MACHINERY'S REFERENCE SERIES

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No. 26—MODERN PUNCH AND DIE CONSTRUCTION

CONTENTS

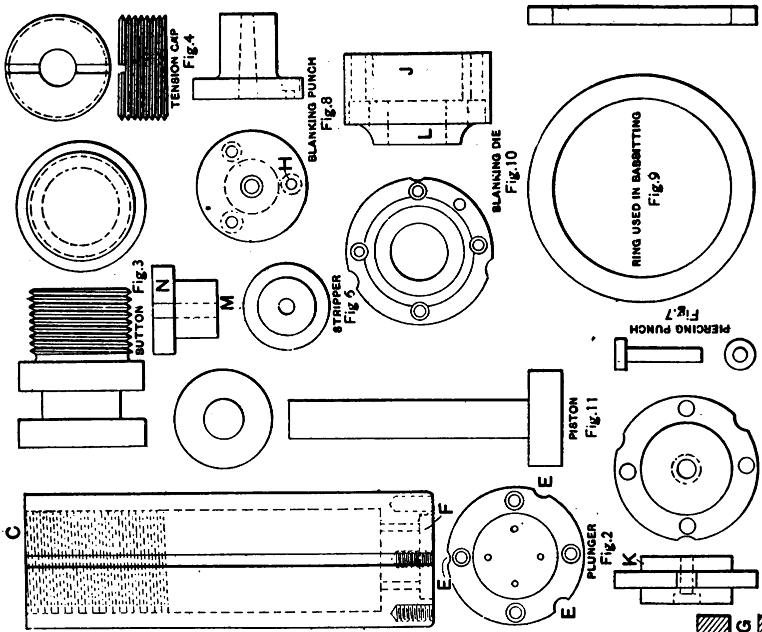
CHAPTER I.

PRINCIPLES OF SUB-PRESS DIE CONSTRUCTION.

If we attempt to define the sub-press die, we find that we cannot define it as a special class of die, but merely as a principle on which all different classes of dies, cutting as well as shaping dies, may be constructed and worked. The sub-press principle is simply that the upper and lower portions of the die, the punch and die, are combined into one unit either by guide rods fastened into the lower part of the die, and extending through holes in the upper part, or by some other provision for guiding. This construction permits of a high degree of accuracy, eliminates the necessity of lining up the punch and die each time they are set upon the press, and thus saves a great deal of time and cost.

Owing to the large number of parts of which a sub-press die is composed its first cost is, of necessity, much higher than that of an ordinary die. When, however, we consider that a sub-die, when properly made, will run ten hours per day for weeks at a time, without grinding, the first cost sinks to a minimum. In using an ordinary double die it is almost impossible to obtain two blanks that are exactly alike, one reason being that the stock to be punched is more or less wrinkled and does not lie flat on the face of the die. The consequence is, therefore, that after the piercing punches have perforated the wrinkled stock, and it is then flattened out, there is a greater distance between the holes than there is between the punches. Also, the pilot pins that are depended upon to locate the stock cannot do so exactly, since they are made a trifle smaller than the piercing punches in order to prevent them from pulling the blank up out of the die. On a certain class of work the double die answers all purposes, but when accuracy is required a sub-die is the only one that will give satisfaction.

In order to avoid a complicated drawing and to set forth the principles of the die in such a way that they may be readily understood by those not familiar with sub-dies, the die used for punching an ordinary washer has been selected for an illustration. The general principles of sub-dies are, of course, the same whether one or one hundred punches are employed. Having selected a frame with its proper cap, as shown in Fig. 1, of size suitable to the work, it is placed in a chuck, being held by the upper end, and, having faced off the bottom, the recess *A A* is bored to fit snugly the corresponding step on the base of the press. This base is finished on both top and bottom, and has a step, above referred to, turned to fit the bottom of the frame. A slot at *G* is cut in each end to receive the finger straps by means of which the frame is fastened to the face-plate of a lathe. The center is recessed to receive the stripper plate and blanking



Figs. 2 to 11. Details of Sub-Press Die.

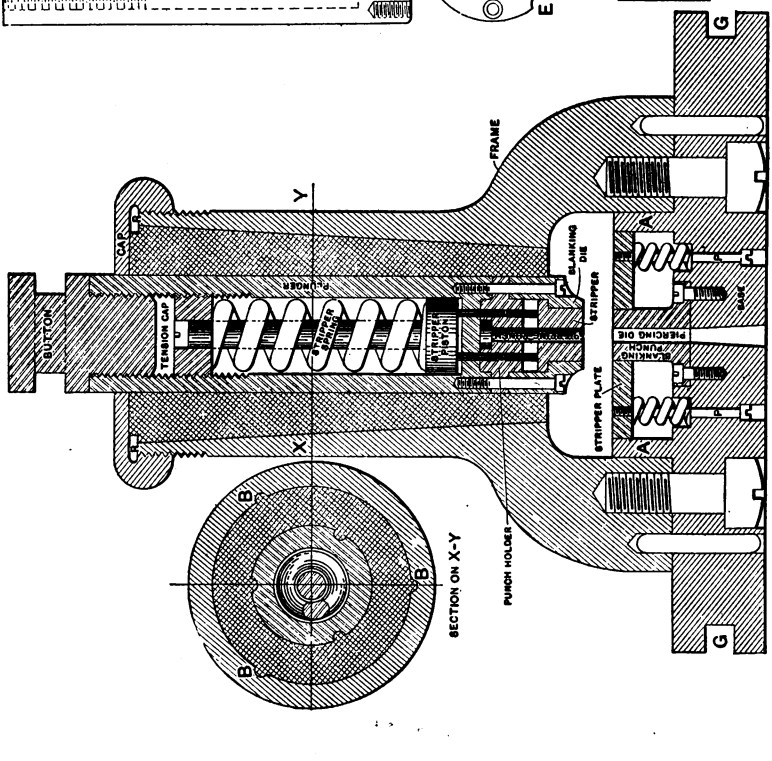


Fig. 1. Section through Sub-Press Die.

punch, and a hole is drilled completely through to allow scrap punchings to fall to the floor. The base and frame are then fastened together by means of bolts and dowel pins as shown. Together they are clamped to the face-plate of the lathe, being centrally located by means of a plug center which fits the taper of the lathe spindle, and passes through the hole in the center of the base. In this position the frame is bored out to a taper of about one-half inch per foot. After boring, a splining tool is substituted for the boring tool, and with the lathe locked by means of the back gears, three or four grooves *B* are cut the entire length of the bore by sliding the carriage back and forth. At the same setting the upper end of the frame is faced off and threaded to receive the cap which is screwed on the frame. After the cap is in place, the hole for the plunger in this cap is bored out to the required size. This insures the hole in the cap being central with the inside of the frame.

The plunger, shown in detail in Fig. 2, is the next piece to receive consideration. After being centered and rough-turned, it is put in the center rest, and the hole *C* bored and threaded and fitted with the button shown in Fig. 3. The internal thread in the plunger is carried down to a considerable depth in order to allow of the insertion of a tension cap, Fig. 4, by means of which a sufficient tension is placed upon the stripper spring to force the punching back into the stock upon the return stroke of the press. A dog is fastened to the button, and the plunger turned to fit the hole in the cap, great care being exercised to keep the sides perfectly parallel. After turning, the lathe is blocked by the back gear, and three grooves *E* are splined, about 1/16-inch deep, for the entire length. It is essential that these grooves be parallel with the axis of the plunger. Before the plunger is completed, a ring, three-quarter inch wide, is made of machine steel and forced unto the lower end of it. The outside of this ring is trued up, using the plunger as an arbor, after which this end of the plunger is placed in the center rest, where the ring prevents it from being scored or injured by the center rest jaws. In this position the recess seat *F* is bored out to receive the punch holder shown in Fig. 5.

The punch holder is made, as are also the die stripper and punch, Figs. 6 and 7, by turning from a bar held in the chuck and finishing complete before cutting off. The recess which receives the head of the piercing punch should be bored at the same time to insure its being central with the rest of the die. The stripper, Fig. 6, should be made of tool steel and left large to allow for grinding after hardening, while the hole is bored sufficiently small to allow for lapping to exact size. The blanking punch, Fig. 8, which also contains the piercing die, is made of tool steel in the same manner, being finished complete before it is cut off, and it is left with sufficient stock to grind after it has been hardened. The holes *H* are drilled and counterbored for screws to hold the punch to the base.

After the parts are hardened, the blanking die is the first to be ground. It is gripped in a chuck, upper end outward, and the large hole *J* is ground out to fit the step *K* on the punch holder. Then the hole *L* is ground perfectly straight and of the same diameter as the master templet. The top face is also ground off, thus completing the die. In the stripper, the hole *M* is lapped to the same dimension as that in the templet. A round piece of cold-rolled steel is gripped in a lathe chuck and turned to fit nicely this hole in the stripper. Without disturbing the chuck, wring the stripper onto this arbor and grind the flange or shoulder *N* to fit nicely the larger bore, and the smaller diameter to fit the smaller bore, of the die. The blanking punch is finished in exactly the same manner as the stripper, being ground to fit the recessed seat in the base. The minor parts such as the stripping plate, stripper piston, pins and springs are then made, and the press is ready for assembling.

In assembling, first force the punch holder, Fig. 5, into the seat *F* of the plunger, and then force the die onto the holder; transfer the holes in the die through the holder and into the plunger, and after they are drilled and tapped, fasten the parts together as shown in the sectional view, Fig. 1. Remove the die and drill four holes in the punch holder and plunger for the stripper pins *O*. Place the stripper piston in the plunger, above this the spring, and lastly screw the tension cap into place. The stripper pins *O*, which are hardened for their entire length, are placed in their holes in the punch holder, and the stripper placed in the die, which is then secured in its place on the punch holder.

The blanking punch is placed in its seat in the base and securely fastened by cap screws, after which the springs shown are placed in position and the stripper plate drawn down by means of the screws *P*, until it is a trifle below the top of the blanking punch. The frame is now ready to be babbitted. Screw the button onto the plunger, and with a piece of oily cloth wipe the plunger all over, then sprinkle flake graphite onto it. The oil on the plunger will cause the graphite to adhere, and after the surplus has been blown away a thin coating will be left over the entire surface. The plunger is lowered inside of the frame until the blanking punch enters the die. In the cap insert the ring shown in Fig. 9, to prevent the babbittt from flowing into the recess *R*, and screw the cap onto the frame. As the cap is an exact fit for the plunger, it therefore aligns it with the frame and with the blanking punch. The grooves on the plunger must be plugged with putty where they pass through the cap in order to prevent the escape of the babbitt while pouring. A pair of parallels, of a height equal to the projection of the button beyond the top of the cap, are now placed on the bench, and the die inverted upon them. Great care should be taken to avoid any vibration during pouring, as very little will affect the alignment of the plunger. Before pouring, heat the frame with a torch or jet of gas, and when the babbitt has attained the proper heat, which is a very dark red, pour it in from both sides of the die simultaneously. Allow it to remain until thoroughly cool, then remove the plunger, strap the frame to the face-plate of a lathe, and cut a spiral oil groove the entire length of the babbitt.

As the blanking punch has already been ground, the next step is to grind the faces of the blanking die, piercing punch, and stripper, while all are in their proper positions in the plunger. They should be ground so that the face of the stripper, die, and punch are all flush with each other. After grinding, the parts should be taken from the plunger and thoroughly cleaned so that no emery can possibly remain in the working parts. Oil all of the running parts in a thorough manner, then put them together in their proper positions, and replace the plunger in the frame. In setting up a sub-press die, care should be taken to have the punch come to the face of the die only, and not enter it.

CHAPTER II.

CONSTRUCTION AND USE OF SUB-PRESS DIES.

The sub-press die is an old device dating back at least one and possibly two generations, and having its origin in watch and clock factories where its ability to perform blanking operations of the most delicate nature was early recognized and fully appreciated. That this tool, though familiar in the field just mentioned, has yet capabilities in other directions which have not hitherto been fully recognized, is the impression that must be strongly borne upon an appreciative mechanic who is acquainted with the work being done in the shops of the Sloan & Chace Manufacturing Co., of Newark, N. J. This firm has for many years built precision machinery for watch makers, fine tool makers and others, whose work requires great accuracy. The tools described in the following were constructed by this firm.

A section of a typical blanking sub-press of the common cylindrical type is shown in Fig. 13. It is doubtless familiar to most tool-makers, so will need but a few words of description. To base *B* is screwed and dowelled the cylinder *A* lined with babbitt, as shown at *C*, this lining being provided with ribs which engage corresponding grooves in plunger *D* which works up and down within the babbitt lining under the action of the ram of the press in which it is used. Nut *U* furnishes an adjustment for tightening the babbitt lining to take up all slack due to wear, as fast as it is developed. The die is usually the upper member, while the punch is placed in the base. *K* is the die, screwed and dowelled to plunger *D*; accurately fitting the opening in this die is the shedder *H*, which is normally forced downward with its face flush with the face of the die by the action of spring *M*, which acts through the piston *N* and pins *O*. A similar construction is used in the bottom member. *J* is the punch, screwed and dowelled to the base. *L* is the stripper, surrounding the punch and accurately fitting it, and held firmly at the upper extremity of its movement by the pressure of the springs *Q*; it is restrained with its face flush with that of the punch by the heads on stripper screws *R*. Thus it will be seen that the faces of the punch with its stripper and the die with its shedder may be ground off smooth and flush with each other, presenting to the eye the appearance of two solid plates of metal, the division between the fixed and spring supported members not being visible if the fitting has been well done.

With this construction in mind, the details of the punch and die shown in Fig. 14 will be readily understood. Similar letters in each

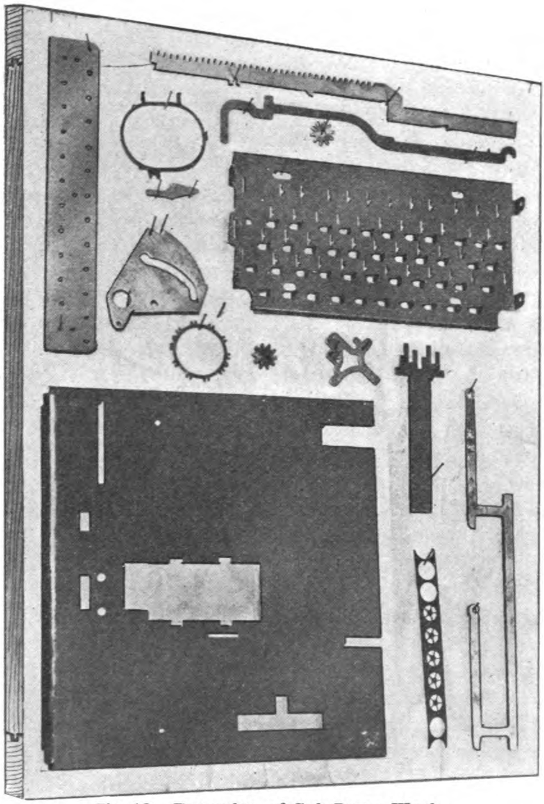


Fig. 12. Examples of Sub-Press Work.

case refer to similar parts, but only the members of the device actually working on the metal are here shown. The outline of the punching which is to be made will be understood from the outline of the punch and its stripper, as shown in the plan view. There are two small holes, *c c*, and one larger hole, *b*, in the blank. For punching these small holes, in addition to the simple arrangement shown in Fig. 13, openings are necessary in the punch, and small piercing punches have to be placed within the aperture of the die, passing through holes in the shedder; the holes in the punch are continued through the base of the sub-press so that the waste material drops through beneath the machine. The piercing punches in the upper member are held to die pad *G* by holding screws *g* which draw these parts up into their tapered seats against the shoulders formed on them for the purpose. The fitting at all the cutting edges is done with great accuracy. The punch *J* fits die *K* very closely; the shredder *H* is fitted to the die very closely; the stripper *L* is fitted to the punch, and small punches *f* are accurately aligned and closely sized to their corresponding openings in the face of main punch *J*. Disappearing pins are shown at *h h*; they are used to guide the strip of stock, and are pressed down by the

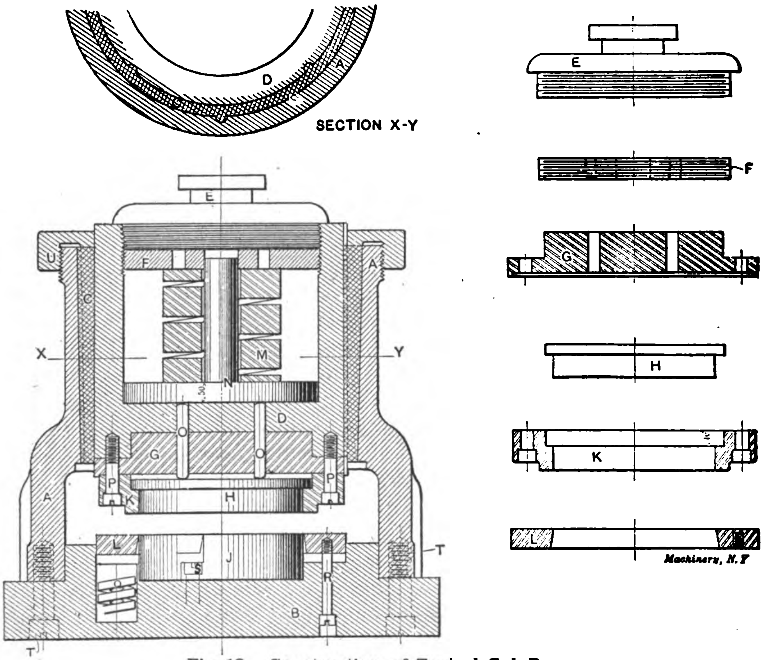


Fig. 13. Construction of Typical Sub-Press.

descent of die *K*, returning under the action of their springs as the ram ascends.

It will be understood, of course, that the sub-press is a complete unit, with punch and die and ram guiding surface always in place, so that no setting is necessary. The operator only needs to place the sub-press on the bed of the punch-press, insert the button on cap *E* in the holder provided for it in the face of the ram of the machine, and strap the base of the tool to the bed of the machine. He is then ready to commence work at once without any need for wasting time in matching up his dies, it only being necessary to adjust the length of the stroke to the proper amount. This is one of the advantages of the sub-press. Another of them will be immediately recognized upon considering the action of the parts on the strip metal from which the blank is punched. With the work in place, die *K* and with it small punches *f* descend, the latter passing through the stock until they almost meet the corresponding cutting edges in the lower member. As soon as shedder *H* strikes the stock its motion is arrested, and it remains behind until the blank is separated, being meanwhile powerfully pressed upon the work by spring *M*. As the stock, while being sheared, is pressed down around the blank, it carries with it stripper *L* which also, by the influence of springs *Q*, exerts a heavy pressure on the stock. The whole area of metal being thus firmly held between plane surfaces, there is no danger of buckling or distortion of the stock as would otherwise be likely. As the ram moves upward again the blank is still firmly held on the stationary top of punch *J* by the shedder *H*. The stock, however, is carried upward with die *K* by stripper *L*, forcing the stock back over the punching again until the movement of the stripper is arrested by the heads of screws *R*, at the time when the face of the stock is flush with the top of the punching. The work is thus pushed back into the stock in the same position that it occupied before it was severed from it and in many materials when the work has been nicely done, it is difficult at a careless glance to believe that anything has been done at all, both sides presenting a flush smooth surface where the parting occurred.

This condition is taken advantage of oftentimes in clock manufacturing. Gear blanks, for instance, are punched out from strips of metal and inserted back in their places again, minus, of course, the stock which has been punched out to form the arms and the hole for the "staff" or little shaft on which it is mounted. These strips, thus prepared, are then taken to machines where the staffs are inserted and fastened, it being much easier to handle the little wheels in this way than if they were severed and handled in bulk. A strip of stock thus treated is shown in the photograph reproduced in Fig. 12, the second one from the right at the bottom of the group; five of the pieces are shown in place in the stock while three have been pushed out. Besides the advantages of permanent setting of the punch and die and the holding of the stock to prevent distortion, which allows very narrow bridges of material to be left between wide openings, the suitability of the device for delicate work such as the piercing of small holes in thick stock will be appreciated by reference to Fig. 14. It will be noted that, no matter how small punches *e* and *f* may be, no portion of their projecting ends is at any time left unsupported laterally by shedder *H* or by the work. The shedder, pressing down firmly on the work, supports the end of the punch at the point where the pressure is applied. It is thus possible to use a very much more slender punch for a given thickness of stock than can be used in any other way. In Fig. 12, where a number of samples of sub-press work are shown, the topmost piece with the rack teeth in it, which is about 0.050 inch thick, has at its left-hand end four 0.025-inch holes pierced through it. It will be seen that the thickness of the stock in this case is twice the diameter of the hole punched. Such a ratio has perhaps been undertaken with ordinary punches and dies, although the writer does not remember ever having seen the ratio of 1.5 to 1 exceeded; and in that case the hole in the die was considerably larger than the hole in the punch with the result that the pierced hole was very much tapered, the scrap coming out in the form of a conical plug. In the die under discussion, however, no allowance of this kind is made, the hole in the die being a very close fit to the punch, with the result that the hole pierced in the blank is as nearly a perfect

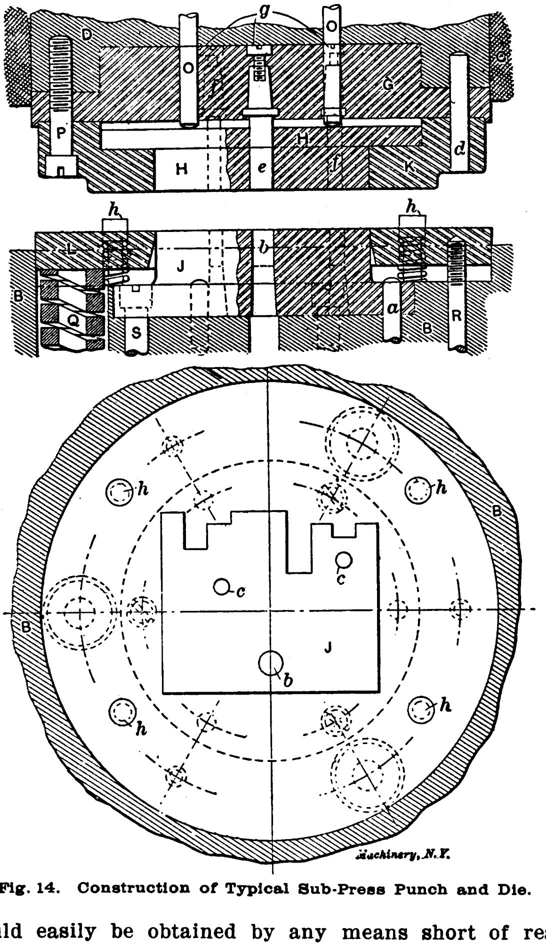


Fig. 14. Construction of Typical Sub-Press Punch and Die.

one as could easily be obtained by any means short of reaming or grinding.

Another advantage of the sub-press, dependent in part on the accuracy of alignment provided, and the corresponding accuracy in fitting which can be given to the cutting edges, is that the work is remarkably free from fins and burrs. A consideration of the action of the press will show that there is practically no chance for burrs to form in a piece even where they would in an ordinary blanking die.

It is of course necessary for the die to descend until the punch has all but entered it, if clean work is to be produced. There appears to be a slight difference in the practice of different operators in this respect, although this difference in practice would be expressed in the dimensions of only 0.002 or 0.003 inch, perhaps. Some of them adjust the stroke so that the die does not quite meet the punch. Others prefer to have them meet and even enter by an infinitesimal amount.

Attention has already been called to two of the samples of work shown in Fig. 12. The small parts there illustrated are within the ordinary range of the sub-press as ordinarily used, but it is safe to say that there are many die-makers who consider themselves familiar with this tool who have yet to see dies built on this principle large enough to blank out such a piece as the largest one shown, which is quite 14 inches square. Nor is this the limit possible. The writer saw here dies of this type being made for heavy armature work, blanking out armature segments measuring possibly as high as 26 or 28 inches across extreme dimensions. The same advantages that obtain in the smaller presses, result from the use of the larger ones. There is a saving of time in setting up the tools; there is a possibility of punching small holes in thick stock or of leaving narrow bridges of metal between openings of considerable area; the dies, owing to their accurate and permanent alignment, may be fitted to each other much more closely, produce work that requires less finishing and comes more nearly to dimensions than can be done in any other way. At the same time, the construction effects a great increase in the life of the die, making it unnecessary to grind it anywhere nearly so often as would otherwise be the case. The only disadvantage that can be set off against these advantages is the increased cost, and it appears to be conceded that even with this consideration the balance is strongly in favor of the sub-press die.

Of course the larger sizes of these tools are not made in the familiar circular form illustrated in Fig. 13. Fig. 15 shows three different styles. The one at the rear has the sliding head guided by four vertical posts carefully ground and lapped to fit cast-iron bushings. This is the construction used on heavy work. At the left is shown one in which the plunger is rectangular in shape. This works in a bearing lined with babbitt the same as the cylindrical form shown at the right of the cut and outlined in Fig. 13, although the bearing is not adjustable. The cylindrical form is used for the smaller sizes.

The making of a sub-press die requires all the skill of a first-class tool-maker. The method pursued by some, at least, of the men who are engaged in this work at the factory mentioned is about as follows: Taking the dies in Figs. 13 and 14 as examples, the base *B* and cylinder *A* are machined and fitted together according to methods that would naturally be pursued by any good mechanic. The inner surface of the cylinder is grooved so that the babbitt may be securely locked in place. Plunger *D* is then machined, and the outer surface ground and fluted with semi-circular grooves. Especial pains are taken to have these grooves parallel with the axis of the plunger in both planes; if this is not done the die may be given a slight twisting movement instead of the perfectly straight forward one that is required, since upon these grooves depends the angular location of the punch and die with relation to each other. The plunger is now inserted within the cylinder and, with proper precaution, the space between them is filled with babbitt which flows into the grooves in the cylinder and those in the plunger as well, locking with one and guiding the other. After being cooled, the plunger is pumped up and down to insure a perfect bearing, and the nut U is screwed down until all slack is taken up. Die K is now made to accurately fit the templet or model furnished the tool-maker as a sample. After it has been completed, it is hardened and fastened in place. Then the model is inserted within it, and such holes as may be called for in the blank are transferred to die pad G. This is done by punches with outside

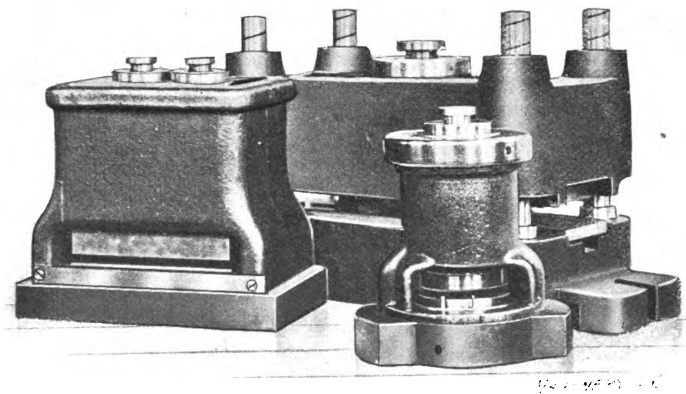


Fig. 15. Three Forms of Sub-Presses.

diameters ground to fit the holes in the templet, and provided with sharp points concentric with the outside. The pad after being thus prick-punched, is put on the face-plate, the slight punch marks are carefully indicated, and holes are carefully bored to a taper to fit the punches which are to be inserted in them. The punches are finished by grinding on centers after they are hardened. They are supported at the shank by a male center, while the opposite end is temporarily ground to a point which revolves in a female center in the other end of the grinder. The punch may thus be ground all over with the assurance that the pointed end is true with the exterior—a necessary provision as will appear later.

It might be noted here that no draft is given to any of the cutting edges of these tools, since they do not enter each other, at least not to any appreciable extent, and since the stock in entering and leaving the cutting edges is positively moved, no clearance is necessary, and the die cuts practically the same kind of a blank at the end of its life that it did at its birth. Shedder H is fitted to die K and the holes for the punches are transferred to it in the same way as for the die pad, by means of carefully machined prick punches which fit the holes in the models, these prick punch marks being afterward indicated to run true on the face-plate. The punch is now worked out a very slight amount larger in all its outlines than the die. The model is laid upon it, the holes transferred to it as in the case of the other parts, these holes being then indicated and bored out, but not ground in this case, being left three or four thousandths smaller in diameter than finished size. The punch is fastened in place in the base, lining up as nearly as possible with the die. The ram is forced downward in a screw press until the punch enters the die very slightly, cutting a thin chip from its sides to bring them to the shape required. The punch is then worked down to this point all around and again entered in the die a short distance further, the operation being repeated until the two parts fit perfectly.

In finishing the holes in the punch, after the hardening process plugs are driven in each as shown in Fig. 16. The punches *f*, Fig. 14, still with their ends pointed concentric with their outside surfaces, are fastened in position in the upper member, and the ram is brought down until these punches mark slight centers in the top of the brass plugs, when the ram is again raised and the punch *J* removed. The punch is then strapped to the face-plate and each of the small plugs is in turn indicated from the prick punch marks, when it is removed and the hole is ground to size with a steel lap charged with diamond dust in an internal grinding fixture. The stripper is fitted to the punch in the usual manner. With the parts thus made and fitted great accuracy is obtainable.

A die of the four-posted type is detailed in Figs. 20 and 21, Fig. 21 showing the lower member or punch, while Fig. 20 shows the upper member or die. This sub-press is used in making the piece with rack teeth shown in the upper right-hand corner of Fig. 12. A slightly different method of procedure is followed in this case than with the sub-press just described. The punch and die are finished before the upper and lower members are lined up with each other. When the time comes for doing this the punch is entered in the die, the two parts being parallel with each other as to their faces, when bushings *A* are slipped over the posts until they rest in the bottom of the cast counterbores in die holder *D*, Fig. 20. This counterbored space has had pockets gouged out in the sides for the babbitt to flow into and lock with. The grooves shown in the posts in Fig. 15 are not yet cut in Fig. 21, they being still smooth and true as the grinding left them. The space *C* being poured full of babbitt and allowed to cool, the punch and die are permanently aligned with each other without possibility of shifting. The posts are then removed and the spiral grooves for oil distribution are cut in them.

One of the noticeable points about this die, as shown in Fig. 20, although the work is so closely fitted in the tool itself that the eye is scarcely able to distinguish the construction, is the fact that the section of the cutting edge which shears out the rack teeth is built

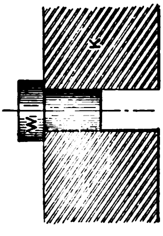


Fig. 16. Plug for Centering Holes for Grinding.

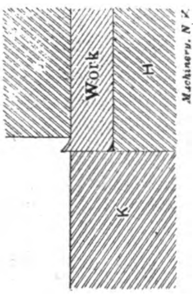


Fig. 17. Action of Badly-fitting Punch and Die.

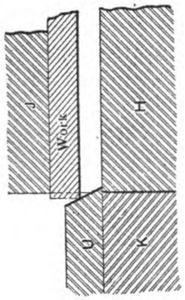


Fig. 18. "Nest" with Work in Place.

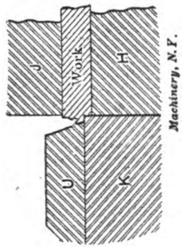


Fig. 19. Work being Trimmed in Shaving Die.

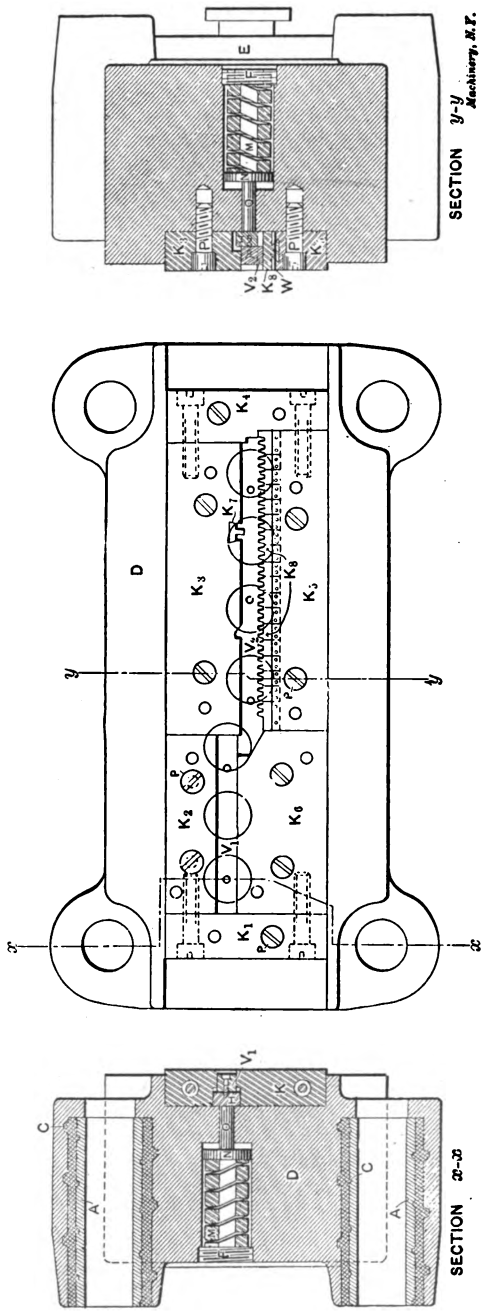


Fig. 20. Plan View and Sections of Upper Member, or Die, of Sub-Press shown in Fig. 22.

up of small segments, each containing two teeth only, these segments being dovetailed into the larger piece, K_5. Each of these small pieces, K_8, is secured by two dowels which pass through from side to side of K_5, locking the parts firmly together. This costly and difficult construction was necessitated by the demand for accuracy in the spacing of the teeth. With the sectional construction shown the parts are not affected sensibly in the hardening. That piece K_5 may not be warped out of shape, it is ground to size in all its surfaces, top, bottom, sides and even in the dovetail, so that when completed its plane surfaces are straight and parallel. The dovetail of the die sections K_8 are next machined to fit this and inserted, being then spaced the proper distance apart. The holes in K_5 are then continued to pieces K_8, which are taken out and hardened, and returned to be doweled in place. It will be seen that this die is constructed on the sectional plan throughout. This makes it possible to finish on the surface grinder most of the cutting edges. Troubles due to distortion in hardening are thus entirely avoided. The proper end measurements between vital points in the model are also preserved by leaving a slight amount of stock where two sections of the die come together, the parts being ground away at this point until the proper dimensions are obtained.

In the few cases where the grinding wheel will not finish the cutting surface, extended use is made of diamond laps, these being in the form of steel sections of proper contour to fit the part of the die they are working in, these steel pieces being charged with diamond dust and reciprocated vertically in filing machines, of which a large number are used in this shop. The little dove-tail in which part K_7 is inserted, for instance, was finished in this way. The back of the dove-tail is perpendicular but the two sides slope somewhat from the vertical forming a wedge-shaped opening enlarged toward the rear. Section K_7 is then driven in from the rear, finished off, and ground with its front face flush with the rest of the die. In Fig. 22, which shows this sub-press, this little section has not yet been finished off, so that it is seen to project above the remaining part of the die.

This is the first operation, or the blanking punch and die. The pieces produced are afterward subjected to the action of a shaving die, the original blanks being left with 0.002 or 0.003 stock for this purpose which is trimmed off in the final operation. The punch for this first or blanking die has the rack section subdivided into four parts only, which are matched up carefully with the sectional die just described. In the shaving die, however, this punch is built in sectional form as described above for the blanking die, so that great refinement in measurements is secured.

The sub-press just described is that shown at the back of Fig. 15 and opened up in Fig. 22. Its action is exactly identical with the smaller one just described; it has all its advantages and presents the same deceptive appearance of perfectly homogeneous surfaces in the punch and die when completed. In the illustration, Fig. 22, the

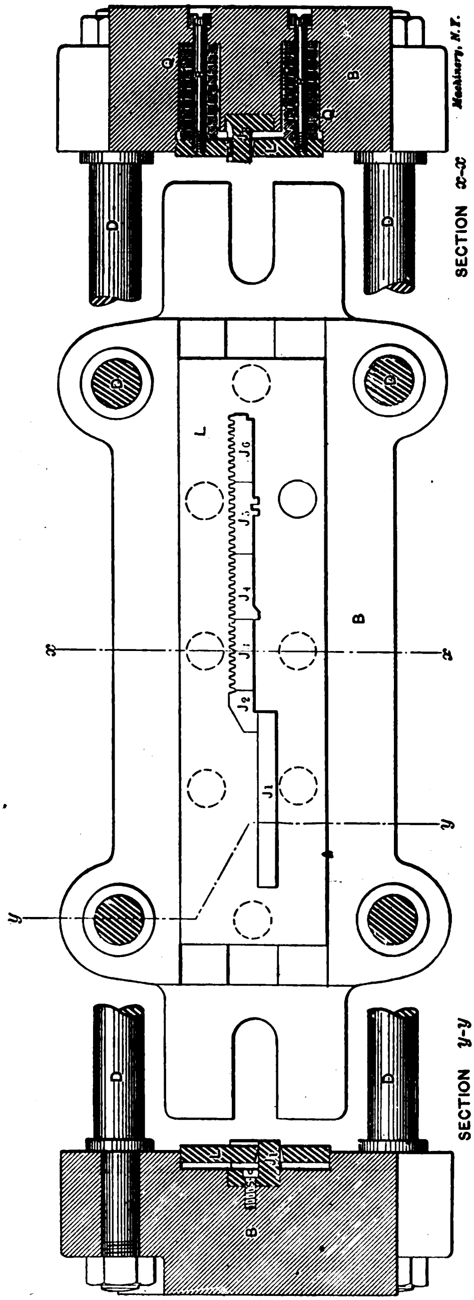


Fig. 21. Plan View and Sections of Lower Member, or Punch, of Sub-Press Die shown in Fig. 22.

shedder and stripper springs have been slacked up in order to show the outlines of the cutting edges, but this is not the normal condition.

A feature of the shaving die system, to which reference has been made, is the use of a "nest" to locate the work. In this trimming operation the punch is in the upper member and the die in the lower one. On the surface of the die, of which an example is shown in Fig. 23, are placed steel guiding plates, U_1 and U_2, which form the nest referred to. They have their edges shaped to the outline of the

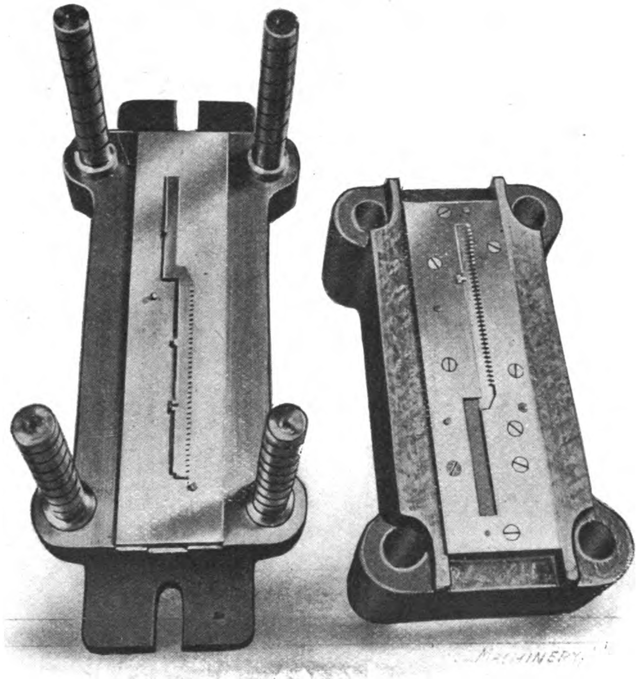


Fig. 22. An Instructive Example of Sub-Press Construction.

piece to be operated upon and they are pressed inward by flat springs *W* at the outer edge, being allowed a slight lateral movement although retained from sidewise displacement by shoulder screws *V*. The holes through which these screws pass are slotted to permit this; the end of the slot limits the inward movement of the plate. As shown in the enlarged views, Figs. 18 and 19, the inner edges of these plates are bevelled backward so as to form a recess in which the work may be located. The descent of the punch forces the plates out, which, as they are displaced, still guide the work so that it is properly centered over the die. These beveled edges of the plates have the further advantage of curling the chip out of the way where it does not clog the tool and may be easily cleaned off. The shedder coming up from below and removing the work, closes the lower opening effectively so that the whole device is chip tight.

Even greater accuracy is advisable in the fitting of the punch and die in this shaving sub-press than is necessary in that used for

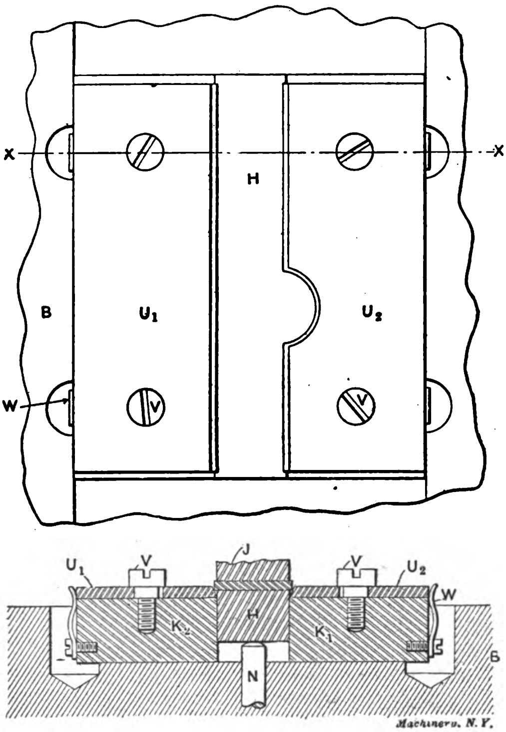


Fig. 23. Shaving Die with "Nest" for Locating the Work.

blanking only, if it is desired to produce clean work free from burrs. The necessity for this will be appreciated upon examining Fig. 17, which shows in magnified form the action of the cutting edges. If the punch does not match up closely with the edge of die *K*, the stock is bent upward, leaving a sharp burr, while the punch impresses the outline of its cutting edge on the top surface of the blank.

CHAPTER III.

MODERN BLANKING DIE CONSTRUCTION.

In the present chapter a number of designs of modern blanking dies for various purposes will be presented. It will, of course, only be possible to show general types, but the suggestions offered by the different designs will prove valuable to the mechanic who is required to design tools of this character.

Sectional Sub-Press Die.

In Figs. 24, 25, and 26 is shown a sectional or built-up die, working on the sub-press principle, and intended for blanking out irregular pieces, the shape of which are best indicated in the center of the punch, Fig. 25. In the assembled view, Fig. 24, the die is shown. It will be seen that the blanks can be changed to different shapes by simply inserting different die sections in different places of the die. At *A*, Fig. 26, is shown a modification of the blank, possible with this die. Another of the principal features of this sub-press sectional die is the means for stripping the scrap and ejecting, when it is wanted to produce punchings in quantities. The die shown in the cut may appear to be unduly light in construction, but several sets have been built on these lines, and given full satisfaction. Their light weight materially lessens the cost of handling, as well as the cost of making. The holder *C* is of good, close grain cast iron, planed on both sides. At the top, a recess is milled with an end mill in a vertical miller. In this recess are held the sectional parts of the die, which are fastened to the body from the bottom. After having made the necessary templets, the various die sections are shaped. A few thousandths of an inch is left on the adjoining surfaces to permit finishing by grinding. The cutting edges of the die sections must be left as hard as possible. Die section *F* is shown in detail in Fig. 26. It will be noticed that two small holes are drilled in the center of the two screw holes in the piece *F*. This is done to enable transferring the screw holes to the cast-iron holder when assembling the die. The bottoms of the die sections are left soft in order to be able to drill all the screw and pin holes through the cast iron holder at the same setting. The dove-tailed slot in the holder *F* is made for the purpose of marking the punching. Each section is reinforced on the two outer sides by four set-screws *H*. In the center of the die a solid block *I* is fastened with three screws and two dowel pins. This block is hardened and ground all over to the shape of the templet. The ejecting or stripping device *J* for the die is made of a solid tool steel piece to the same shape as the templet, but is a very free fit, amounting to a few thousandths of an inch on the sides. This part is left soft and is located a few thousandths inch more than the thickness of the punching below the top of the die. When the die is sharpened, the stripper is ground off the same amount. No springs are used with the stripper, it being actuated by two 1-inch studs fastened with screws on the stripper. These studs pass through the die and holder, and are actuated by a bar fastened to the gate of the press, thereby forcing out the punchings from the die. The six punches *N*, Fig. 26, are upset, as shown, at the end where they are inserted in the holder,

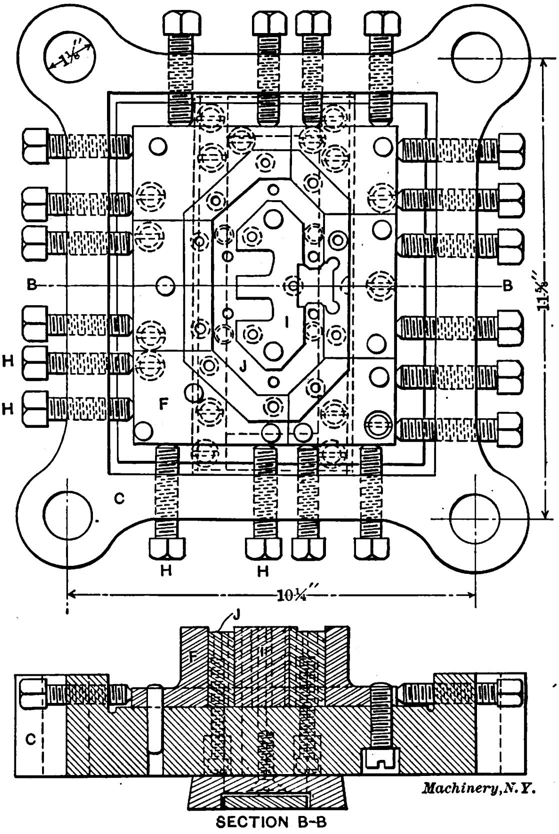


Fig. 24. Sub-Press Die for Irregular Blank.

while the other end is hardened, straightened, and lapped to size. The holes for the punches are located after the die is finished and assembled.

The cast iron punch holder *K*, shown in Fig. 25, is planed on top and bottom and across the four bosses. The four sub-press pins *D* are of tool steel, hardened as far as the head, ground to a light driving fit on the head end, and ground to a sliding fit in the die holder on the other end. The holes for these pins were located so that they are strictly in line with each other, and at the same time square with the punch and die. When the punch and die parts were hardened, they were placed together with two parallels placed between the castings, the punch placed inside the die, and the two clamped together with four C-clamps. In this way the holes, when bored, were bound to come in alignment.

The punch part which is shown at *E*, Fig. 26, is made precisely as

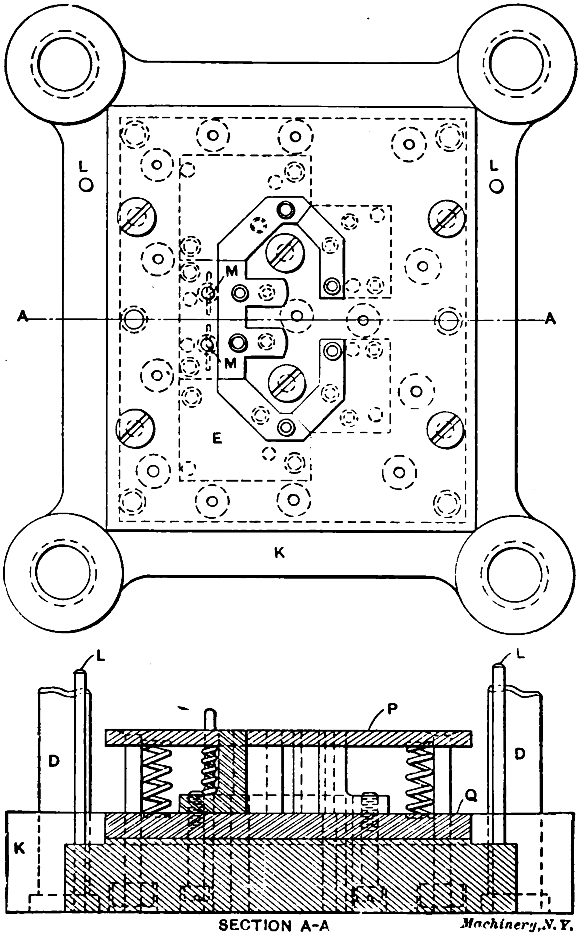


Fig. 25. Punch for Sub-Press Die in Fig. 24.

the corresponding die section, only that in locating the positions for the piercing bushings *O*, it sometimes happens that the holes for the bushings are so many and so small that they cannot be conveniently bored. The holes are then transferred by a drill that runs through the die, and is of the same size as the piercing plug, the die being used as a drill jig. After drilling, the holes are counterbored to the right size for driving fit for the bushings. The latter are hardened and ground all over, and the holes in them taper one-half degree. A straight pin, driven in so as to be located halfway in the bushing, and halfway in the section *E*, holds the bushing in position while in operation. A stripper plate *P* is placed over the punch sections with a free fit on both inside and outside. It is held by flat head screws which are adjusted with nuts from the bottom of the holder. Between

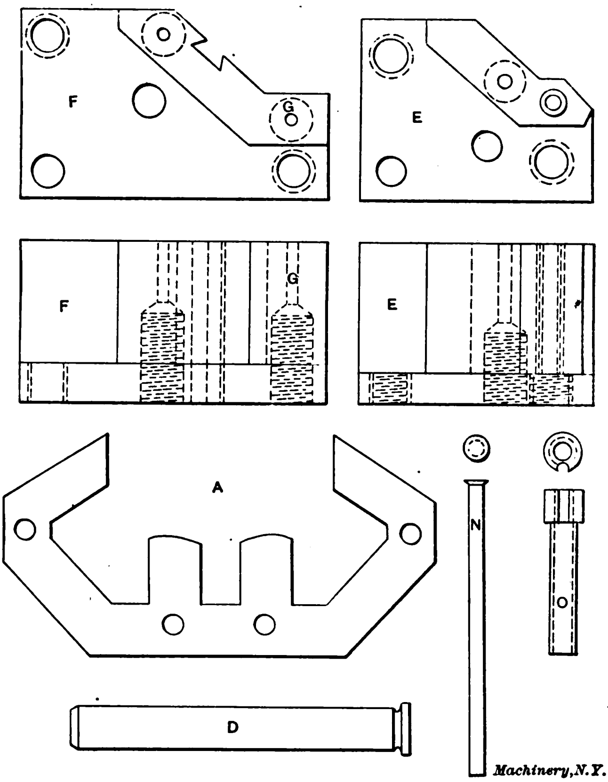


Fig. 26. Details of Sub-Press Die in Figs. 24 and 25.

the stripper and the punch-shoe *Q*, which is made of tool steel and hardened, sixteen spiral springs are placed to strip the metal. The punch-shoes themselves are secured with six screws to the cast iron holder *K*.

Two guide pins *L*, Fig. 25, are driven into the top of the cast iron holder *K*, and two gage pins *M* are located 1/16 inch from the cutting edge. A small wire is driven through the gage pins, below the stripper, having a spiral spring underneath, which latter is seated on the punch-shoe. When the die comes down, forcing down the stripper plate, the gage pins follow, coming up again on the upward stroke.

Punch and Die for Armature Disks.

A compound die for armature disks for the cores for electric motors, which has many interesting features, was described in the September, 1907, issue of MACHINERY. The punch and die are shown in plan views and also in cross sections in Figs. 27 and 28. The die-holder *A*, Fig. 27, is of cast iron, and is first planed on the bottom.

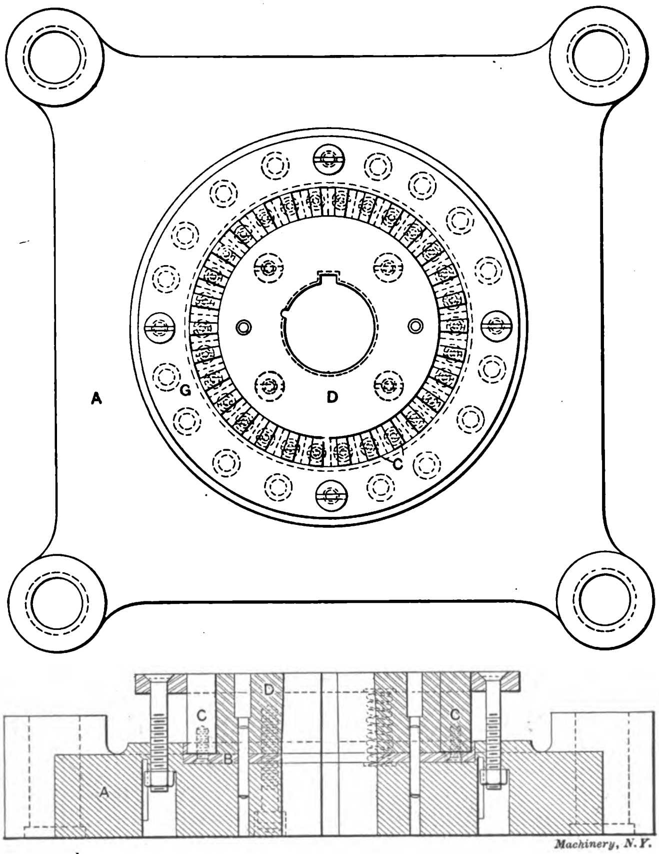


Fig. 27. Die for Making Armature Disks.

It is then strapped to the face-plate of a lathe, and faced and bored to receive the plate *B*. This plate is also first faced on the bottom. It is then turned over and bored to the outside diameter of the disk to be punched; the depth of the bored hole is about ¼ inch. The die sections *C* are all milled in a fixture; they are then drilled and tapped for ¼ inch flat-headed screws. After this, the sections are hardened and tempered. The plate *B* and the sections *C* are then assembled, and after being assembled, the sections are ground. The inside ring *D* is now machined. The keyway and marking notch are tapered one-half degree for clearance; the large hole for the shaft in the armature tapers also one-half degree. The ring is drilled and tapped for four ½-inch screws, and drilled and reamed for two dowel pins. After this the ring is hardened, tempered, and ground to a very close fit in the circle formed by the sections *C*. The center hole is

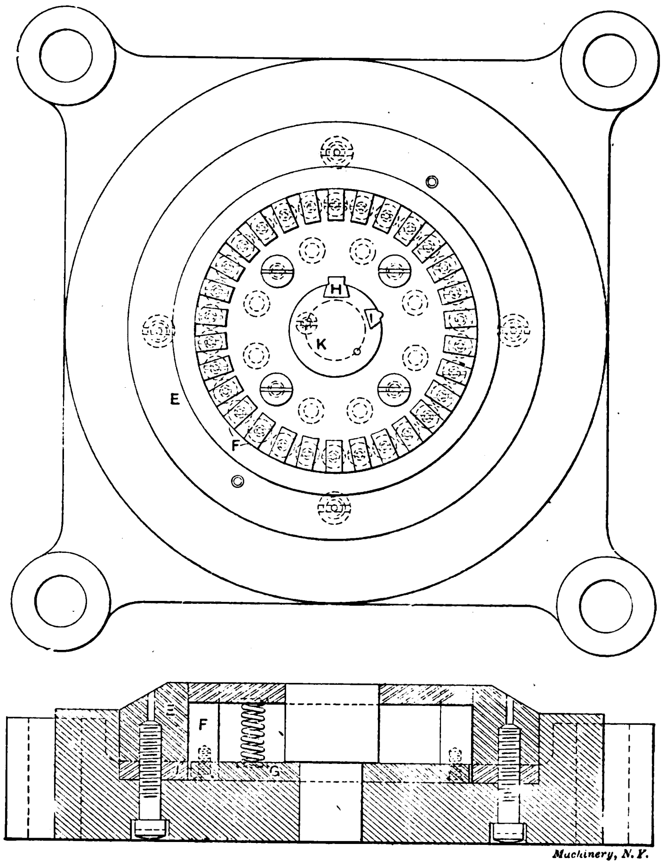


Fig. 28. Punch for Armature Disks.

also ground to the required dimension. The stripper is now made, the working of which is plainly seen from the cut, and the whole is assembled, and the die is ready.

We are now ready to proceed with the punch. In this, *E*, Fig. 28, represents a tool steel ring, which, after it is machined, drilled and tapped, is hardened and ground. Punch sections *F* are located in the plate *G* which is milled with the proper number of slots. The punch sections should be left a little softer than the die, because the punch and die will wear much longer and give much better results if this is the case. The sections *F* are held in place by a ring *J* which is shrunk on the outside at the bottom. At *H* and *I* are shown the punches for the keyway and the marking notch. These are fitted into the center punch, being dove-tailed into this. They taper from the bottom up when the punch is in working position, and are driven in so that when punch *K* is assembled they cannot work out. The

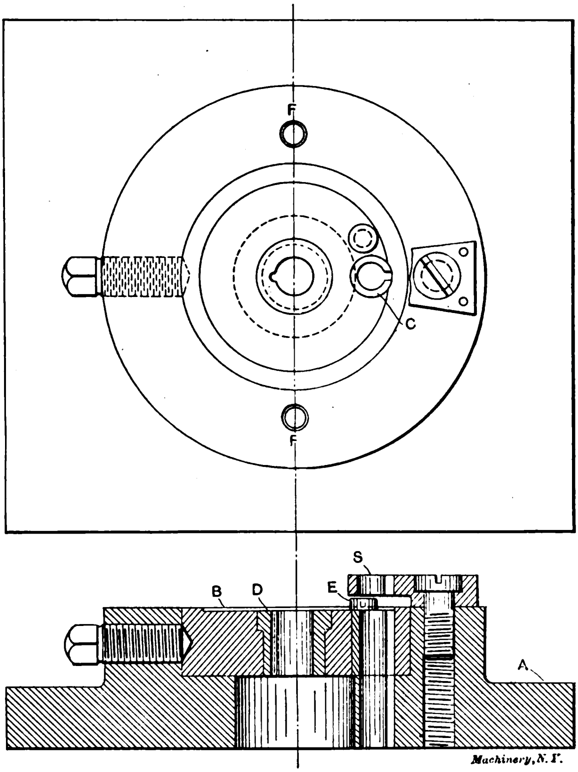


Fig. 29. Die for Armature Laminations used during Experimental Stage.

holes for the sub-press pins are drilled and reamed with the punch and die together, and the holes in the die counterbored to a depth of about ⅜ inch. The pins should be a driving fit in the die and a working fit in the punch.

Tools for Making Armature Laminations.

The engravings, Figs. 29, 30, 31, and 32, illustrate the method of producing the armature lamination, Fig. 33, of a motor, during the experimental, and, later on, the manufacturing stage. In the first case the cost of tools is considered, and in the second, the manufac-

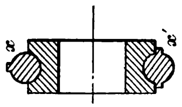


Fig. 32.

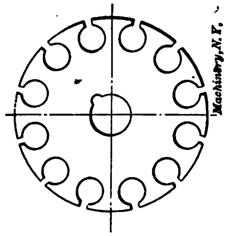


Fig. 33.

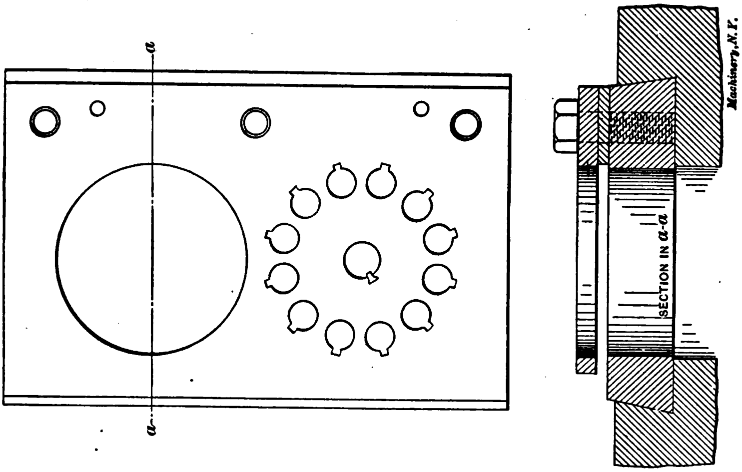


Fig. 31. Die used with Punch in Fig. 30.

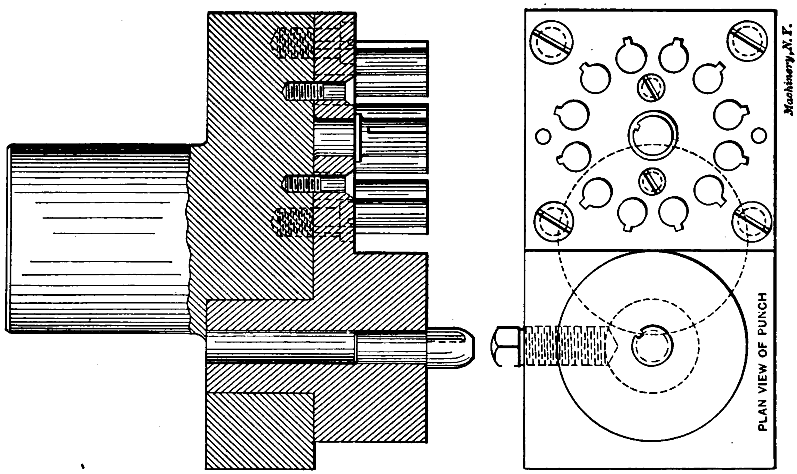


Fig. 30. Punch for Manufacturing Laminations.

turing cost. In Fig. 29, *A* is a die holder for holding round dies. These holders were made for holding ordinary blanking dies, and instead of fastening the stripper to the die, it is fastened to the bolster or holder. The first operation is punching the blank; the second is the punching of the slots. This is done with the die, Fig. 29. The pilot or index pin *E* is removed, and one slot is punched in the blank. After this operation is completed, the pin is replaced and the rest of the slots are punched, the pilot or index pin being located so as to

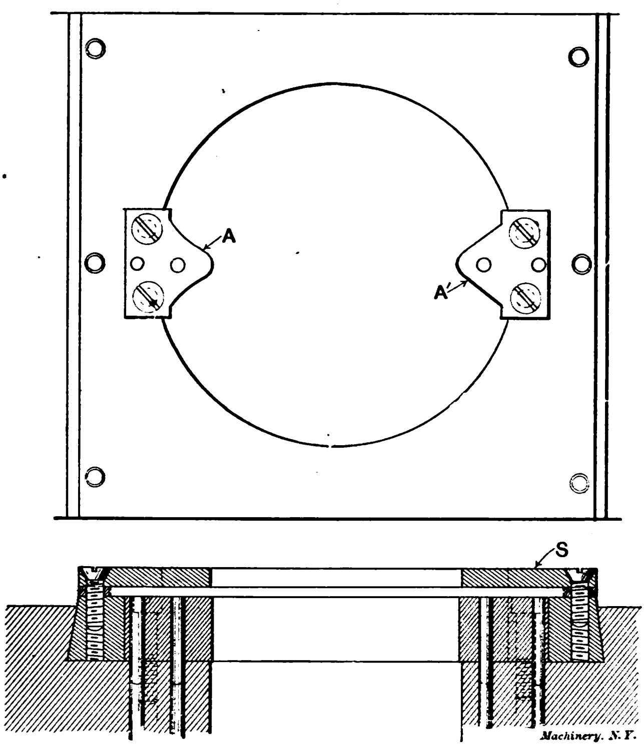


Fig. 34. Die for Outside of Blank shown in Fig. 38.

index correctly. The die holder *B* is made from machine steel and recessed to allow the blank to fit properly; the die proper, *C*, is sweated fast in its place so as to avoid any chance of shifting its position. The die *D* is used for the last operation, the punching of the center hole for the shaft. The stripper *S* is removed when punching this hole, and another is fastened at *F F*. This latter is, of course, removed when punching the slots. The pilot pin *E* is used in the last operation also for locating the keyway properly in the blank. The cost of these punches and dies was small, but the manufacturing cost would come high if used to produce large quantities.

As enough of laminations were wanted to warrant a more expensive punch and die, and the manufacturing had to be cheapened, the design shown in Figs. 30 and 31 was adopted. These illustrations need no further explanation as to the operation of the tool. It is readily seen that a complete lamination is obtained at each stroke of the press. A special milling cutter was made to mill the punches. Fig. 32 illustrates the method of milling the punches as well as the broach for sizing the holes in the die. First both sides are milled,

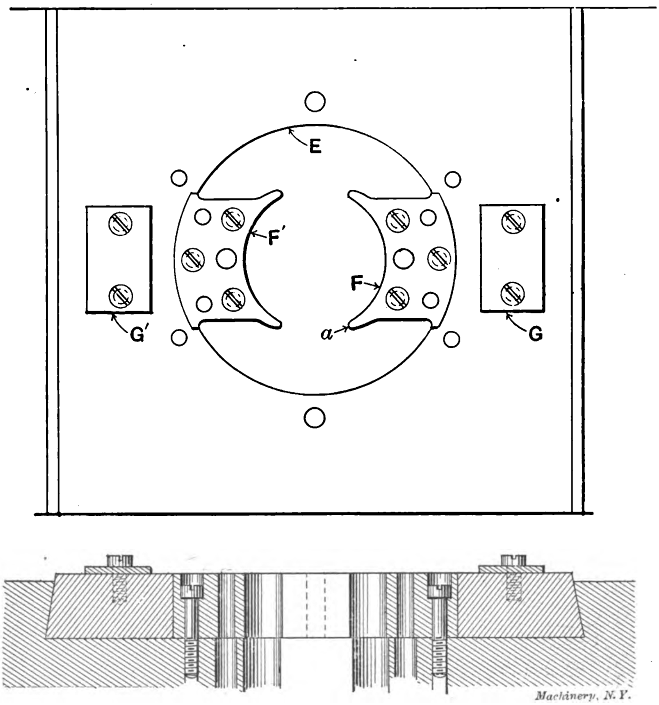


Fig. 35. Die for Inside Shape and Holes of Blank in Fig. 38.

as shown at x', leaving a key at both sides of the punch or broach. Then one of the keys is milled off as shown at x. A small section is inserted at the center hole of the die, leaving a solid key in each blank instead of the keyway in the experimental lamination shown in Fig. 33.

Sectional Punches and Dies.

The punches and dies in Figs. 34, 35, 36, and 37 were made for producing the punching Fig. 38, in two operations, and illustrate to some extent sectional die making. As a perfect punching was required in regard to the inside and outside diameters, the design shown was adopted, which proved to be all that could be desired as to accuracy and cost of making, particularly when compared to previous methods

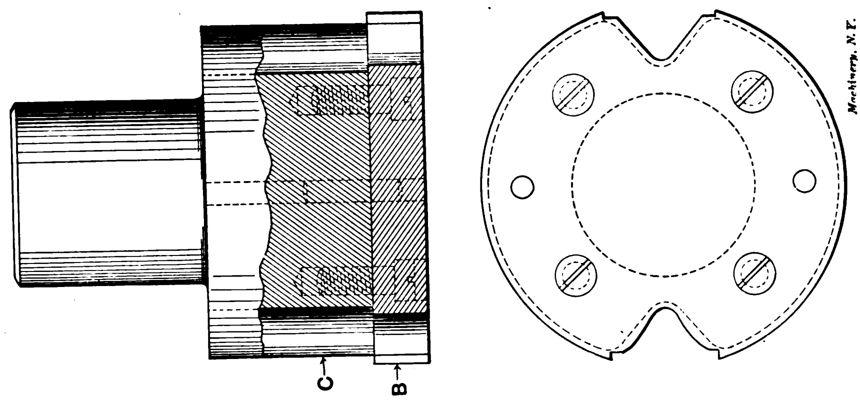


Fig. 36. Punch for Punching Outside of Blank.

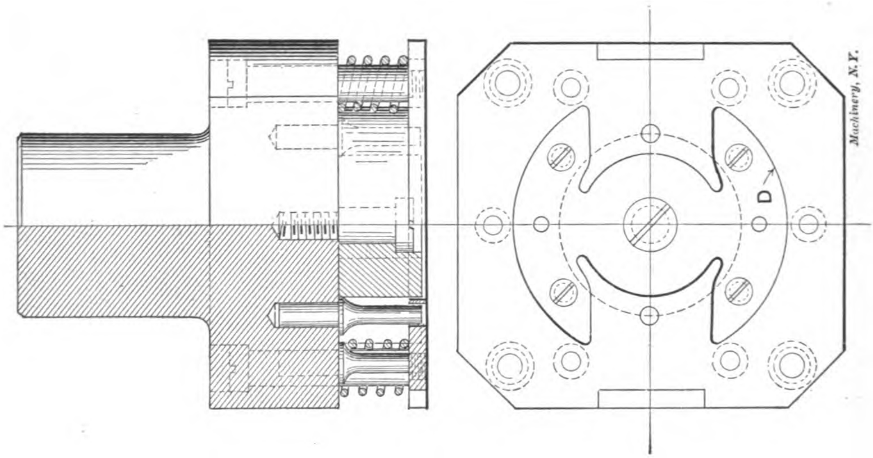


Fig. 37. Punch for Inside Shape and Holes.

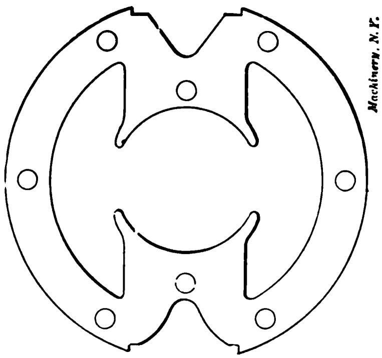


Fig. 38. Finished Punching.

and results. In making the punch and die for the first operation, Figs. 34 and 36, the punch was made first. *B* is the punch proper, and *C* is the holder which is made of cast iron. The punch was hardened and screwed and doweled to the holder before grinding the outside diameter to the correct size. Then the die was machined, and after hardening ground to fit the diameter of the punch. The sections *A* and *A′* were then fitted to the die and fastened with the screws and dowel pins as shown, and sheared by the punch. As the sections *A* and *A′* were small, they did not alter any in hardening.

For the second operation, the punch and die, Figs. 35 and 37, were made in the same way, that is, the punch was hardened and ground on the diameter *D*, and the die ground at *E* to fit diameter *D*. The sections *F* and *F′* were then machined in the proper way and sheared by the punch. In hardening the sections *F* and *F′*, one of them altered so much at *a* that it had to be discarded and another made. This could have happened had the die been made solid; which would have condemned the whole die, and a new die would have had to be made. The rest of the design is readily understood by referring to cuts, Fig. 34, where *S* is the stripper, and Fig. 37, where the stripper is on the punch, the blank being placed on the die guided by strips *G G′*.

CHAPTER IV.

DRAWING AND FORMING DIES.

Only those who have made a specialty of drawing sheet metal know just how to proceed to lay out a die so that the desired result will be a certainty the first time it is tried. First, we are confronted with finding the diameter of the blank. There are several methods by which we can determine the size of the blank. One way is to cut out a blank of the same thickness as the stock of which the model shell is made, and then keep reducing the diameter until the blank balances the model. Another way is to multiply the circumference

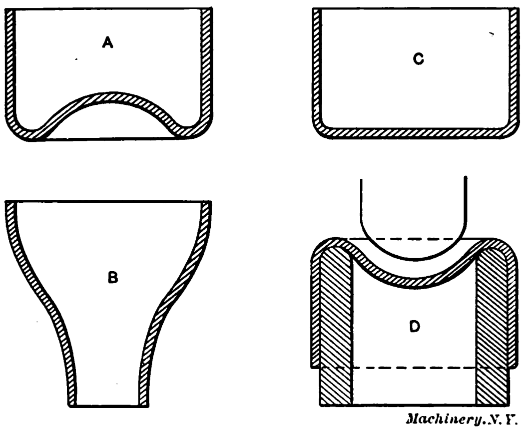
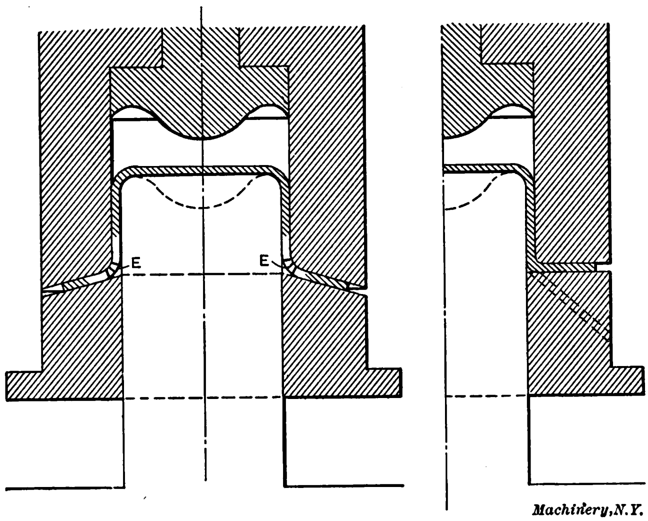


Fig. 39. Method of Drawing Shells which gives a Minimum Variation in Wall Thickness and a More Even Distribution of Stretch.

by the height and add the area of the bottom, which gives the area of the blank, then find the diameter of a circle whose area is equal to the area found. This latter rule applies to blanks that must be of a uniform thickness on the sides and bottom; but if the article should be an ordinary box or something allowing a variation of thickness, the size of the blanking die can be much smaller, that is a shell 1½ inch long can be drawn from a blank 3 inches diameter, or from a 2-inch blank. The sides and bottom will, of course, be thinner in the latter case. A good rule to follow is to make the height of the shell at first draw, one-third the diameter of the blank, that is, a 3-inch blank, for best results, should produce a shell 1 inch long at first draw. The shells should be annealed if drawn to any length.

Fig. 39 shows a novel method when the blank is to be drawn into a shell of great length or into a shape as shown at *B*. The first operation leaves the shell as shown at *A*, and this will save at least one drawing operation. It will be noted that the indented end in the shell bottom presents surplus stock, so to speak, whereas, if it is drawn at the first operation in the ordinary way as shown at *C*, the succeeding operations must be gentle to prevent a greater reduction in the thickness of the walls on the angular sides of the shell. Another advantage in shaping the first shell as shown at *A* is that when drawing it to the angular shape, the stretch or draw of metal is more evenly distributed over the entire surface and the strain on the metal is not as great as if the draw commenced at the corner. Another novel feature is to shape the blank as at *A* (if the shell is to be a long one) and then use a die for the second operation, as illustrated at *D*. The



Figs. 40 and 41. Diagrammatical View illustrating the Stretch of the Metal and the Effect of Angular Punch and Stripper Faces.

blank, when forced through, is actually turned inside out. This operation presents two good points. First, we are enabled to get a suitable amount of stock in the shell so distributed as to draw to the best advantage. Second, if the shell is to be a long one, the diameter of the blank must of necessity be large, therefore the stock is distorted considerably in changing from a flat blank to a shell of much smaller diameter, and if we could see the grain of the stock as it passes over the die, it would present an appearance similar to that shown by the lines *E* in Fig. 40. That is, the inside of the stock stretches and the outside compresses. Therefore, by turning the shell inside out, the stock is apparently restored somewhat to its original texture of close grain, which will allow further stretching.

A very important point which must not be overlooked is the angle on the face of the stripper and blanking punch. In making long, small diameter shells, if the angle on the stripper and blanking punch is, say 8 degrees, the shells will break out at the corner; but by changing the angle to 10 or 12 degrees, they will come out without breaking. This point can be better understood by referring to the half section, Fig. 41. It would be almost impossible to draw the shell when the edges of the blank were at right angles to the shell, but by making the angle of the punch and stripper as shown exaggerated by the dotted lines, the shell is practically drawn by the blanking punch, and leaves very little work for the drawing punch. The above suggestions were contributed to the August, 1908, issue of MACHINERY by Mr. Frank E. Shailor.

Dies for Making Tin Nozzles.

In the following pages is described and shown a set of dies for the production of nozzles for tin cans of large sizes used to ship liquids. The dies are of the combination type used in single action presses, and perform from one to three operations at one stroke of the press. From 12,000 to 15,000 pieces of finished work can be turned out per day from these dies according to the speed of the operator.

The first die, Fig. 43, is composed of eight principal parts: *A* is a gray iron bolster plate made to separate at the line *a-b* so the die can

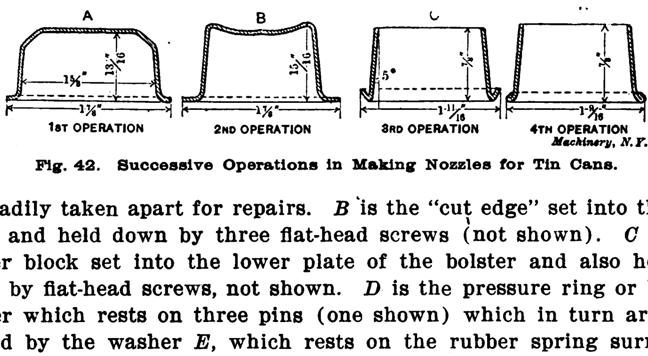


Fig. 42. Successive Operations in Making Nozzles for Tin Cans.

be readily taken apart for repairs. *B* is the "cut edge" set into the top plate and held down by three flat-head screws (not shown). *C* is the center block set into the lower plate of the bolster and also held in place by flat-head screws, not shown. *D* is the pressure ring or blank-holder which rests on three pins (one shown) which in turn are supported by the washer *E*, which rests on the rubber spring surrounding the stud *F*, and held in place by another washer and nut (not shown) with which to regulate the pressure while drawing the shell. *G* is the punch and drawing die combined, the outside diameter of which is fitted to the cut-edge *B*. The inside diameter equals the center block *C* plus twice the thickness of metal. *H* is a forming pad made to fit the top of the center block *C*. It forms the top of the shell at the end of the stroke and also serves as a knock-out for the shells.

In operation the tools are set into an inclined press. The punch coming in contact with the cut-edge *B* cuts the blank, which is held by the pressure ring *D* against the end of the punch *G*, but as punch *G* continues down the blank is drawn over the center block *C*; and, as the punch ascends, the stem *I* in the top of the punch shank comes into contact with a bar in the press pushing the pad *H* down, and the shell represented at *A*, Fig. 42, slides off back of the press.

Fig. 45 shows the second operation or redrawing tools. *A* is the bolster plate, *B* is the drawing ring, supported by pins and a rubber spring, the same as in Fig. 43. The center block in this die is tapered and the punch *F* is also bored out tapering to fit it. The pad in punch *F* is of peculiar shape, as will be noticed and will be explained later. The shell is placed on the drawing ring, and the punch, as it descends, draws it down and compresses it to the shape of the center block *C*. The shell is knocked out on the up stroke by the stem *H*, same as in the first operation, and the drawn piece looks like *B*, Fig. 42.

Fig. 44 shows the tools for the third operation, which really consists

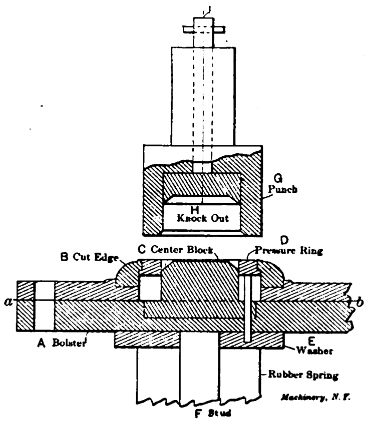


Fig. 43. First Die for Tin Can Nozzles.

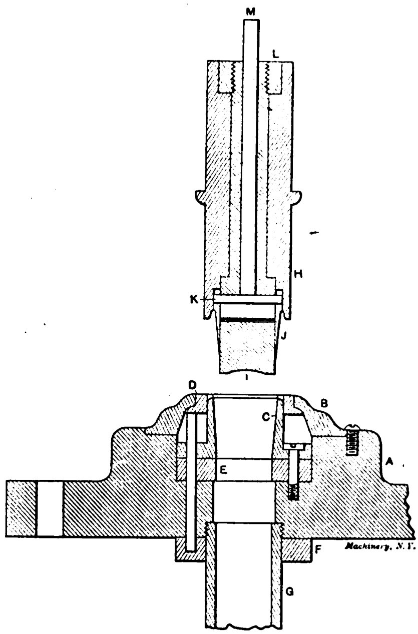


Fig. 44. Tool for Third Operation.

of three operations. *A* is the bolster plate of the die; *B*, the trimming die; *C*, the center block; *D*, the drawing ring; *E*, the lower die; *F*, washer; *G*, tube through which the bottom of the nozzle passes after being punched out. These bottoms are used for roofing shells for fastening tar paper in place on roofs, etc., so that in the process we really make two articles at once. These tools are used in an inclined press. As the punch comes down, punch *I* cuts out the bottom, and at the same time punch *H* trims the lap edge; as it continues downward, it presses the shell over the edge of the center block *C*. As the punch ascends the knock-out bar comes in contact with the pin *M*, carrying the stripper *J* down by the cross-pin *K* and ejecting the nozzle in the shape of *C*, Fig. 42.

Fig. 46 represents the tools for the fourth and finishing operation. It consists of a simple punch and die, yet much depends on these tools, for the nozzles all have to be of an exact size on the finished edge to receive a sealing cap and this cap when closed on must be watertight. The die consists of a bolster-plate *A* and a die-block *B*, made of tool steel, hardened and tempered. The punch is also hardened and tempered and ground out to gage. The tools are set in the press, and the nozzle is slipped on the die-block. The punch in coming down passes over the work until the edge turned up on *C*, Fig. 42, comes in contact with the shoulder *F* on the inside of the punch. As the punch continues downward, this edge is curled over and pressed down to the

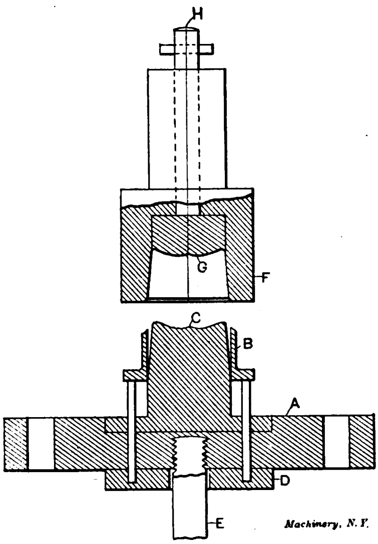


Fig. 45. Redrawing Tool for Second Operation.

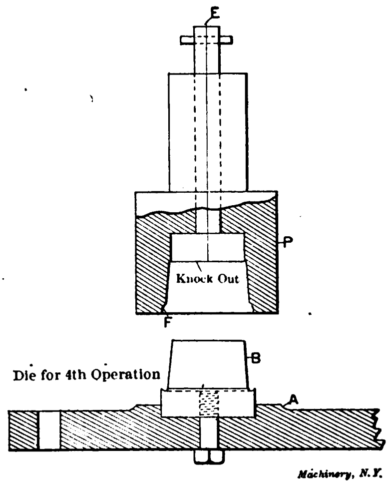


Fig. 46. Tools for the Finishing Operation.

shape of *D*, Fig. 42. As the punch rises the shell is knocked out by the knock-out stem same as in all the other dies.

Punch and Die for Blanking and Forming Copper Cups.

The die in Fig. 47 is designed to blank and form up a copper cup or capsule used in the manufacture of balance wheels for watches. The copper strip is fed into the press, which then blanks out and draws the metal into the shape shown at *R*, at the same time punching the center hole. Referring to the illustration, *A* is the base of the sub-press, *B* the body, *C* the cap, and *D* the plunger; all these being of cast iron machined to size. The body and base are held together by two screws *E* after the usual well-known manner. *F* is the buffer plug which receives the thrust of the press piston, and *G* is the babbitt lining of the body *B*. *H* is the outside diameter die, held in place by four screws and two dowel pins. *H'* is the outside diameter punch, also held in place by four screws and two dowels. *I* is the die for cutting out the center hole, and *J* is the punch for this hole. *H'* and *I* also serve as forming dies in bringing the metal to the proper shape. *K* and *L* are shedders, supported by four push-pins, those of the former resting upon springs whose tension is controlled by short threaded plugs, as shown, and those for the latter abutting against the piston *M*, which is in turn pressed down by the large spring *N*, the tension of which is controlled by the plug *O*. The block *P* is used merely to hold the punch *J* firmly in place.

The operation of the die is as follows: The press ram being at the

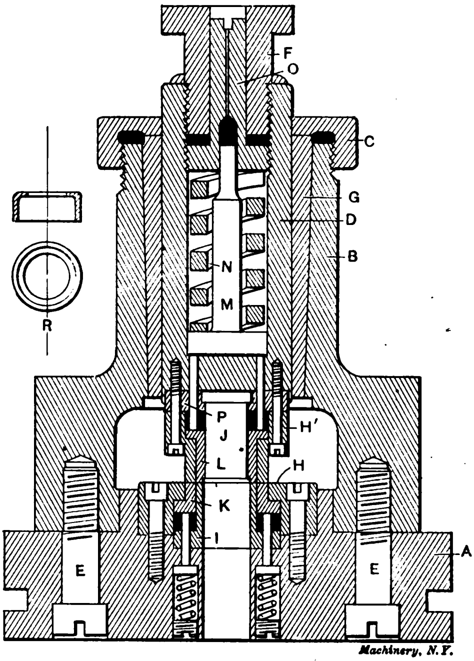
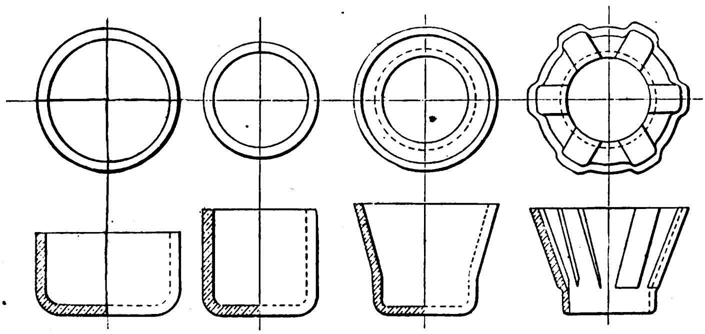


Fig. 47. Punch and Die for Blanking, Piercing, and Forming the Copper Capsule shown at R.

top stroke, the copper strip is fed in across the top of *H*, and as the ram descends, the blank is cut from the strip by the punch *H'* and drawn to a cup shape between the inside edge of *H'* and the outside edge of *I*. Simultaneously, the center hole is punched by *J* and *I*. As will be seen by referring to the illustration, *J* is made a trifle short so that the drawing operation will have begun before this hole is punched. This prevents any distortion of the piece by the punch *J*. Some little trouble has been experienced with this tool at first on account of the air in the hollow plunger *D* forming a cushion when it was compressed by the rising of the piston *M*, thus preventing the proper working of the die. This was finally obviated by making a small groove at the side of the piston where it worked in the plug *O*, and drilling a vent hole through *O* as shown. This allowed free communication to the atmosphere, and from then on the die gave complete satisfaction. The variation in size among the cups, or capsules, as they are called, is never more than 0.001 of an inch either in diameter or in length.

Punches and Dies for Drawing an Odd Shaped Brass Cup.

The set of punches and dies described in the following paragraphs, while not exceptionally out of the ordinary, may have one or two points that will be of interest to any one engaged in this class of work. Figs 48 to 51 show the progressive operations from start to finish by which the piece shown in Fig. 51 is produced. This is a corrugated, conical cup, drawn from a round blank of soft brass 3-32 inch thick and 2 5-16 inches in diameter. The corrugations project



Industrial Press, N.Y.

Fig. 48. Fig. 49. Fig. 50. Fig. 51.

externally, and internally form six equally spaced, square grooves which converge radially and disappear within about 3-16 inch of the bottom. The specifications in this case require that there shall be developed on the outside a distinct shoulder at the base of the conical part and that this shoulder be formed on the corrugations only. On the inside no shoulder is to be visible, but the formed grooves are made to disappear uninterruptedly near the bottom. It will be seen that the pressure in the last drawing has to be much greater than ordinary, in order to accomplish these results, for the stock at the point where the straight and conical portions met was pressed out quite thin in order to develop the shoulder.

The dies and the shanks of all of the punches used are made of a uniform size so that two holders, one for the punches and one for the dies, are all that are required. The punches are secured by a setscrew, and the dies are seated in the holder and held fast by four set-screws, equally spaced around the side, with their points set into the circumference of the dies. To make the change from one operation to the other it is only necessary to loosen the screws, remove the tools in use, and substitute the ones next in the set. Each drawing operation is followed by a careful annealing in order to insure the equal flow of the metal, and to minimize any possibility of cracking.

The main problem is to make the finishing punch as cheaply as possible, and have it stand up under the severe work required of it. It was first made in sections by turning it to shape, and then dovetailed to receive the elevated pieces which were made separately and forced into the dovetails up against a shoulder. Then the end was drilled and tapped, and the straight tip screwed on. The parts hav-

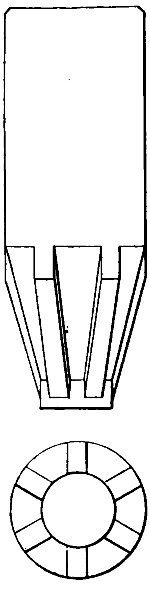


Fig. 52.

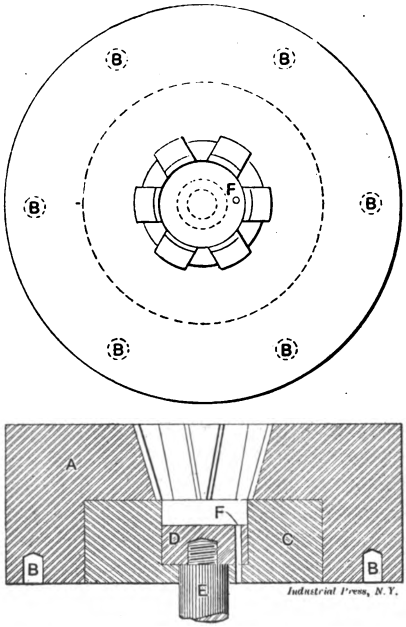


Fig. 53.

ing been carefully fitted, were marked, removed and hardened, and then replaced as before. The punch made in this way had been used but for a short time when the elevated pieces began to chip and crack, where the strain was the greatest, and often one hundred or more cups would be run through before the defect was noticed. For this reason the hardened sections were replaced by soft ones, but after a short run they would flatten down and make continual repairing necessary. To overcome the trouble the punch was finally made as shown in Fig. 52, from a solid piece of tool steel. This was milled, chipped, and filed to a finish, and after hardening was drawn to a light straw color. After this no more trouble has been experienced.

The first and second drawing dies were made from tool steel disks, 5 inches in diameter and 2 inches thick, with holes to draw the cups as shown in Figs. 48 and 49. These dies were of the plain push-through type with a sharp edge on the under side to strip the work from the punch which was made slightly tapering and of a diameter equal to the inside of the cup. In this case the punch was made two thicknesses of the stock plus 0.008 inch, less than the hole in the die. Previous to the last operation it is general to make the punches more than twice the thickness of the stock smaller than the die and to taper them 1/8 inch per foot to assist in stripping the work, for in most cases the exact sizing of drawn work is of little importance up to the last operation. Consequently tapering the punch and making it below size will in no way interfere with the finishing of the work which is all done in the last operation by a punch and die that must be made of suitable dimensions to meet the requirements. The rule usually adopted is to make the punch small and tapering for short cups of thick metal and nearer to size for thin stock, for the latter is more apt to develop body wrinkles if not properly pressed out in the die. The die for the third operation is made the size of the finishing die but with plain walls.

The die for producing the finished work is shown in Fig. 53. The part *A* was first turned and bored in the lathe and then fastened on a special arbor fitted to the spindle of the dividing head of a milling machine. Six 1/4-inch holes were drilled and reamed, as at *BB*, the piece being indexed so that they would be accurately spaced. A special angle iron was made for holding this piece at the angle of the sides of the die, and two holes were carefully drilled in its face to correspond with a diametrically opposite pair of the drilled holes in the back of the die. In these holes were driven 1/4-inch guide pins which projected 3-16 inch above the face of the angle iron. The angle iron was then bolted to the knee of a shaper, and the die located on its face, by the pins, and strapped firm and true. The six drilled holes provided a means for accurately locating the die for planing the grooves, which was done with a formed tool screwed on the end of an extension shaper tool of the kind usually used for internal work. After shaping, the grooves were filed and polished dead smooth and the die was hardened. The piece *C* was turned and ground to a light driving fit in the back of the die and both pieces surfaced on the under side. *D* is a steel pad and *E* a stud for stripping the finished work. They are operated by the press ram on its upward stroke. The vent *F* is for the escape of air. Following the drawing of the cup the bottom was punched out in a plain cutting die. The description of the above die was contributed to the August, 1903, issue of MACHINERY by Mr. C. H. Rowe.