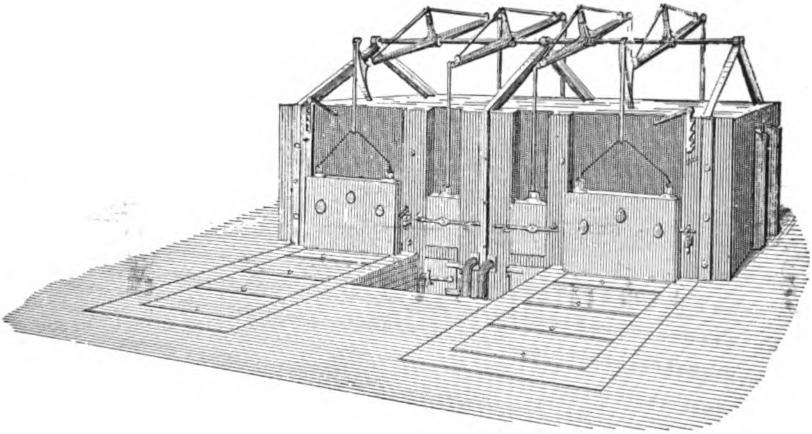


Fig. 127.

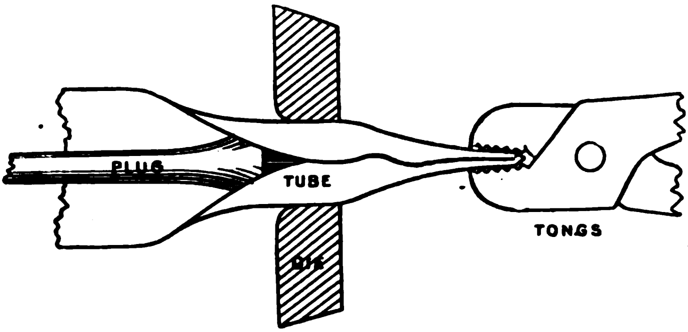
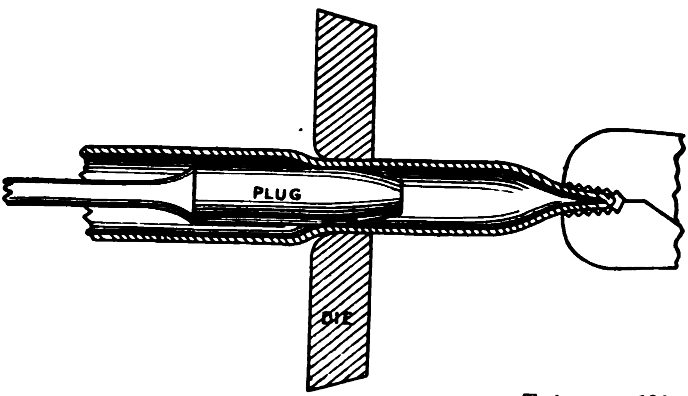


Fig. 128.



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CHAPTER XIII.

ANNEALING, PICKLING AND CLEANING.

For pickling copper, brass or German silver use a mixture of one part sulphuric acid to two parts water. These proportions may be varied somewhat, the copper requiring a much stronger pickle than brass or German silver. All work as it comes from the annealing oven or muffle is covered with a coating of oxide, which is usually removed with acid. Large objects are put in stationary tubs till the scale peels, and afterwards washed off with running water. Small articles such as shells, cartridges, rivets, etc., are put in large open copper tubs set on an incline and revolved slowly around while the acid is poured over them. After the scale has started and the pickle is drained off, the shells are washed by showering with water. Though it is customary to do the annealing in open iron pans, round drums with nearly air-tight covers are preferable, as only a very thin scale will form if the metal while hot is kept away from the air.

Copper may be scaled by coating with a weak solution of sal amonniac before heating and plunging in water while still hot. All copper work is cooled on coming from the oven. Brass is allowed to cool, but may be cooled off with water if desired. Iron, steel and German silver must be allowed to cool very slowly. Especially is this true with work which has been cold drawn or rolled, such as hollow ware, rivets, wire, etc., water causing the pieces to split open in the direction in which the metal has been drawn. Such articles as are to be kept for any length of time should be finally dipped in hot soda water and dried, which will kill the acid and prevent both corrosion and rust. Iron or steel tack plate should be allowed to dry with a thin film of soda or lime on its surface which will prevent rust if it is shelved for a long time. A hot pickle of sulphuric acid and water will scale iron or steel very quickly, but if there are no conveniences for heating, the pickle, hydrochloric or muriatic acid may be used cold and undiluted. This operation must not be performed in a closed room, as the fumes are poisonous. Your dies will give you much better service and last much longer if all stock is scaled or pickled before running through the tools. The black oxide scale on iron and steel is very hard on the cutting edges of all cutting tools.

In pickling iron or steel avoid any accidental getting of copper or brass or zinc into the acid. Where a piece of iron is put into acid containing copper or zinc salts, a sort of electric battery is formed, and instead of removing the scale, the copper will be deposited on the surface of the iron as long as any exists in solution.

When using sulphuric acid, keep the tub open and avoid any accumulation of the gas formed from coming in contact with fire, as the gas given off is pure hydrogen, and very explosive when mixed with air.

CHAPTER XIV.

TOOLS FOR THE DRAW-BENCH.

MODERN draw-benches are composed of a long iron or wooden frame, having on one end a shaft and sprocket-wheel driven by a powerful and heavy set of gearing, and at the opposite end an idler for the chain to pass around, and a die-block for the reception of the drawing-dies. Between the sprocket-wheel and idler runs a heavy link and pin chain, the top portion running away from the die-block. The grip tongs either slide along the top of the frame in the smaller sizes, or are attached to, or provided with a wheeled carriage, in the case of heavy benches. In both cases, the tongs are provided with a triple link and hook for attaching to the chain when in use.

Round dies are made in about the same manner as those for cartridge work, with the exception, that they are belled out more, and the edge, made sharp in dies for press work, is rounded off, no stripping being necessary.

In forming up the tube from flat strips, the metal is either first pointed by folding and hammering the end over, or is formed with suitable dies under a press.

The pointed end is then entered through the die, and the tongs "hooked on," Fig. 127. To keep the tube from overlapping, a "plug" fastened to a long rod and reaching into the die only sufficiently to keep the metal snug against the sides of the die is used. This plug is stationary, the metal drawing between it and the die. The plug is held from drawing in by the rod being fastened to an extension on the bench or a firmly-fastened post with an eye for passing the rod through. For the purpose of adjustment, the rod is threaded for a short distance, and provided with two nuts for locking when the proper point is reached. To prevent distortion of the holes in hardening, it is usually customary to have the steel die-blocks to conform more or less to the shape of the die. Consequently, for round work round dies are used, and for square or rectangular holes, square steel pieces are suggested.

After forming up, the seam is filed bright and scraped out slightly with a pointed scraper, forming a V-shaped groove for about half the thickness of the metal. Next the seam is "striped" with a mixture of about one part by bulk of fine half-and-half spelter, and five parts of fused borax ground to a fine powder and mixed up to a cream-like consistency with water, having about one ounce of sal-ammoniac to the gallon in solution. The spoon or tool used for such purpose, has a lip at one end provided with a small point on its under side to follow the seam. Some practice will be needed to get the spelter and borax of just the right consistency, and to stripe it on so that the borax and spelter will keep in the right proportions. After striping, the tubes are laid aside to dry, as unless the borax is thoroughly dry, it will boil all over the work, when heated. Boracic acid may be substituted for borax with equally good or even better results.

The furnace commonly used for brazing consists of a detached fire chamber reverberating into the brazing furnace proper through a series of narrow holes in one side; the flames from the hard coal or coke heating the furnace to an even heat, regulated by blowing the fire with a blower. There are two exits from the brazing chamber for the escape of the flames, one upwards and one downwards, each regulated by a separate damper. Across the opening in the bottom are placed narrow bricks to support the tube, and still allow the escape of the flames. By regulating the blower and the two dampers a perfectly uniform heat is maintained in the chamber, which is aided somewhat by the reflecting qualities of the fire brick lining. On the opposite sides are doors for passing the tubes through the furnace while brazing, keeping the seam side up. A very little practice will enable one to tell the right moment when the spelter flows and sinks into the seam. Small sizes may be brazed several at a time. Large tubes of thin metal will open out when heated, and must be bound every few inches with iron wire. After the work has cooled from the brazing, the excess of spelter is filed off, and the tube pickled to remove the scale, and given the finishing draw.

Ordinary tube is drawn with a plug in the same manner as when formed up, the plug being tapered, and forming between it and the sides of the die a space equal to the gauge of the metal. The further the plug is allowed to enter into the die the thinner will be the tube, and vice versa, see Fig. 128. For moderate speed and smooth work, the work can be suitably lubricated by keeping it in a long trough filled with the same soap mixture used in drawing cartridges.

In drawing with a plug, the tube is run on over the plug and rod, and then the taper end of the tube entered in the die, the plug pushed up snug, and lastly the tongs are hooked on to the tube and chain, and the piece pulled through the die. If the tube is required to be very hard temper, it will be necessary to form it up from stock one gauge heavier than the finished size.

As the dies wear, they may be shrunk and polished again to size. The plugs will wear shoulders or rings when the pinch comes, and can be re-tapered by grinding. When the plug is very much "ringed," there will be a tendency to make wavy work. Large plugs are generally drilled out and täped for screwing in the rods, but small ones are welded. After the finishing draw, the tubes are straightened, sawed off at the ends, and are ready for the market.

Owing to the excess of zinc in the spelter, too strong a pickle should not be used, as it will eat out the spelter from the seam. Instead of filing off the surplus spelter, it can be removed with an emery wheel running under an elevating V-shaped rest. This is a very neat method which is adapted to all sizes of tube, and will grind off only what is outside the diameter of the tube. It should be noted that when first folded, the tube is somewhat larger than the finished size necessary to insert the plug, and have fold-in enough to draw well in finishing. With the exception of tubes of varying thickness, ordinary shapes, such as square, three-cornered, oval, etc., can be made in two draws.

Solid rods can be either worked down from slit stock or from cast bars, annealing from time to time to prevent splitting. Large sizes of brass and German silver rods are subject to a peculiar phenomenon called "checking," caused by the metal drawing harder on the outside than in the centre. This checking may occur when the work is drawn or when it is annealed, and is prevented by breaking, which means, bending the rods from side to side to loosen up the grain of the metal. Running the rods through a five-roll straightening machine several times will accomplish the same result.

Channels, Ells, and other angles, must be drawn from stock both wider and thicker than the finished sizes. The extra width is required to force the metal into the corners of the die and make sharp corners, and the extra thickness is to produce both a hard temper and good finish, the folds requiring a soft strip to prevent splitting where the angles occur.

In drawing such shapes as have thick and thin portions, there is a tendency for the thin portions to pull the thick portions in two, unless the dies are properly proportioned to draw the metal out equally at all points. The theory of the successful drawing of such shapes rests in reducing the thick portions edgewise and the thin portions flat-wise. In Fig. 129 is shown a shape made in five draws. No. 1 shows how the piece has been reduced from the original strip; No. 2 shows a bend and still further thinning of the thin part and widening sideways and narrowing edgewise of the heavy portion; Nos. 3, 4 and 5, show each successive shape of the die to the final finish. Such work must be annealed and pickled between each draw. In No. 5 it will be noticed that a plug is used. This is necessary to prevent the part represented by the plug from pulling loose from the die.

In drawing such pieces, if the thin portions crack or pull in two, the thicker parts are being drawn too fast, and if the thick parts crack along the edges, narrow up that portion of the die in order to cause the metal to stretch as much as the part not cracked.

In drawing some pieces open on one side, a plug let into one side of the die provides a form of tool which saves much difficult die work. In Fig. 130 is shown such a die and plug, which is intended to form and draw the moulding in one pull.

For convenience in construction, many dies can be made in two or more pieces, keyed up in a holder. Fig. 131 shows six forms of such dies, five of which are also provided with plugs.

By this construction it is possible to mill out the

PLATE LVII.

Fig. 129.

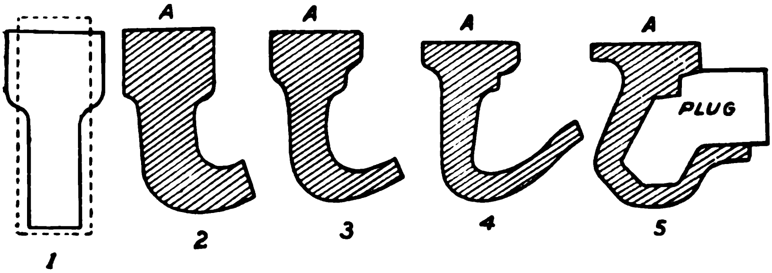


Fig. 130.

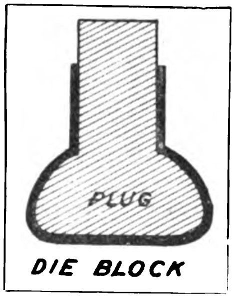


Fig. 131.

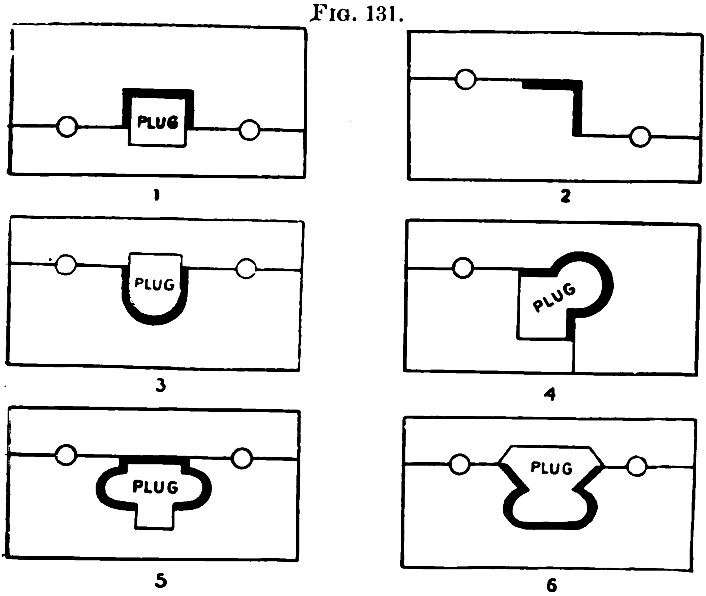


Fig. 132.

To face page 144.

shapes in the die to such an extent as to leave only a little filing to finish the dies. The round dowels between the joints in the dies are to prevent shifting of the parts.

Most tool-makers who fit tools for draw-benches, face off only one side of the die, and finish out the hole, principally as an item of economy. Unless it is desired to make the dies look pretty, there is no necessity of any more finish.

In drawing moulding pieces, strips which are folded up and are of various thickness on the edges or in the center, it will sometimes be found necessary to construct the dies to draw the work flat first, and fold up the piece afterwards.

Nearly all work coming from the draw bench will spring or bend, and must be straightened, which can be accomplished by running through calender rolls, or by bending by hand in the prongs of a wooden stake, the workman using the divine art of squint as a guide to accuracy.

Telescopic tube is usually mandrel-drawn to overcome any tendency to spring and to keep the internal diameter accurate, which varies somewhat with plug-drawn work. With mandreled tubing the mandrel is drawn through the die along with the tube and afterwards stripped or pulled out. The mandrels are turned, as in Fig. 132, 4 or 5 thousandths larger than they are to be when finished, draw-filed to remove all circular scratches, and then drawn through a die of the right size. The ends are turned taper and also flattened, and notched similar to the teeth of the grip tongs.

A set of dies for mandrel work consists of a drawing die, mandrel and stripping die, the latter made of hard brass or soft steel and just sliding over the mandrel. In drawing the tube the mandrel is pushed into the tube, one of the taper ends entering the pointed end of the tube and the grip hooked on, the jaws catching hold of both the end of the mandrel and of the tubing. After drawing on, the mandrel and tube are reversed or changed end for end, the stripping die slid on over the mandrel and the tube stripped off by catching hold of the mandrel with the grip. Owing to the difficulty of stripping very long pieces, telescoping tubes are necessarily made in short lengths, seldom more than ten feet.

After drawing the mandrel to size, it is best to return it to the lathe to detect any spring, which sometimes occurs. For lubricating the mandrel while drawing, use good lard oil with a little white lead mixed with it. You can also rub the steel with a solution of one part blue vitriol or sulphate of copper to twenty parts of water; this will leave a thin film of metallic copper on the metal, which, when drawn, will not only produce a very nice finish, but also prevent rusting of the mandrel when not in use.

Do not fail when drawing on the mandrel to thoroughly oil or soap it before each draw. The thinner the metal in the tube, the shorter piece you will be able to draw, owing to the tendency of thin tube to roll up rather than strip.

As commonly run with the tubes, lubricated by keeping in a soap tub, too fast a speed will heat the dies and cause them to cut.

For rapid work the bench may be provided with a pump to deliver the soap water on the die and tube, or strip being worked or drawn. The liberal supply of water thus insured will permit of speeding the bench about twice as fast as in the ordinary way. In order to keep the plug properly lubricated, it will be necessary to keep the tubes in the soap tub also before drawing as in the ordinary way.

Hydraulic drawing presses have many advantages over chain draw benches of equal capacity. The speed is entirely under the control of the operator, and the start may be made without shock. Work can be either pushed or pulled through the dies. For breaking down by pushing, the piston rod is made extra large for stiffness, and is thoroughly supported in all positions. If the press is intended for pulling only, the piston is returned without material waste of power, the only water used being that displaced by the piston rod.

In addition to the form illustrated, Fig. 133, there is made a style having the bed of same design as used on chain draw benches (for pulling only), having tongs or grip attached to cross-head, and arranged with extension to support triplet rod.

In size these presses vary from 6 to 24 inches in diameter of cylinders, and from 3 to 25 feet in stroke. All sizes are furnished with valves and couplings, and arranged to be directly connected to the supply pump, or with an accumulator, as desired.

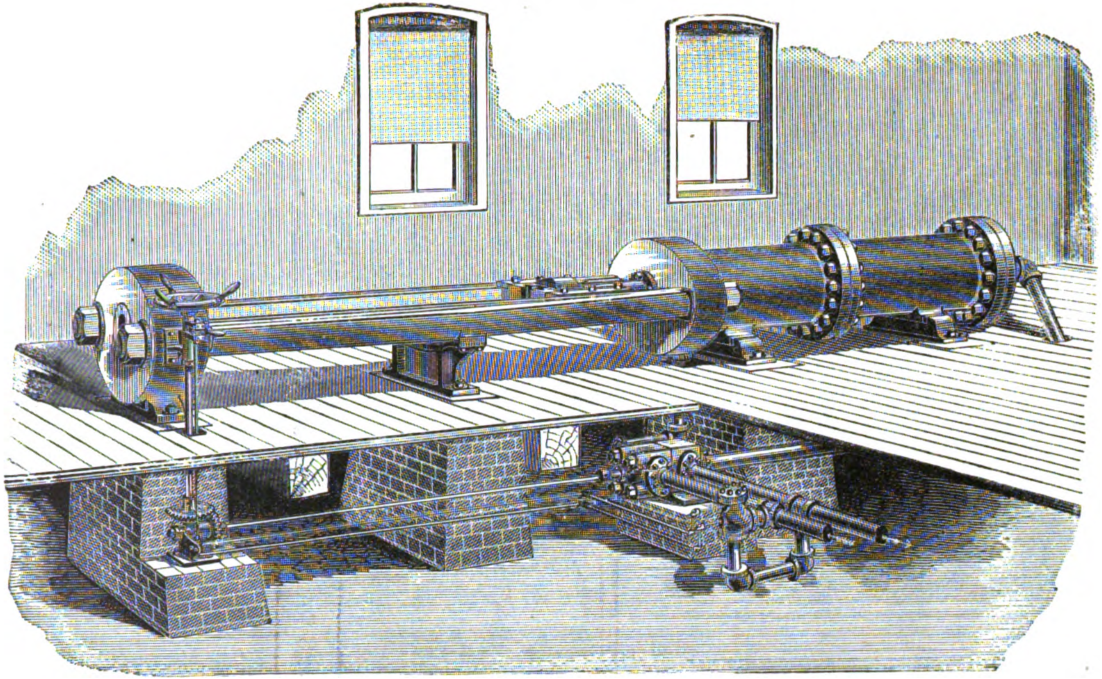
The illustration represents a press having a cylinder 22 inches in diameter and a stroke of 10 feet, with steel piston rod and cross-head, and arranged to be driven directly by a power pump.

The motions of the press are controlled by the hand wheel shown in front, which reverses the movement of the ram.

The press is instantly stopped at any time by a slight movement of the small handle which is located under the hand wheel, and controls a powerful hydraulic by-pass valve, allowing the pump to run continuously and the press to be started and stopped at will.

PLATE LVIII.

FIG. 133.



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CHAPTER XV.

CUTTING AND ASSEMBLING PIECES BY MEANS OF RATCHET DIAL PLATES AT ONE OPERATION.

So far as the die work is concerned, button tools and those for jewelery and similar articles, are, with the exception of size, the same as have already been described. One of the features, however, which is seldom employed in any other manufacture, is the liberal use of the ratchet dial and automatic feed to avoid hand work. This special feature, as applied to this branch, consists in cutting, stamping, forming and assembling all the pieces in a single operation, thus producing a finished piece, in some instances, from several different kinds of materials. Sometimes more than one dial can be employed to advantage, the pieces transferring from one dial to another, the holes in the two plates coinciding at one or more points for the purpose. As an example of such work, Fig. 134 shows a button composed of a brass eye plate or back, a zinc stiffener or filling, and an oxidized copper ornament or top. In the plan of tools and dial, Fig. 135, there are five separate sets of tools, and three of them are progressive dies arranged over the top of the plate. All three pieces are fed to the dies by a single feed roller, three check fingers acting as stops to locate the position of all the cuts. The scrap may be allowed to run into a box or can be wound on a reel. No. 1 at the first operation pierces the four holes or eyes; second, it cups the center portion, stamping or rounding all the edges of the holes, so that they will not cut the thread; third and last, it punches out the blank, forcing it down into the dial as shown in No. 1, Fig. 136. These holes in the dial plate are steel bushed, and have a shoulder just the thickness of the stock in depth, the balance of the hole being of the outside diameter of the finished button. No. 2, Fig. 136, punches a circular piece of zinc down on top of the first piece, the dial having shifted one hole for the purpose. This piece of zinc or stiffness is forced down a sufficient distance to turn up the edges of No. 1, pushing it down into the smaller diameter of the bushing. No. 3, first operation stamps or embosses the thin copper medallion or top; second, it cuts out the piece, pushing it down on top of No. 2; the dial having revolved as before. No. 4 turns down the rim on top of the two pieces, fastening them in place. In order to get a firm support for this operation, a support is raised up against the under side of the button by means of a wedge operated from the gate or ram of the press, this method being necessary to obtain a perfectly solid support for so heavy a pressure, and to permit of the free revolution of the dial plate. No. 5 pushes the completed button down through the dial and into a box to receive it.

Many buttons have the medallion or top folded on the under side enclosing the back. In such a case, the arrangement of the tools would be reversed, the eye-

PLATE LIX.

FIG. 135.

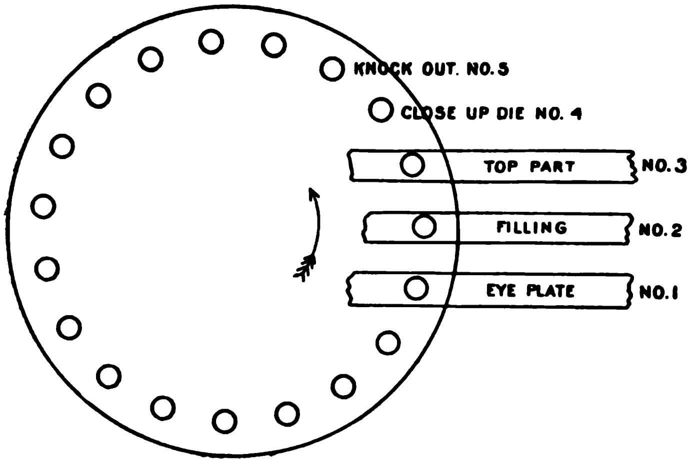


FIG. 136.

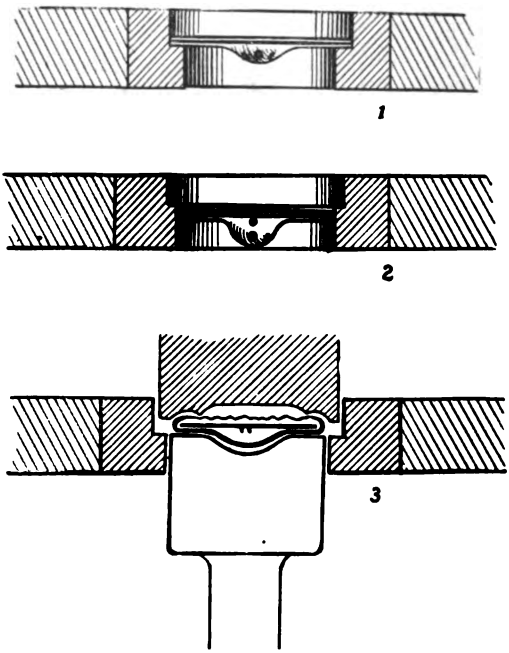
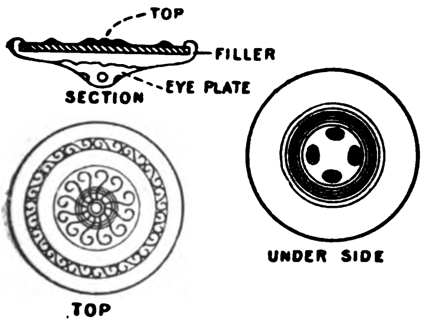


FIG. 134.



To face page 150.

plate being the last piece to be made, and the medallion is made the other side up. Work which is transferred from one dial to another, is in detail about the same as single dial work, the principal feature being the feeding of previously partly finished pieces into the holes in the lower dial, either by hand or automatically. One of the reasons for such a necessity is that many parts may have to be brazed or soldered, or be finished or polished between some of the operations.

As a means of rapidly handling work for piercing or performing secondary operations not possible with compound or progressive dies, the dial plate offers advantages too often overlooked. For perfectly round pieces, which do not require to be set in any particular position, except centrally, a friction dial may be conveniently used, it being necessary however to provide a second slide or feed bar working at right angles to the regular one, for the purpose of pushing the finished pieces off from the die.

Another variation of this fixture consists in bending wire into numerous forms. The simple piece illustrated in Fig. 137, requires only two operations. The wire is fed between straightening rolls against a stop, and cut off, and the ends bent up at one stroke. The next revolution of the dial brings the wire under another punch, which pushes the wire down through the second or smaller diameter of the hole, bending the two ends together. The punch that performs this last operation, Fig. 138, is cut away in a diagonal manner, which, when the punch returns upwards, strips the link downwards and sideways, and free from the punch.

CHAPTER XVI.

THE HEADER.

VARIOUS forms of headers are in use for a number of purposes. The dies of such machines are made both open and solid, and the machines are constructed to head the blank in two strokes. Solid die machines are usually double-stroke, rivet or screw-blanks, having only a moderate amount of stock upset into the head, being made in them. To get the wide flat head seen on copper and other flat-headed rivets, requires a double blow to prevent splitting or cracking of the stock, and also to obtain uniformly round heads. In open die headers the stock is commonly cut off after the head is formed. In the operation of the machine, the dies open and the feed-rolls advance the wire or rod beyond the face of the die, sufficient to form the head, when the dies close and the ram or gate upsets the head. If a single-stroke machine, the gate returns, and a shear working against the face of the die, cuts the rivet off as it is advanced forward the proper length. In all headers, Fig. 139, the cut-off plays a most important part, as upon it depends the perfection of the result. If in cutting off the rivet the end of the wire be jammed out of

FIG. 137.

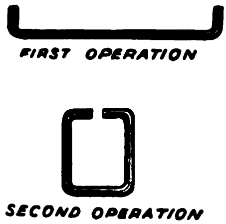


FIG. 138.

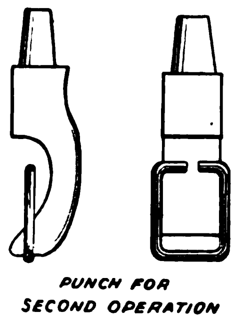
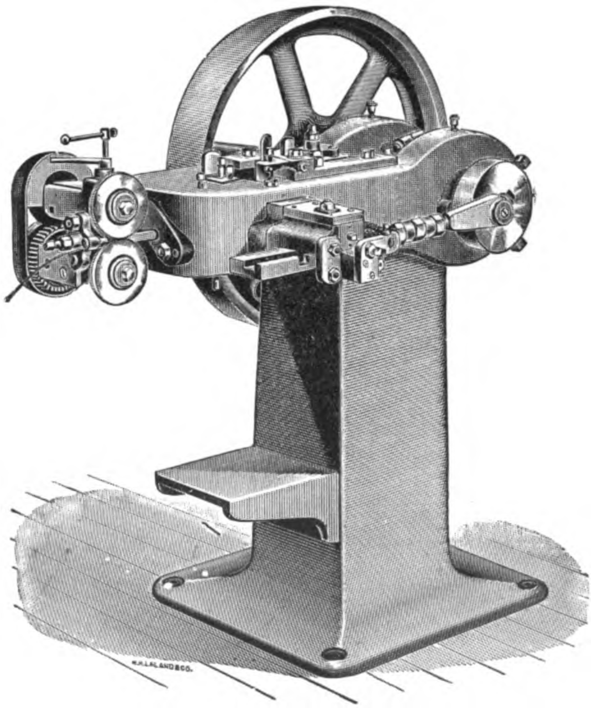


FIG. 139.



shape, a one-sided head will surely be the result, this being especially true of single stroke machines.

In the operation of solid die machines, the stock or wire is passed through a cut-off die situated at one side of the heading die, where it strikes against a stop for length, and is cut off by a shear or knife having a spring or springs to retain it against the end of the knife, while it is carried opposite the heading die by the continued motion of the shear, and forced into the die by the first stroke, and further flattened by the second blow of the gate or ram. A knock-out pin working through the back of the die forces the finished rivet out as the gate returns after making the last strike.

There are two sources of trouble attached to the solid die machines, Figs. 141 and 140, viz., the wearing of the dies and the difficulty of keeping the springs in order. When the springs become somewhat worn, the piece of wire will not be carried forward straight, and will sometimes even flip out of the grip of the springs altogether. Keep the cut-off bushing sharp, as well as the knife, and look to it that the springs hold the blank squarely in line with the die. Solid dies should have a shoulder formed by drilling the die just the length of the rivet under the head, and then drilling the balance of the way with a smaller drill. This slight shoulder is sufficient to cause the rivet to check at even lengths during the first stroke. In all double stroke machines the first die should have a cup-shaped recess for partially bringing the head into shape. This cup must only be large enough to contain the amount of stock in the head ; the second blow must be carefully gauged as to distance to prevent opening or spreading of the stock.

In finishing both the solid and open dies, a half-round reamer will be found a very convenient tool to make, and a very efficient tool to use, especially on small sizes.

In making open dies, a clamp for holding the dies together is very necessary, the drilling and fitting being done just as if the die were a solid piece.

There are many special forms of headers, one example, Fig. 142, of which is given.

The upsetting machine has a special clutch action instead of a roll feed, made necessary in order to have the pieces remain straight after passing through the straightening rolls.

The other form of machine, Fig. 143, is not automatic, as it is intended to head the ends of long rods, either at one or both ends; such pieces as stove bolts, bicycle spokes and similar articles are within its range.

The following description of the different styles of machinery built for the making of rivets by cold heading will give a fair idea of the particular class of work each machine will make:

Fig. 139. *Open Die, Single Stroke Headers.*—These machines are designed for heading wood-screw blanks and tire bolts, or for any kind of iron work intended to be trimmed or shaved after heading. They are also suitable for making rivets upon which the necessary

PLATE LXI.

FIG. 140.

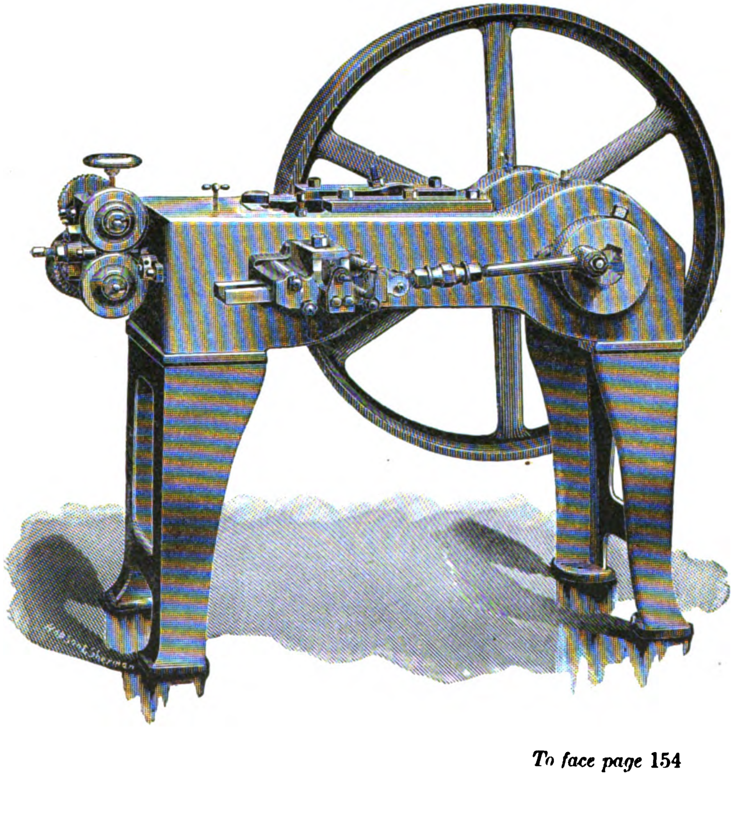


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PLATE LXII.

FIG. 141.

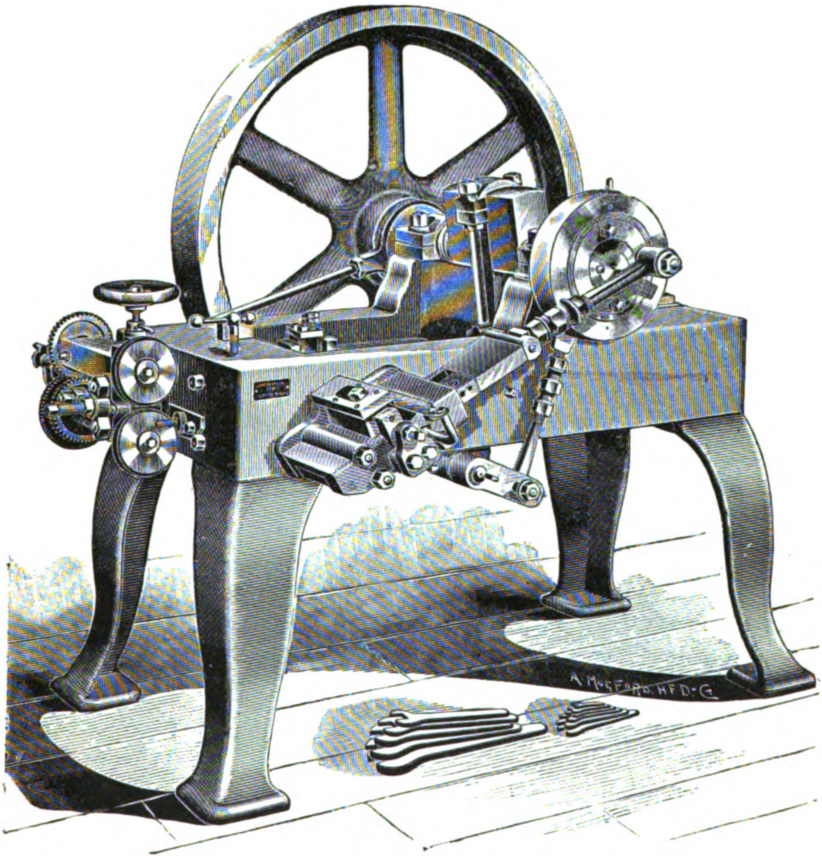

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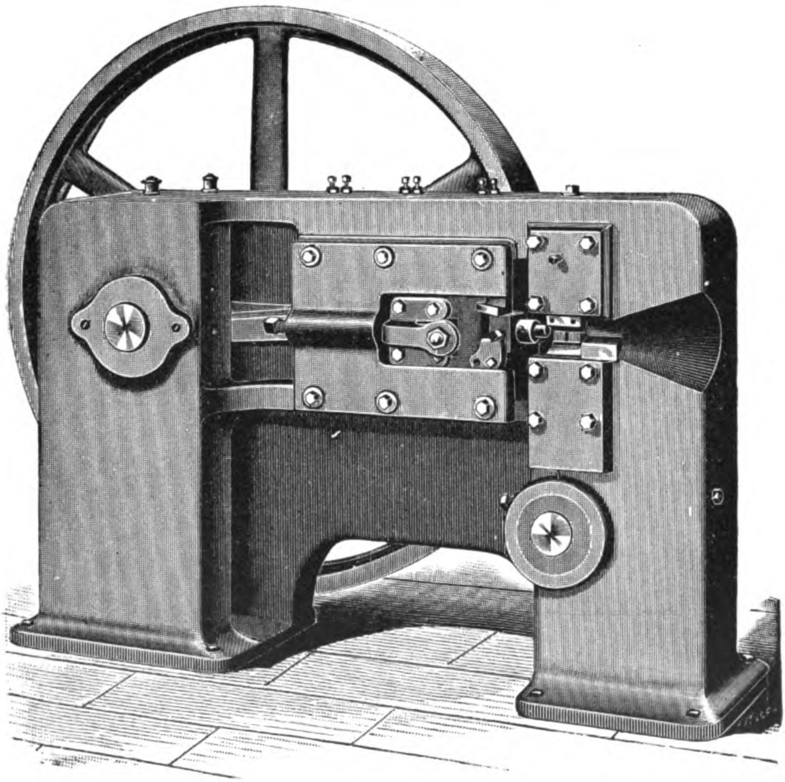
PLATE LXIV.

FIG. 143.



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mark or fin left by the dies will not be objectionable. For some kinds of small work—especially brass rivets—the dies can be so nicely adjusted as to make rivets upon which the mark of the dies will be hardly perceptible, and considering the rapidity of the process it will be found preferable to the solid die.

Fig. 140. *Solid Die, Single Stroke Headers.*—Rivets to be made in solid dies should not, as a general rule, exceed in length over seven times the diameter of the wire on account of the difficulty of driving them out of the die after heading, but this limit may be exceeded in some cases, especially with double stroke machines. The single stroke, solid die headers are suitable for making all kinds of rivets and screw blanks of moderate length and size of head, upon which the mark of open dies would be objectionable.

Solid Die, Double Stroke Headers.—This class of machinery is adapted for making all kinds of copper and brass rivets, especially those requiring large heads which cannot be made with a single stroke. These machines are suitable for making many kinds of screw blanks of either iron or brass.

Fig. 142. *Solid Die, Double Stroke, Geared Headers.*—This class of machine is especially designed for heading machine-screw blanks, iron rivets having large, true heads, and for making many kinds of bolt blanks and rivets which have heretofore been made by the hot process. They differ from the plain, double stroke machines in having bearings of increased size, and a

crank shaft making two revolutions instead of one for each blank, and by having two fly wheels, whereby the strain upon the crank is distributed upon both sides, giving the machine greatly increased heading power. These machines will produce work with true, smooth and solid heads of large size.

Open Die, Double Stroke Headers.—These machines are designed for long work, such as cannot be driven out of solid dies, and requiring heads too large to be made by a single stroke.

PLATE LXIII.

Fig. 142.

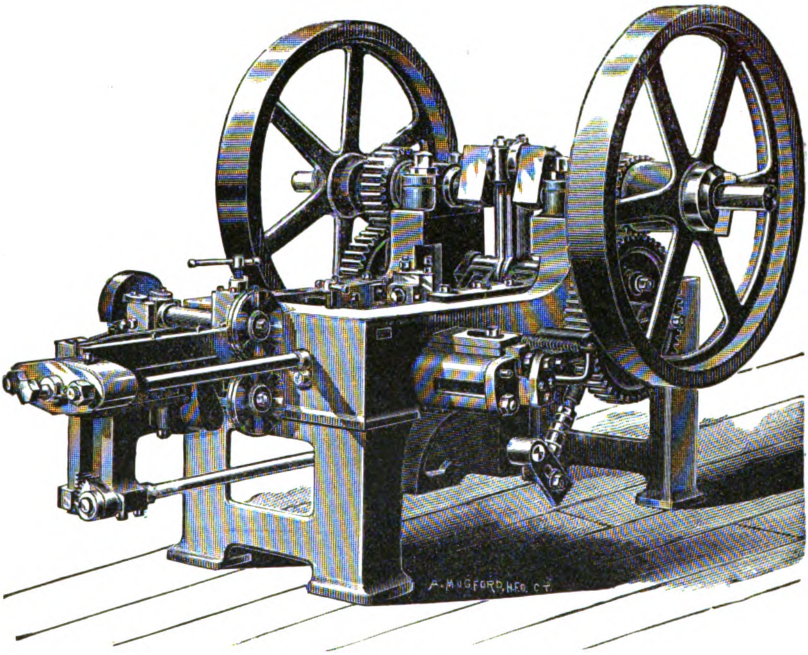
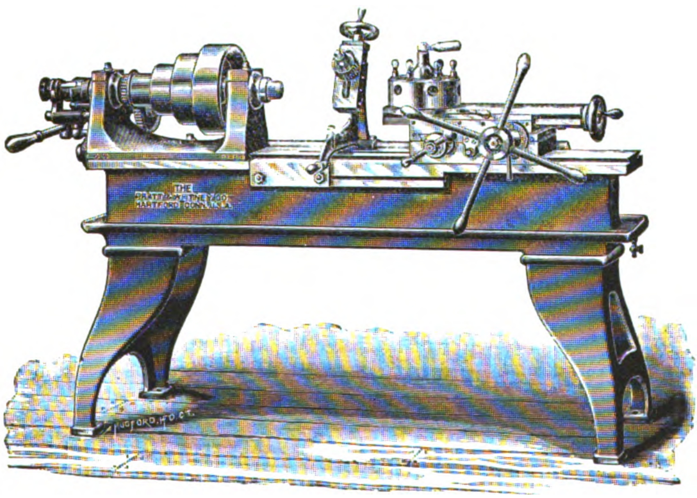


Fig. 144.



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CHAPTER XVII.

TOOLS FOR FOX LATHE.

THOUGH the Fox Lathe is no more than a monitor or turret lathe, with special features, it deserves some mention, as it is almost exclusively in use by brass finishers. There is, however, a growing tendency to make it almost a universal favorite in many shops using engine lathes for turning out short work. For small drop forgings and castings of iron or brass, this tool, Fig. 144, has no equal for efficiency. The friction cut out, between the back-gear and belt-speed, the heavy cross-slide, chasing-bar for cutting threads, monitor tail-stock with hand-lever feed, and screw feed in both directions, making of the monitor not only a revolving tool-holder, but a slide-rest as well, are the principal features causing its coming favor. For cutting short threads either inside or out, the chasing-bar is without doubt the most accurate and rapid fixture except a tap or die. As a chucking device, it is customary to use a two-jawed chuck, with removable jaws, boring or shaping out the face of the jaws to fit the work. By means of the hand screw-feeds to the turret-slide, pieces may be bored out, faced off, counter-bored, a tool run through and the back face finished, or any other internal or external turning or lathe work accomplished that is possible to do with a slide-rest. Not a small feature, is the use of forming-tools, either fixed in the turret or cross-slide, for uniformly producing irregular shapes. For reaming out, or finishing straight holes, a half-round gun-drill seems to do not only good work, but maintains its size longer than any other form of tool. There are few tool-makers who, once their attention is called to it, but will readily adapt a large variety of work to a monitor lathe with chasing-bar and slide-rest combination. A great many well informed workmen, however, habitually when cutting or chasing threads, run the lathe forward. Such a method is wrong, as it was not only the intention of the inventor, but also of most makers, to run the lathe backwards when cutting a right-hand thread; backing the chasing-tool out of a hole or away from a shoulder. At first thought it may seem as though such a method would cut a left-hand thread; such, however, is not the case. All the tools recommended as useful for the screw machine may be equally well employed with this machine. Die and tap-holders with trip, box tools, butt-mills with adjusting clamp collars, taper turning or boring tools, are a few useful fixtures. Different makes of lathes have various methods of returning the slide to the central point, all of them being perfectly satisfactory. In chasing threads on brass, if it is desired to have them smooth, a chasing tool similar to a hand-chaser should be used.

CHAPTER XVIII.

SUGGESTIONS FOR A SET OF TOOLS FOR MACHINING THE VARIOUS PARTS OF A BICYCLE.

THOUGH many of the features shown and described in the following pages have become back numbers as parts of the modern cycle, much of the detail of tool construction is of such general utility as to be worthy of more than passing notice. Not all of the tools are of the author's designing, but were the result of a composite effort through the medium of about twenty workmen.

For convenience of reference, each piece is both numbered as well as named. No drawings of the fixtures are shown, but occasional reference is made to some other portion of this work where tools of the same class have been described.

Fig. 145 is a finished Crank Hanger, and the method of "Jigging" the piece has already been described under the head of "Box Jigs."

Some more detail may, however, be added regarding the origin of the forging.

The forging for this piece was worked out of a rolled bar, see *C*, Fig. 146, which is a cross-section of the bar as received from the mill. The bar was first cut into lengths for one hanger, and then trimmed into a rough shape, as at Fig. 147, in a heavy trimming-press, used in conjunction with a drop-hammer. Note that the projections have been produced by cutting away the stock at *a-a*, *b-b-b*, in dropping this piece. Note the parting line of the die *A-B*, Fig. 146, and also that the part *2*, *A*, Fig. 146, must be very tapering to "draw" from the die readily.

Fig. 148 is the crank shaft, and was "formed up" from a solid bar of steel in one cut, the face of the tool having the exact shape of the piece. At first glance, those who have never tried forming tools for such work will doubt the practical working of such a tool on so slender a piece.

The operation is as follows: After having set the tool in the holder, the rod is gripped in the chuck the first time, in such a manner as will allow only a short piece to project, which short length is formed or shaped to size, to provide a steady rest center for the first perfect piece. The rod is now advanced the length of a completed piece, plus the thickness of the cut-off tool. To the forming-slide, and on the side away from the headstock, is fastened a hinged steady-rest of very solid construction, and in this steady-rest will be held the short piece first turned up. A careful study of this arrangement will develop two features: First, that the tool or forming-slide can not get away from the piece; and second, that the first piece turned up acts as a center for the second while it is being turned up.

Some machines have an extra slide provided with a

PLATE LXV.

FIG. 145.

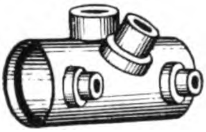


FIG. 147.

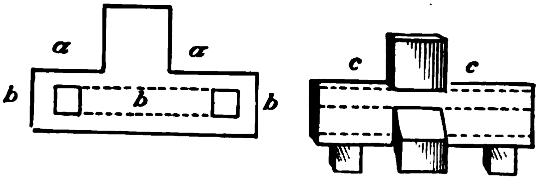


FIG. 146.

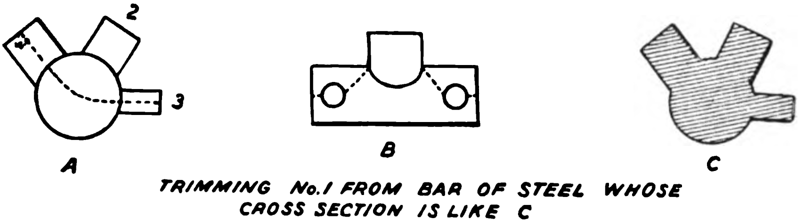


FIG. 148.

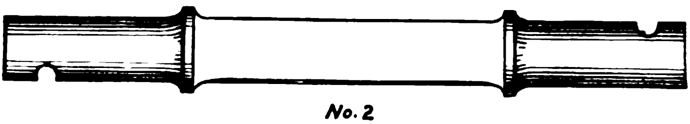


FIG. 149.

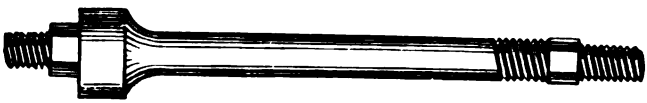


FIG. 150.

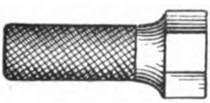


FIG. 151.

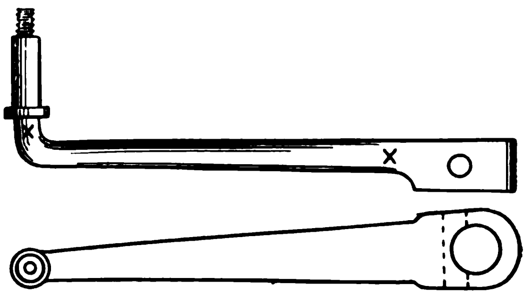


FIG. 152.

To face page 160.

cut-off—some have a hack saw arrangement, and some manage the cutting off with a special fixture fastened to the turret slide. The two slots or key ways were drilled out in a small jig having a sleeve which is fitted on each end against the shoulder.

Fig. 149. Rear bearing is formed up in the same manner as Fig. 148, but presents some difficulties in the way of milling and screw threading.

The longer portion with the two diameters may be turned up at one cut—cutting the threads on the first piece while the second is being formed. The short end can best be reached by a second operation, rechucking the piece for the purpose.

The hexagon portions for wrench holds were milled in a small hand milling machine.

Fig. 150 is also a formed up piece and is check knurled, and also drilled out and tapered at the larger end to act as a combination nut and step. All the operations on this piece, except milling the nut, were performed at one chucking. Afterwards hexagon stock was used, which made it possible to complete the piece in one setting.

Fig. 151. *Crank for Left Side of Machine.*—This piece is first drawn out under a trip hammer, and dropped to size and shape while straight. The crank is bent over after dropping and trimming.

All the rest of the work is executed with a box jig, having one open side. Clamp piece in open side, using points marked x as contacts, Fig. 151, which will center and square piece both ways. Drill small hole for key first, ream tapers with half round reamer. Next drill small hole with suitable bushing, in center and direction of hole which intersects key-hole. Remove bushing, and with pin drill and combination reamer counter-bore to full size; facing inside of crank square. By using a small hole and counter-bore, there will be no danger of dodging. For a fine fit this hole should be hand-reamed atfer leaving the drill press. Next mill down roller bearing with hollow butt mill having an outer projecting part to mill off the collar at the same time. This mill should run through a bushing to insure accuracy. Mill off threaded part with butt mill, having a guide to go down over the bearing, which will insure the thread being central with the larger part. Thread with trip-die holder, having press provided with a reversing attachment for the purpose. All the other work is best finished upon a polishing wheel. List of tools consists of: Box jig; taper reamer for pin; combination pin drill reamer and facing tool for large hole; hollow mill for turning off pedal bearing and collar; mill with advance guide for milling threaded portion; die for cutting thread; gauge for diameter of bearing; gauge for thread; gauge length of pedal bearing; taper plug gauge for gauging taper holes; gauge for thickness of part fitting crank shaft. The taper plug for determining the size and depth of taper hole should have with it a plug fitting in the large hole, and having milled in its side a key way accurate as to depth and distance from the end. This will insure the accurate fitting of the pin, care being taken to have the key way of such size as will cause the pin to bind between it and the hole in the crank.

Round-Taper, Steel Key, with Smaller End Threaded.—Fig. 152. Mill up in the screw machine from polished steel drill-rod, with a box-tool having broad cutter and guides, both ground taper. Thread end and cut off with slide. List of tools: Hardened fac-simile of end of shaft and crank to act as try-gauge; Taper-cutter and guide for box-tool; Die for cutting screw, with hardened steel collar-gauge to maintain uniform size.

Steel Balls.—Though steel balls of uniform size and nearly perfect temper can be had in the market much cheaper than they can be made in small quantities, the method employed by the author for making balls of both large and small diameter, is submitted.

Tool steel of the proper diameter is either cut off with an automatic or hand screw-machine, using two tools in cross-slide. The first tool turns one side of the ball, and rounds up the end of the rod, forming half of a ball on each side of the tool. This tool is flat on the end, and leaves the ball still on the rod. The second tool is narrow, and cuts into the small part left unturned by the first tool. See Fig. 153. Where only one tool is used, the strain of taking so wide a cut as half of the ball, will tear it loose from the end of the rod. The small amount of surface presented by the cutting edges of the second tool, causes it to cut the ball off nearly perfect. To get nearly uniform work, Pratt & Whitney tools, which can be ground without changing their shape, are to be preferred. After turning, examine for any small projection where cut-off tool makes the last cut, and file or grind off level if need be. Harden by placing in wire basket and lowering into lead bath, heated to dull cherry red, and plunging basket and all into hardening pickle, violently shaking till cool. Draw immediately in oil bath heated to 480° F. The object of drawing at once is to relieve the strain from hardening just as soon as possible, thus preventing chips from scaling off, and the developing of fire cracks.

The grinding machine is a modification of the old German method of making marbles, and consists of a horizontal grooved wheel, Fig. 154, which contains the balls, and has running above it three inverted cups or ring emery wheels. The arbors on which the emery wheels are fastened rest in a fixed step at the bottom, but should be allowed a slight vertical liberty. The circular grooved table is adjusted by an elevating step or lower bearing. The emery wheels should run at the cutting speed advised by the makers, and the grooved wheels from ten to twenty revolutions per minute. The direction in which each of the parts runs is denoted by the arrows. See Fig. 155. The whole of the upper part of the machine should be encased by a rim, as the grinding is all executed with the grooves full of water, a small screw pump operated from one of the emery wheel arbors furnishing a continuous stream on the center of the grooved wheel. It is well to use soda water to prevent rusting of both the machine and the balls.

PLATE LXVI.

Fig. 153.

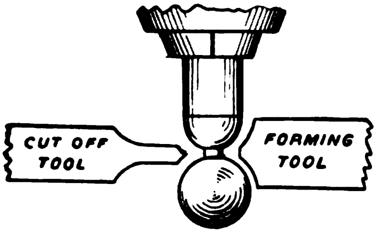


Fig. 154.

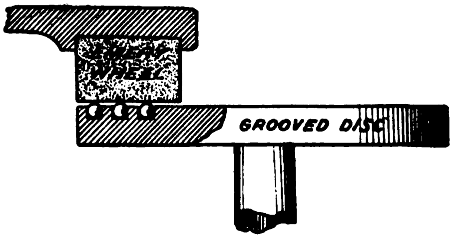
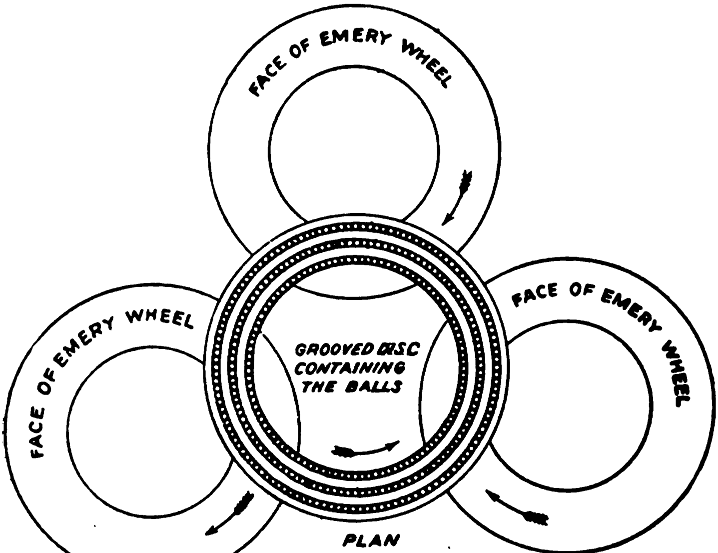


Fig. 155.



PLAN
DIAGRAM OF GROOVED WHEEL
AND CUP-SHAPED EMERY WHEELS
FOR GRINDING BALLS.

Fig. 156.

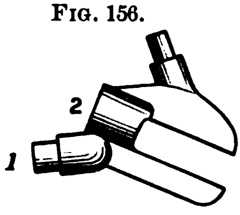


Fig. 157.

END VIEW OF FIG. 189
SHOWING PARTING LINE
OF DROP DIE.

To face page 164.

To start the machine, charge the grooves with balls for about nine-tenths their circumference, and start all the parts to revolving, being careful that the emery wheels do not touch the balls till everything is in motion. Then gradually raise the table till the wheels begin to cut, quite hard at first, and very light as the balls get near to size. One of the balls can be removed occasionally and measured with a micrometer without stopping the machine. The constantly changing direction of the balls, the grooves and emery wheels, brings every portion of each ball in contact with the emery wheels, causing them to be reduced in size very much faster than would be supposed. Grind to within 2½ thousandths of finish-size with wheels of No. 100 grade. Grind again to within ½ thousandth with wheel of 160 grade made very hard. To give the final polish, tumble in barrel with fine cork saw dust and rouge till the final size is reached. For balls of ¼ inch diameter, the size as turned in screw machine should be .260, first grind, .2525; last grind, .2505; and the final finish, .250 inch.

The grooved wheel and emery wheels should run very true at the start to get quick work, but after the machine has had a few charges of balls, everything will naturally true itself. The grooves should be about the depth of the diameter of the balls, and a loose fit sideways. A machine having a grooved wheel of 24 inches diameter with 6 grooves, and containing about 1,500 balls at one charge, will grind out a charge in less than 30 minutes for each grade of wheel, the capacity of the machine being about 12,000 finished balls per ten hours. The only special tool for this machine is a wheel for each size of ball.

Rear Wheel and Tube Connection.—This piece, Figs. 156–157, is first punched out of steel in thickness about the diameter of the thickest portion, and then dropped and trimmed to size. In dropping this piece only one drop and trimming die will be required, as the shape of the piece admits of alternately dropping and trimming till the dies come together without leaving any flash or fin. The two halves of this die are right and left duplicates, the parting of the die being shown in Fig. 157 by dotted line.

The round portions 1 and 3, Fig. 156, intended for rear fork and brace connections, were milled off in a small box jig having three surfaces or sets of feet. At 2, Fig. 156, there was drilled and tapped the hole for the chain tightening screw. It was found most practicable in this instance to tap the hole at a separate operation in a small hand tapping machine. As the drop hammer work on this piece was very perfect, no other machining was found necessary.

Fig. 158. *Tube Connection for Frame, with Clamp for Seat.*—Piece punched out and dropped in same manner as Fig. 156. Drill out 1 and 2 to outside diameter of tube in box jig. Drill and face off both sides of 3. The slot in this is milled after frame is brazed together. Tools required: Blanking die, combination drop and trimming die, box jig and counter bore.

Fig. 159. *Top Part of Frame.*—Tube sawed or cut to length in cut-off machine. The flanged end which goes around and is brazed to top of head, stamped hot with die in knee-press, and trimmed to shape in trimming-die. It is necessary to provide a support for the lower end of this tube while forming the flanged connection, and also to have the die hinged in order to get the tube in and out. You may, however, fit both the stamping and trimming die in the slide, but you will have trouble in getting the tube out of the forming die, unless it is made open. Tools required: Gauge for exact length; Die for forming end; Die for trimming end.

Fig. 160. *Bushings for Rear Wheel Bearing.*—These pieces may be turned from the solid in a screw machine, or drawn up from sheet steel. When made in screw machine, the stock is box-tooled off to outside diameter, and then drilled and milled with counter-bore mill of correct shape, cutting off with cross-slide. Where the pieces are drawn, they should be carefully annealed, and then gripped in draw-in chuck collett, and reamed out to size and finish. Pieces made in this way, of good steel, if not too high carbon, will be found equal to any. Sheet steel rolled from open hearth billet, and hardened with prussiate of potash, if drawn to a deep straw color, will stand the rolling of the balls, and will not break or crack open from pressure. Tools required for machine turned bushings: Gauge for diameter and thickness; Combination counter-bore and reamer. For the drawn bushings: A drawing die; A die for punching out the

hole; and the same gauge and reamer as would be required for those turned from solid steel in a screw machine.

Fig. 161. *As this Hub is shown*, it consists of a straight piece of steel tubing, with drawn steel flanges forced on at each end. If properly done, no brazing will be needed, but brazing will insure the improbability of the flanges ever becoming loose. The flanges are made with single-acting press and progressive die in three operations, as follows: Pierce hole, draw hub with taper punch, cut out outside diameter. The piece of tubing can be cut off, milled to the shoulder on long end, and counter-bored, and threaded left hand with die. Cut off and reverse in chuck, and mill up short end and counter-bore. Force on flanges with press, one end at a time. Put the hub on expanding collett in screw machine and trim up flanges with tools in cross-slide, being careful to have flanges of same diameter. To jig the 18 holes in each end, turn up a standard or mandrel to fit counter-bore, having solidly fastened at one end a circular jig-plate, with 18 bushed holes the size of the spoke heads. The removable plate should be fitted to the end of the mandrel with square end, having the square small enough to allow of a hub on the under side of the plate fitting into the counter-bored end of the tube. Fasten down the plate with a round nut, having a milled edge, to be turned on and off with the hand. The holes in the circular jig-plates are not opposite each other, but just half way between, 18 holes in each flange.

FIG. 159.

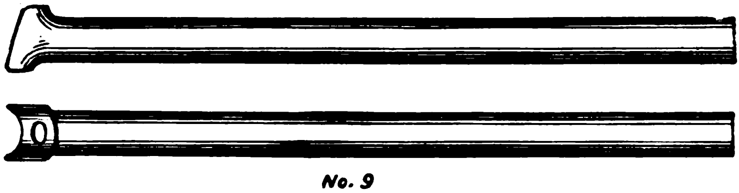


FIG. 161.

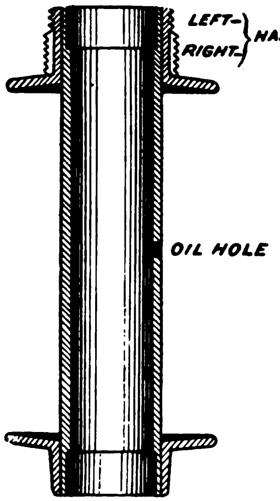


FIG. 158.

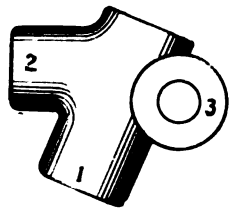


FIG. 160.

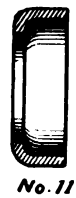


FIG. 163.

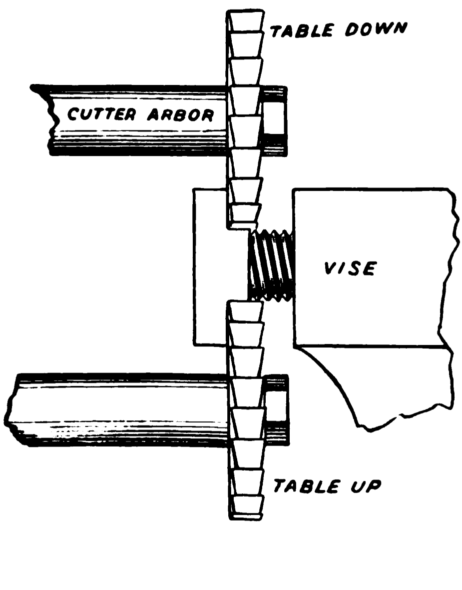


FIG. 162.

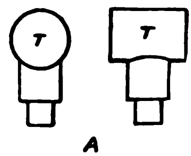
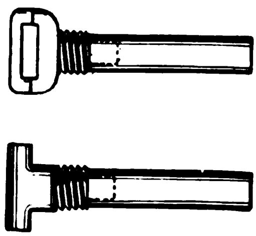


FIG. 162.



To face page 168.

The right hand thread cut on the hub of flange for screwing on the small sprocket, may be cut on with a die, holding the hub on expanding mandrel in the screw machine, or may be chased on with a chasing-bar. Tools required to complete hub: Counter-bore for inside of tube; Progressive die for stamping hubs; Jig for drilling hubs; Set of tools to go in cross-slide for trimming hubs; Die for forcing flanges on tube; Left hand die for cutting thread on tube; Right hand die for cutting thread on one of the flanges, to be dispensed with if thread is chased on; Gauge for size of counter-bore, outside milled off portion of tube, full length of tube, and length of counter-bores; and screw collar gauges for each of the threads.

Fig. 162. *Seat Post.*—Made of two pieces. Short piece of tube whose outside diameter is equal to diameter of the inside of frame upright, and forging dropped first in the shape of *A*. The piece is first upset in bolt header, and then dropped and trimmed to finish size of *A*. Next a hole is drilled through the *T* part, and the *T* heated and slightly flattened at first blow; a drift with taper end driven into the hole, and then by alternately driving the drift, and with light blows of the hammer, the slot in the *T* is finished. The part fitting into the tube is then milled by holding in a two-jawed chuck on screw machine, the hole bored to obtain lightness, and the threaded part milled and thread cut on with a die. Brazing on the short piece of tubing and milling away the under part to permit the clamp, Fig. 164, to grip the

under side of the seat spring. The milling away of the under side can best be accomplished by catching the piece in special jaws of hand milling machine, see Fig. 163, setting the table to stop up and down, milling the top side when table is down and the lower side when table is up. Tools required: Drop die with drift; Drop die to shape up *T* round; Mill for part fitting into tube, mill for outside of thread; Die for cutting thread; Jaws for two-jawed chuck; Jaws for vise of hand milling machine; Small milling cutter, fitted on end of arbor, and screw collar gauge to keep thread constant in size.

Fig. 164. *Clamp Washer to Hold Seat-Bar or Spring.*—Punched out cold, and then turned up at the ends with drop die while hot. The piece is then dropped into plate jig having proper shape to keep from turning around, and the hole reamed to size, and flat side faced off at the same operation.

Tools required: Blanking die made progressive to punch hole in center; drop die to form up ends, and combination reamer and mill with jig holder to ream hole and face of the flat side.

Fig. 165. *Pedal Hubs or Bearings.*—Blanked out, drop forged, and trimmed to shape.

Owing to the counter boring of the bearing, it will be necessary to bore it out in a lathe or monitor having a cross feed attachment to the turret slide, holding the piece in a two-jawed chuck fitted with suitable jaws. This counterbored hole can then be used as a means of fastening the piece in the jig, while the hole which receives the pin that fits in the pedals is drilled up and the end faced. The bushings of the jig are then changed and the rivet holes drilled. As there is no adjustment to the bearings of this pedal owing to the small wear of the large bearing surfaces, it is necessary that the counterbored part be kept very uniform in size. A very neat gauge for gauging counterbored holes is shown in Fig. 166. It consists of a bushing in three pieces, cut sufficiently open to permit of their insertion, and a taper plug fitting a corresponding taper inside the bushings. A very slight variation in size will cause the plug to enter more or less, as the hole is larger or smaller. By making the plug one-hundredth of an inch taper in ten inches, each one-tenth of an inch movement of the plug will denote a difference of one-thousandth inch. This form of gauge will be found handy for many other kinds of hole as well, and especially in gauging all holes of irregular shape.

Fig. 167. *Rat Trap Pedal.* — Owing to length and numerous bends, several operations are required to finish up this piece. With a sufficiently large press it would be possible to pierce all the holes, and make the bends at the end at one operation. Lacking the large machine, you can blank out the piece, then pierce the holes, and bend down the ends at the second operation. It can then be bent at the two center bends forming the complete circle. The bending over of the part designed to keep the foot from slipping sideways can be accomplished on a horn die placed in the knee press. The

fastening of the loose ends is accomplished by riveting the ends together as shown by the holes. It is intended that there be spring enough to the sides to spring on over the pins on Fig. 165 when putting the two pieces together. The opening where the two ends come together must be of sufficient size to admit of passing the pedal over the collar on Figs. 151–184. Tools required: Blanking die; combination piercing and bending die; die to bend two center bends; horn die to bend outward side guards. Fig. 168 shows the finished pedal.

Fig. 169. *Cap Nut for End of Crank.*—Made from the solid in screw machine. The slot across end for reception of screw driver can be sawed or milled in with either hand milling machine or screw slotter. Tools required: Tap; pair of jaws for vise of milling machine.

Fig. 170. *Front Brace to Saddle.*—Punched from steel with progressive die, and afterwards dropped to shape. Hole tapped in tapping machine, or drill press having reverse motion. Tools required: Progressive die; drop die and tapping fixture with tap.

Fig. 171. *Rear Brace to Saddle.*—Owing to the length of this piece, it will require three operations, one to blank out and one to pierce the holes, besides a drop die to form up. The tapping may be done with tapping machine without special fixtures. Tools required: Blanking die; piercing die; drop die, and the same tap as was used on Fig. 170.

Fig. 172. *Left-hand Jamb Nut for Locking Sprocket Wheel on Fig. 161.*—Owing to large diameter and thin gauge, it

Fig. 164.

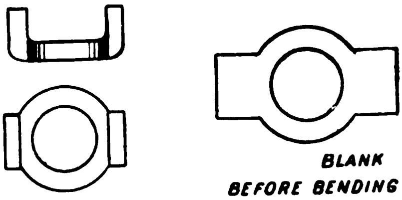


Fig. 165.

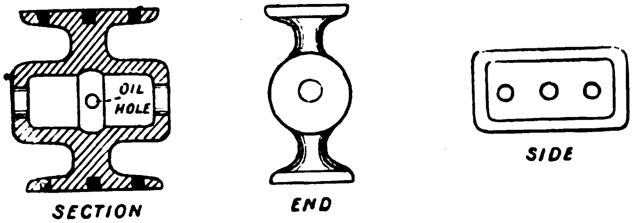


Fig. 166.

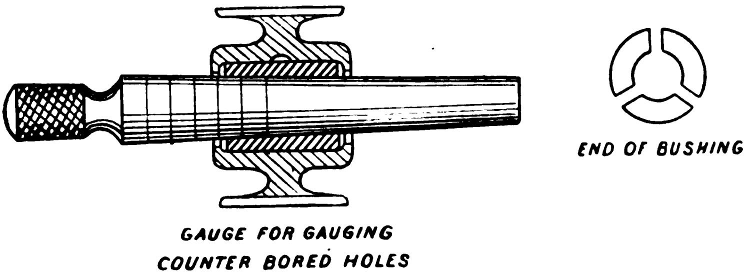


Fig. 167.

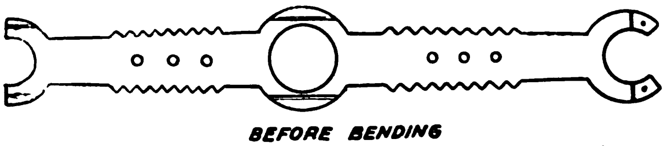


Fig. 168.

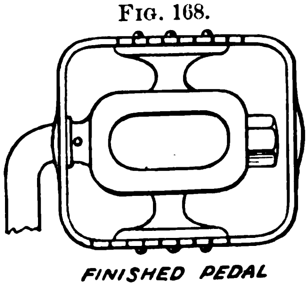


Fig. 169.

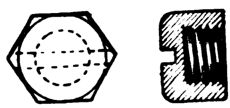
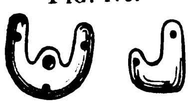


Fig. 170.



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will be found advisable to punch this nut from sheet steel with a washer die, afterwards facing off and tapping in screw machine. Tools required: L. H. tap; progressive die; collett for screw machine.

Fig. 173. *Small Sprocket for Rear Wheel.*—There are two methods of dropping this class of piece: One the way we have already explained, to blank out and afterwards drop, and the other to drop first and afterwards trim to shape. This latter method has the merit of being the cheapest way to get up the tools, but does not produce so good work. An excellent way to get out a wheel die is to bore a hole part way through the die block, the diameter of the outside of the teeth, and fit into the hole a piece of steel with one-half the form of the wheel cut into its face. This method permits of the boring and milling of the die very quickly, and also provides an easy means of renewal in case of injury. Extra care must be used to get the jaws true in the chuck which holds the wheel while the hole is bored out and tapped. To turn up the wheel quickly, fit a short stiff center in the head of screw machine with a screw on its end which will fit the wheel. Bore and carefully ream a hole about half the diameter of the screw in the center, and about two inches deep. Make a tool for the turret, having a pin to nicely fit this hole, and fit over it a mill having in its face the shape of one side of the wheel. Chuck the wheel by screwing on the center, and mill the entire surface at one cut. When the wheel is first bored and tapped, one side of the hub should be faced off and used as a square

surface against which to screw the wheel when milling the second side. In milling the first side, set a stop to gauge the cut, and go over all the wheels on one side first. Afterwards screw the wheels on the other way, and mill the wheels on the opposite side, setting the stop to gauge the thickness required. By this method all the wheels will be alike and will run true with the thread. If it is desired to mill the sprocket teeth, make several bushings that will screw into the wheels, and which are just a little shorter than the length of the hub. The hole in the center of the bushings may be as large as will leave the bushings of sufficient thickness for strength. By means of these bushings it will be possible to put a number of wheels on a mandrel at one time, and set the teeth all in line, cutting the teeth either in an automatic gear cutter or milling machine. Two sets of bushings and mandrels will enable the workman to be fitting up one while the other is in use. Tools required: Blanking die; trimming die, chuck jaws; tap; facing and turning mill with screw center; bushings and mandrel for holding while cutting the teeth; gear cutter.

Fig. 174 is the forging for fork crown, and needs care as to size in forging. The oval parts where the forks are brazed on need to be right in this particular to avoid too much fitting. The hole can be drilled and afterwards used as a guide from which to shape up the ball seat, all of which comes in as jig work. Another way was to grip the piece in a two-jawed chuck on a screw machine, and drill, and turn off ball seat at one chucking, the tools being

PLATE LXIX.

FIG. 171.

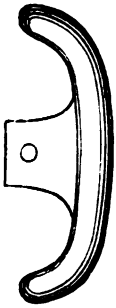


FIG. 172.

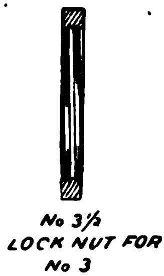


FIG. 173.

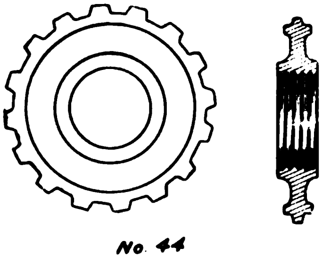


FIG. 174.

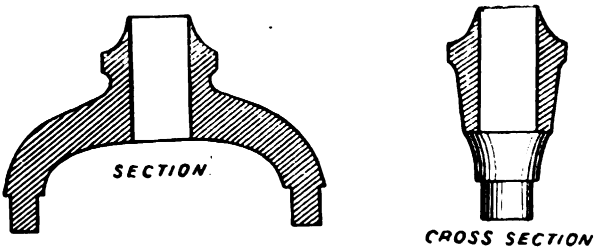


FIG. 175.

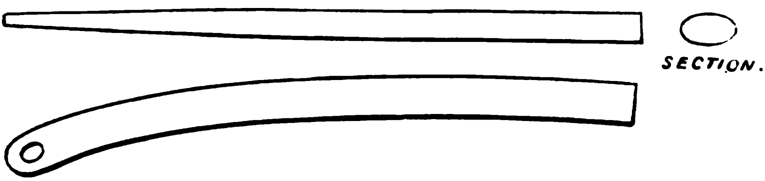


FIG. 176.

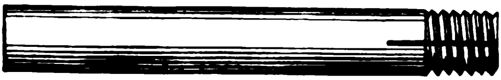


FIG. 177.

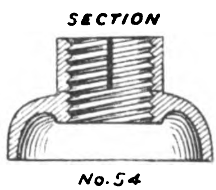
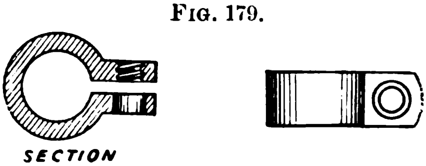


FIG. 178.

FIG. 179.



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held in the turret. It was found difficult to harden this piece after brazing on the forks, and a separate steel ring for ball bearing was forced on after all parts had been brazed together.

Fig. 175. *Tubular Forks.*—Cut off and then tapered in tapering die, while in round form, bent and then dropped to give oval shape and flatten end ; trimmed and hole punched in one operation. There are several ways of tapering long pieces. They may be pushed into a long taper die by means of a rack and pinion press. Tapered while either hot or cold under a hammer. A "Swaged" in a cold swaging machine. Such operations as are attempted cold, need some care that you do not go too far before the pieces are annealed. Several annealings may be required. A variation of the method would be to shape into the oval before bending.

Such tapered tubular forms can also be rolled out taper with a pair of rolls having cut in their surface several "passes" or grooves, gradually reducing the piece to the desired form. A groove cut length-ways of the roll marks the beginning of the die form, and also indicates the point at which to start the piece into the rolls.

Fig. 176 is the fork stem and is brazed in or rather into Fig. 174. We made them from the length of tubing, holding in the screw machine and threading with a die. They were cut off after advancing for the next length, which gave only a short piece projecting from the chuck. The slit was sawed in a hand milling machine, using the vertical movement.

Fig. 177. *Ball Adjusting Cup for Steering Head, upper bearing.*—Turned from steel in a screw machine from the solid bar. The first operation was to form the outside with a forming tool covering the entire length, and also the width of the cutting-off tool. Next a hole was drilled the right size to tap the thread. Third, forming mill with pin fitting hole was used to mill or cut out the cup at one cut. The piece was then tapped and cut off. The slot was cut in the same manner, and with the same cutter, as Fig. 176. It will be noted that this piece, with the exception of slotting and polishing, is made in one chucking.

The small hole was drilled, counterbored and tapped under a two spindle drill press having a tapping attachment. To slot the pieces we strung several of them on a mandrel and slotted them all at once.

Fig. 178. A cup bearing drawn from sheet steel. Only the inside of this piece was machined, and the drilling or reaming was accomplished in a screw machine, the bushing being held in a two jawed chuck. Pieces of this form where drawn up have a tendency to crack when hardened, the cracks mostly occurring where there are any sharp bends.

Fig. 179 is a clamp collar which fitted the small portion of Fig. 177 and answered to not only clamp the ball bearing, but also the handle bar post as well. The only novel feature of machining this piece was that we used a bar of steel drawn to the shape of the section, only having to drill the holes and cut off in the screw machine.

Fig. 180. *Handle bar post.* Cut off from tube and formed up, as shown in *B*, Fig. 180. In trimming this piece some experimenting will be required to get just the right amount of stock to fold around the handle bar. Also the ends of the *T* may crack unless the tube be of good quality and carefully annealed. When convenient it is best to form up this *T* part hot. The trimming die for this needs to have a finder or guide pin on the end of the punch. Before closing up, file bright on the surfaces where the brazed joint is to come, and note instructions about brazing.

Handle bars—cut off and bent from cold drawn steel tubes. These bars, as a usual thing, are bent with a die, and to prevent flattening where the bends are short, are filled with a hot mixture of rosin and plaster-of-Paris. Having had a very wide range of experience in bending tubing, the author has invented a device for bending tubing of any size or gauge without filling, or injury to, or kinking of the tube. Fig. 181 illustrates a diagram of this fixture, which is no more nor less than a machine for drawing tube around a circle instead of in a straight line. The position of the plug, *C*, can only be determined by experiment, and a separate form, *A*, for each size of tube and bend will be needed. One roller, *B*, for each size of tubing is all that is needed. The plugs must fit the internal bore of the tube very nicely to obtain good work. The lever arrangement, to which the plug rod is attached, was found necessary owing to the contraction of the tube onto the plug. The operation of the machine is as follows: Push tube through hole formed by roller, and form till it strikes the stop for length. Insert the plug as far as it will go, pull the form around and make the bend. Pull out the plug by means of the lever, throw the roller around and remove the tube. Where the bend is around a very small circle, you must follow the principle of all cold drawing, viz.: *anneal,* bend the tube first around as small a circle as it will safely go; anneal, and then repeat around a smaller form, and so on, till the desired bend is reached. The author has bent brazed brass tubing two and one-half inches in diameter, and No. 20 gauge around a radius of five inches, annealing the tubing twice and bending around three different sized forms. By having the roller pressed against the form by means of a spring or weight, many irregular bends may be accomplished. S and reverse bends will require bending twice, using, as will be found on trial, a separate form for the second bend. Square, oval and corrugated tubing can be bent in this way.

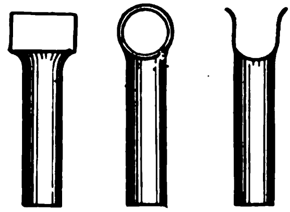
Fig. 182. Grip with ferules or cups, 36–38, show examples of the diversified industries required to make a cycle.

The German silver ends, 36–38, were fastened on with shellac—hot, and small foot press used for the purpose. They were afterwards finished by hand by sliding on a mandrel, turning down the cork and polishing the ends, and given a final finish by lightly buffing.

Fig. 183 presents no new features except that both the die for flattening the end and also for trimming and

PLATE LXX.

FIG. 180.



No. 35

FIG. 182.

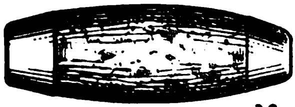


FIG. 181.

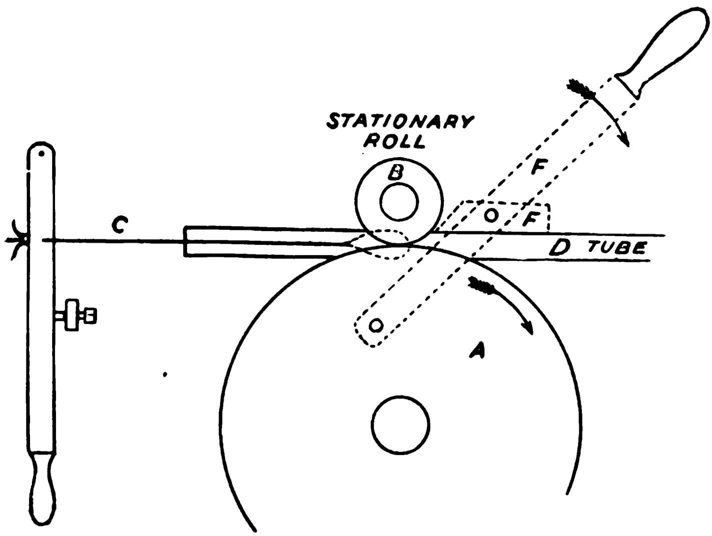
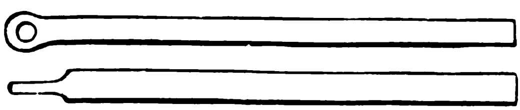


DIAGRAM OF TUBE BENDING MACHINE

FIG. 183.



No. 46

To face page 178.

punching the hole, were mounted in the same block, thus enabling the operator to finish the end at one handling.

Fig. 184. *Combination Sprocket and Crank.* The forging of the wheel part is accomplished in the same manner as Fig. 173, and the forging of the crank in the same manner as Fig. 151. The chucking, boring, and turning of the sprocket, except in size, is a duplicate of the small sprocket. It is well, however, to divide the turning tools into two or three different tools, owing to the width of the cut. A jig which will drill and ream the taper hole for the key, at right angles to the large spoke in the wheel, is next. Note that this crank is directly opposite the other one. The holes in spoke for the screws which hold the crank on are drilled in the same jig. For milling the pedal bearing, tools have already been described. The inside surface which fits the spoke of the wheel, is milled at a single cut, holding the crank in the jaws of the vise and resting on a leveling block.

Tools: Drop and turning die; Jig for wheel; Jig for crank; Chuck jaws for holding wheel while boring, facing and turning off; Reamer; Milling machine, vise jaws for crank; Milling cutter; Tap.

The Seat Leather can be blanked out in the same manner as a piece of metal with a suitable die. Owing to the irregularity of the sides of leather, no stripper can be used on the die, the blanks being cut around the edge of the side, the scrap trimmed off out of the way, and the operations repeated till the leather is used up. The leather is then dampened and pressed into shape in a pair of brass dies, and laid away on racks to dry. After drying the seats are trimmed up by hand with a knife, and the center hole or slot pierced out with a die in a foot press.

The metal parts attached to the leather elsewhere described, are riveted on with either tubular or bifurcated rivets, which punch their own holes, and are provided with a machine for setting, made by the makers of the rivets. Tools required: Blanking die; brass mould for shaping; piercing die for slot. Some knowledge of working leather will be required to finish up this piece. If made of russet leather all the edges after trimming are sand-papered smooth, and then slicked up with a bone slick or burnisher. Black saddles have the edges blackened with a solution of copperas and water, are then greased with a little tallow, and slicked in the same manner as the russet pieces. Any name or ornament may be pressed into the leather with embossing dies, which work nicely if made of brass. In order to keep their shape properly, the seat bar or spring should be fastened in place as soon as possible.

In the brazing together of bicycle parts, especially where the tube is thin or the joints close together, much skill and experience will be required. In the preparation of the joints there is a special method not generally known; in fact it has not been used in any cycle factory in the United States. If you will take two pieces of copper carefully cleaned and braze them together, you will

PLATE LXXI.

FIG. 184.

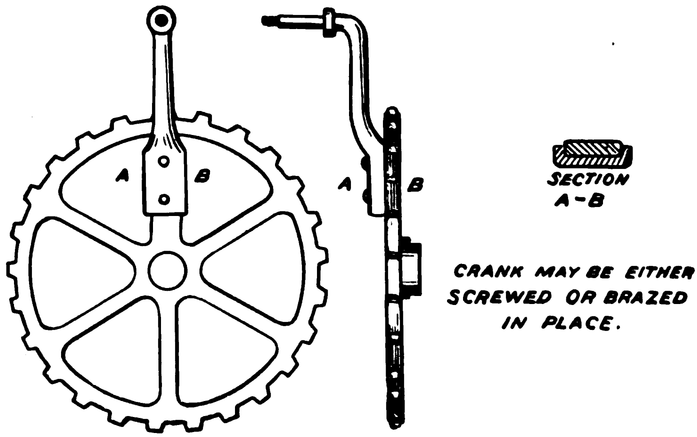
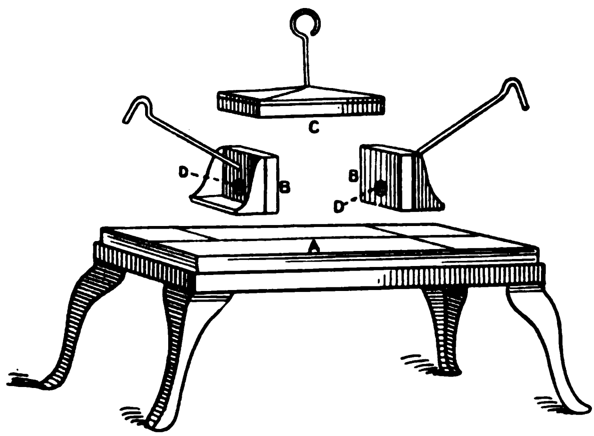


FIG. 185.



BRAZING TABLE FOR GAS

To face page 180.

discover that the spelter or brass will flow or sink into the joint just the moment it melts. This is not the fact with steel or iron. Not only must the spelter be melted, but the whole must be raised many degrees above the melting point before a perfect flow of the brass occurs on the surface of the steel. This is owing to the fact that the alloying of copper and iron is difficult except at a high temperature, and is made more difficult by the easy fusing together of iron and zinc. This fusion occurs at the temperature at which zinc turns to oxide, and a film of zinc oxide forming on the iron or steel prevents, like any other oxide, the union of the metals. The method to which I refer, and which will obviate the high temperature, consists in first cleaning the parts, and then electro-plating with a good deposit of copper, using for the purpose a cyanate of copper solution made by dissolving carbonate of copper in cyanide of potassium and water. Joints prepared and brazed in this manner will be found, on examination, to have become thoroughly united. Electro-plating with brass instead of copper will make a joint at a still lower temperature, but will be found not so strong. The principle on which this method works, depends on two phenomena, first, the uniting of metals by galvanic action, and second, the thorough protection of the steel from the formation of oxides until the fusing point is reached. For brazing the frames, a light iron form or holder with arms, having at their extremities clamps for holding each piece in place, is very essential, both for keeping the frame square and for preventing the joints from starting before they become cold. Brass is very brittle while hot, and should be handled accordingly. In brazing use fused borax, or better still boracic acid and lots of it, spooning it on from time to time as needed. Wind the joints with soft brass wire, and paint with borax and water mixed to a thick paste and dry before putting in the fire. Never under any circumstances use any but fused borax or acid, and never put a joint in the fire wet. If you cannot dry the joint, put the powdered borax on after the joint begins to heat. Where gas can be had, especially natural or water gas, it should be used, employing a double blowpipe pointed towards each other through a fire-clay or brick plate, as shown at *D D*. Fig. 185. This brazing table consists of a flat iron table, *A*, covered with fire-brick, and two or three fire-brick slabs, *B*, *B*, mounted in iron angle plates having handles screwed in the center of the back for convenience in handling. Combined with the brick cover, *C*, a small gas furnace, suited to the size of the piece to be brazed, can be arranged at will. The blowing of the gas and air through the holes, *D D*, in the side plates seems to draw in air with the gas in addition to what is furnished by the blower, producing a very intense heat. The piece to be brazed should be held at the point where the two flames meet and the gas and air cocks should all be within easy reach, that just the right amount of heat may be applied at the last moment. When joints are brazed on the naked steel, the heat must be brought to the point where the zinc burns slightly, rapping the piece lightly to cause the brass to flow well into the joint. With the coppered work, the joint will be found perfect just the moment the metal flows. The copper deposit should be good and heavy for satisfactory results. The blow-pipe may be constructed of gas pipe, a central pipe for air from the blower, and an outer tube surrounding it, the gas passing through the space between the two. A rotary air pump or positive blower will give better results than a fan blower, the latter not giving enough pressure. After all the parts are brazed, put the whole frame in hydrochloric acid for five or ten minutes, which will not only remove all the scale from the steel, but the melted borax as well. Take from the acid, rinse in water, and then in hot soda water, drying off in sawdust. The result will be a perfectly clean piece of work, requiring, before enameling, only the filing off of the surplus brass and milling or sawing of the slot which forms the seat-post clamp. The object of the hot soda water is to prevent the rusting of the frame by neutralizing the acid. A substitute for the soda water consists of a milky solution of lime and water, the lime neutralizing the action of the acid. Use hot, and allow the lime to dry on the work.

Metal to enamel without afterward peeling must be free from rust. The three joints of the forks and head can, by proper handling, be brazed all at one heat. It will be found necessary to drill a small hole through each of these joints and with a piece of iron wire rivet each together. The heat having a tendency to loosen the joints and cause them to fall apart; and in the case of this piece it is impracticable to arrange a form that will not be in the way. It is sometimes advisable to put spelter or brass on the inside of the tube joints, together with plenty of borax, as such a method prevents the blow-pipe from blowing the borax away and also assists in flowing the brass and borax from each end of the joint. In all kinds of brazing it is very essential that the parts be covered with a film of borax just as soon as the melting point of the borax be reached.

It is not generally understood to what an extent polishing has become an art. The degree of accuracy and finish reached at this day by the skillful polisher must be seen to be appreciated. All the parts of a bicycle which are not essentially machine parts requiring accurate surfaces, can with suitable wheels be finished to such a degree as will satisfy the eye as to appearance. Consequently it is not necessary to machine the cranks and other nickeled parts except where fits are required, as the polisher will do the work equally as well, and at less expense. Much of the work and some of the tools described are not needed in the practical production of a bicycle. All screws, nuts and bolts, spokes, nipples, most of the forgings, etc., are now made by firms who have invested considerable capital in special machinery and tools for producing such parts as are universal in all machines. Special machines of all kind are in the market. Wheel rim drilling machine, chain testers, hub turning lathes, etc., etc. All these should be made use of for economical results. In forcing in the bushings, which can best be executed with a screw press, always provide a punch or forcing mandrel fitting the ball bearing of the bushing, which will insure the bushing being true. Also provide a support which will insure the proper allignment of the two bushings, should there be two.

Though much has been explained in regard to drop forgings, the entire expense of the dies can be avoided by the use of wrought iron castings sometimes called "Mitis" iron, an alloy of wrought iron and soft steel scrap with about 4 per cent. of aluminum. Such castings are very soft and easily worked and can be cored out in such a manner as to save much heavy drilling. They braze nicely and if sufficient steel scrap is used will be found very tough and strong.

CHAPTER XIX.

THE PLATER'S DYNAMO.

In order to understand intelligently the following, or in fact anything pertaining to electricity, it will be necessary to comprehend the meaning of the various electrical terms used.

An *Ampere* is the measure of quantity. To make this clear the electrical current may be compared to water under pressure, and the term ampere might be said to represent both the water and electricity in gallons.

A *Volt* is the unit of electrical energy or pressure which in the water would be indicated in pounds per square inch of exposed surface.

A *Watt* is equal to a volt multiplied by an ampere. Its equivalent in the case of the water being the gallons of water multiplied by the pressure.

An *Ohm* is the unit of resistance and represents in the case of the water the size of hole through which the water escapes, as well as the friction of the water through the pipes.

A current of 10 volts tension and 50 amperes quantity would be equal in electrical effect to one of 50 volts and 10 amperes, the sum of each being 500 Watts. There is, however, an element in favor of the 50 volt current, as its high pressure enables it to pass along the wire with a less number of ohms resistance. It is clear that you can get a given quantity of water through an inch pipe at 50 pounds pressure, with far greater ease than you could the same amount of water at ten pounds pressure. From this it will be seen that much larger wires will be required for currents of low voltage than for those of high tension. The word "*Potential*" is sometimes used to denote the quantity or amount of voltage, expressed as high potential and low potential.

Currents of high potential, though easy to conduct along the wire, are hard to keep *on* the wire, having a a tendency to jump across short distances and form an arc or connection through the air, this being especially true when the wires or other electrical connections are in any way separated. Low potential currents, however, will not jump across the most minute space and require not only large wires as conductors, but all connections must be kept clean and bright, even small particles of dust being sufficient to break the connections and stop the flow of the current.

Referring to Fig. 186, the parts of a dynamo are named as follows: The part which revolves as a whole is called the *armature.* The projecting part of the armature, usually made up of bars of copper or bronze, is called the *commutator.* The copper plates resting against the commutator are called the *brushes.* The two or more iron pieces inside of which the armature revolves, are called the *poles*, while the part of the poles in conjunction with them and wound with wire are designated as the *field*.

Dynamos for plating purposes are usually wound for currents of from two to four volts tension, the amperes or quantity depending on the size of the machine. They are also "shunt" wound, that is, part of the current passes through the field and part through the wire leading to the plating solutions. For this reason the field pieces have a large amount of large wire wound on them in order to make such a resistance as will force the current when needed through the solutions. If all the current were to pass through the field the resistance of the baths would cause the current to be broken and also make the voltage vary so much as to spoil the work. The passing of the current through the field all the time, whether the baths are working or not, keeps the dynamo constantly magnetized, causing it to act instantly whenever the work is hung in. Increasing the resistance or length of wire in the shunt will lower the voltage. Putting resistance in the wire which leads to the bath will reduce the quantity or amperes of current. Increasing the speed of the machine will increase both the voltage and quantity of electricity generated. The finer and longer the wire is on the armature the higher the potential of the machine. The shorter and coarser the wire the lower it will be. Increasing the amount of iron in the poles and the wire on the fields will increase the quantity or amperes of the current.

The most common form of repair upon the plater's dynamo consist in the frequent turning off of the commutators and the renewal of the brushes. In turning the commutators, see that there are no small particles lodged in the spaces between the bars of the commutator, which must on no account be connected; therefore, remove very carefully the small particles of metal which may lodge in turning. If a wooden block be made to fit around about one-fourth of the commutator and lined with sand paper, a few minutes' work each day will keep the commutator in good order for a long time. Owing to the low voltage of such machines, the brushes must remain in very close contact. If the commutator is round and smooth a very light pressure will be sufficient; but when it gets out of round more pressure will have to be applied, which will not only increase the trouble but wear away very rapidly the brushes and commutator. For lubricating the brushes use vaseline, applied quite often with a small piece of soft leather or felt. Always see that the shaft of the armature has quite a little end play, and that the machine sets perfectly level, which will be indicated by the armature constantly moving back and forward. Do not allow the machine to become greasy and filled up with oil, as the grease or oil may get where it will do harm to the insulation of the wires. If the wire on the machine shows a tendency to become so hot as not to bear the hand, the machine is too small for the work it is doing, and a larger one will be needed. Should the machine fail to generate after running all right for a time, examine and clean all the connections, and try again. Should it refuse to generate when short circuited or when a wire is placed across the wires running to the baths, the trouble is internal and must be repaired by an electrician having the necessary instruments to locate the trouble. Excessive sparking may be caused by particles of metal between the bars of the commutator, or improper setting of the brushes, which should be exactly opposite to each other. You may sometimes remedy the trouble by rotating the brushes around the commutator by means of the handle provided for that purpose.

In setting up a dynamo put it in such a place as will prevent any oil from being thrown into the plating baths. A very little oil in a nickel bath will make much trouble for the plater.

Fig. 186. PLATE LXXII.

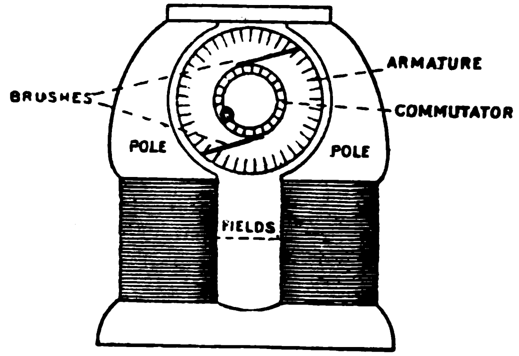


Fig. 187.

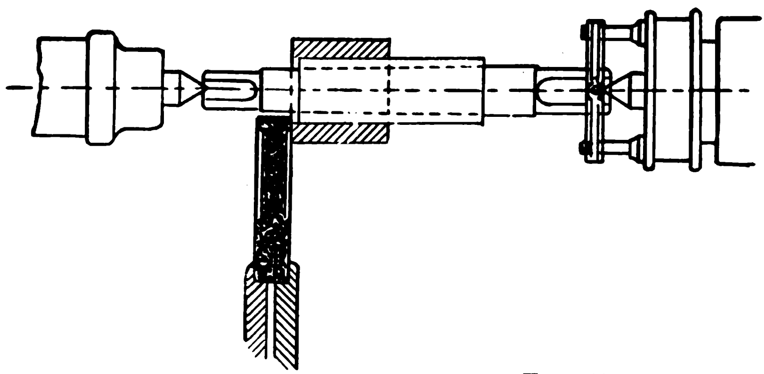
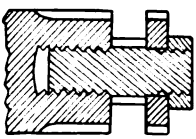


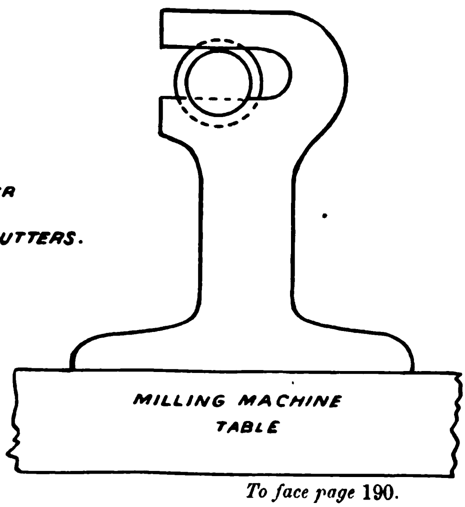
Fig. 188.



SMALL MILLING CUTTER

MADE UP OF 3 SEPERATE CUTTERS.

Fig. 189.



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CHAPTER XX.

CONCLUSION—WITH A FEW RANDOM IDEAS, CULLED FROM MANY SOURCES.

THE first and most important thing in grinding is the truing of the emery wheels. The best method is to secure the diamond holder to the slide, which will not only insure accurate work, but will save the stone from being loosened from the holder. Just a few words about diamonds or "Bortz," as they are called in the trade.

There are many varieties of these stones, and they vary in color from a brown or green-black to a semi-transparent color. The more transparent, the harder and more durable the stone. Also what is called a "Natural" is the best. By natural is meant a diamond in the original shape in which it was found, it being the custom to crush or break up the larger ones, and such broken pieces do not seem to have the strength and durability of those of original formation. For convenience of fastening in the holder a more or less elongated shape is desirable.

The centers of any grinding machine must be kept perfectly true and always hardened. The table is set at an angle of 30° while grinding the centre, which will produce the 60° angle usually preferred.

Cutter Grinding. For grinding all kinds of cutters, avoid heavy cuts across the face of the teeth, especially when grinding dry, as the edge of the teeth will have the temper drawn if the cut be forced. Keep the wheel clean and sharp and narrow on the face. A wide faced wheel will not do good work, as the pressure will spring the parts away from each other.

Always run all cylindrical pieces on the dead centers. In fact, never use the live center at all. Only imperfect and unsatisfactory results will follow.

For grinding *lathe tools* with square or angular surfaces, cut-off tools, side tools and those of similar shape, the grinding machine has no equal. The tool may be of the kind used in making the broad finishing cuts practised by all good machinists, and leaves the clearance face of the tool absolutely straight. A very nice clearance line can be made that will give a smooth cut free from chatter marks.

Cutting-off tools may be ground in this way with just the right amount of side clearance, using for the purpose, if desired, a vise or similar fixture.

All kinds of dies may be held in the vise and sharpened or have the face ground off. The wheel generally used is of the cup form.

The Walker machine has a universal movement to the emery wheel head, as well as the lateral movement of the table, thus making possible many combinations of arrangement.

For testing holes, circular limit washers fastened a short distance apart on a handle and having the same features except as to size, may be used to advantage. The smaller washer or disc will, of course, be on the end, and will pass through the hole, the larger size not entering if correct.

By the above method a great number of pieces can be inspected by one person in a day, with the absolute certainty that they are within the limit and will fit when required for use.

A novel feature is to have, where a piece has a number of sizes, all the limit gauges around the edge of a circular plate, when all the dimensions may be tested before the piece is laid down.

As all work springs more or less when chilled or tempered, hardened bearings require to be trued by grinding. Only imperfect results can be produced unless all wearing parts are ground to size.

Fig. 187, a method of squaring the end of steel bushings. The wheel is turned away on the side, leaving a narrow cutting corner, and should be very soft. If the axis of the arbor and the axis of the wheel spindle are exactly parallel, the surface will be perfectly flat and at right angles with the axes. A concave or convex surface can be obtained by varying the relation of the axes.

By this way you can finish the end clean. Note that the mandrel is smaller at the end to allow the wheel to pass clear of the inner edge, and that the wheel is hollow-ground or turned. A saucer or dish shaped wheel gives equally good results without the necessity of turning. It is not necessary to drive the work very tight on the mandrel for grinding.

APPENDIX.

In making small cutters for slots that have outer groove wider than slot, it is very difficult to get the edges of the work sharp with a solid cutter, owing to the impracticability of getting at the cutting edges of the cutter.

Fig. 188 illustrates a way of piecing together the cutter out of three separate cutters, which may be taken apart to sharpen, and which are readily made in the first place. This system bears on many forms of cutters, as it is much better to make up a forming cutter of several pieces where practicable, providing, as it does, a ready and cheap way of renewal without re-making a whole cutter.

Fig. 189 is one of a set of tools, and was used, as shown, for getting two slots opposite each other on two positions on a small shaft. The tool not only squares the first slot for the milling of the second, but also gauges the depth and holds the piece from turning.

A quick and cheap manner of making short pieces of straight shafts or studs, consists in grinding the pieces from lengths of cold drawn steel. The work is not centered, but is held by means of special steady rests, so constructed that the wheel will pass entirely over the piece with the exception of a short length used for driving, which is afterwards finished by reversing.

There is a growing tendency among the best tool designers to perfect automatic features.

The automatic screw machine is about to be duplicated by a second cousin in the form of an automatic milling machine. Automatic drill presses with dial features for advancing the work; lathes that will cut a thread, by going over it in the same manner as a workman, and large numbers of special machines for working wire, flat strips, etc., are only a few of such advances.

As most tool-makers and advanced machinists have presented to them the features of "Organization," it is desirable to note the methods of some of the best examples of machine "Placing."

Good practice always observes the following rules:

Place every machine and tool in such a position as will carry the work forward in a progressive manner, but before doing so, make a plan of all the floor space, and diagram every machine in place.

Carefully arrange, and condense everything from the start, and if necessary put in duplicates of any machine, if by so doing you can avoid returning the work to a former place.

The main point is to continually move onward in one direction. Circumstances may advise the placing of machinery in what appears a rather mixed order, but it will be found less expensive than to hire extra hands to move the product from place to place.

As an example—the author was consulted about the cost in a certain plant employing three kinds of machines, lathes, milling-machines, and drill-presses. An investigation disclosed the fact that the plant consisted of three principal rooms—lathe room, drill room, and milling room, each on a separate floor, connected by an elevator. This same elevator was the hardest worked feature of the plant, making on an average four hundred trips per day. Seventeen per cent. of the labor was for transporting the work back and forward from one department to another, and one lot of parts, when carefully tallied, were found to have received "elevation" forty-one times, and to have been moved otherwise ninety-six times, thus having been handled one hundred and thirty-seven times. It was suggested that the machines be "mixed" on a definite plan, placing each one in such a manner as would permit of each successive operation to have its proper tool following in regular order. By this arrangement the men simply passed the work from one to another, which gave the elevator a much needed rest, and reduced the transportation labor to five per cent., a saving of twelve per cent. in labor alone.

In final conclusion, it is desired to impress the importance of careful plans in everything. Do not do as one old-time foreman did, and move a forge nine times, thus leaving eight holes and patches in the roof, as a history of its migrations from place to place.

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