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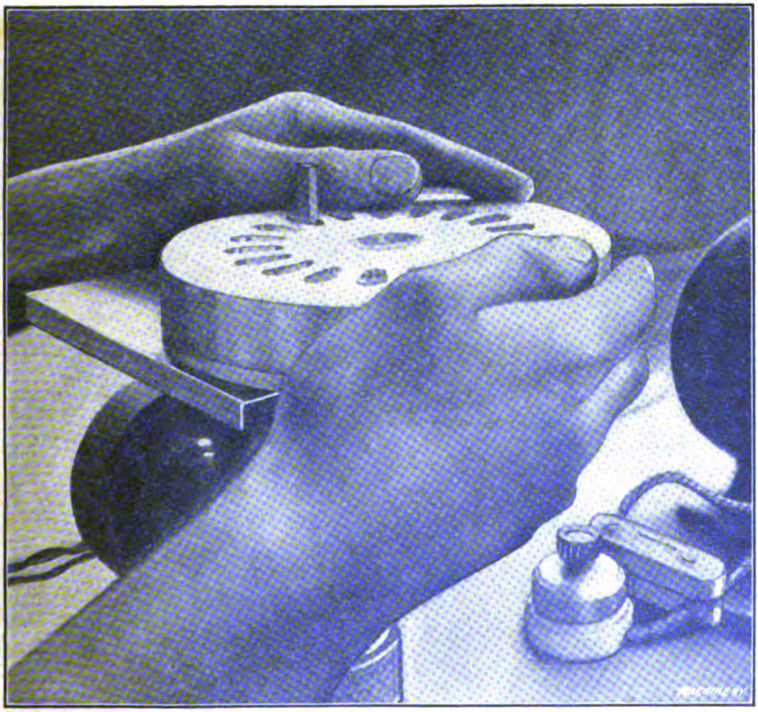
DIEMAKING PRACTICE

GENERAL INFORMATION ON DIEMAKING—THE MULTIPLE PLUNGER PRESS AND ITS TOOLS—SUB-PRESS DIE CONSTRUCTION



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NUMBER 131

DIEMAKING PRACTICE

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CHAPTER I

GENERAL INFORMATION ON DIEMAKING

In any branch of machine or tool manufacture there is always some variation in the methods employed in different machine shops and toolrooms for doing the same general class of work, and diemakers are not an exception to this universal rule. In fact, there is probably a greater difference in methods of diemakers than is found in any single branch of tool or machine manufacture, because of the almost endless variety of dies which has often made it necessary for individual diemakers to devise their own methods of procedure in accordance with the requirements of the work in hand. Therefore, this treatise on diemaking methods presents general and specific information which represents the practice and experience of different diemakers, and while there may be other and perhaps better methods for accomplishing the same results, an effort has been made to secure information that is not only reliable but which will be of practical value to those engaged in this kind of work.

Practical Hints on Blanking and Piercing Die Construction

When making a blanking die it is common practice to begin by making a templet that conforms to the shape of the blank which the die is to produce. This templet is then used as a gage when finishing the hole in the die. It is absolutely necessary if accurate work is to be produced by punches and dies that the templet be accurate. This is one of the first points which the diemaker should be sure of before commencing to make the punch or die. When templets are made from copper and brass, a good method of coloring them is to apply some ordinary steel coppering solution, and mix with this a little steel filings; then rub this around on the brass sheet.

Always remove at least 1/16 inch from the top face of the die blank, as this amount is generally decarbonized and will not harden perfectly. In laying out the blanking and piercing die always allow for scrap between the blanks. This amount should never be less than the thickness of the stock. When putting on a gage plate, always allow for variations in the stock, and the spreading of the metal while being worked. A good method of working out die blanks after the core has been removed is to set them up in the shaper vise between two parallel strips which should hold them at the angle required for clearance, and then remove the stock with a tool made similar to an ordinary internal keyseating tool. If the hole in the die is large enough to permit adopting this method, it has an added advantage of leaving the sides perfectly straight, which simplifies the operation of filing them to shape.

The stock should be removed to within about 1/64 inch of the finish line, and then the mouth of the die beveled with a file to the line, before the finishing cut is taken. When filing out the die, the angle to which the die is beveled should be adhered to as much as possible, because trouble will occur after the die is hardened, if it has not been filed on a straight bevel. For instance if the opening is slightly larger at the top, this will cause the blanks to scrape on the sides of the die when being forced through, which sometimes bends them out of shape. The templet should be worked through the die from the back, as in this way the correct shape is more easily attained. All the guide pins in the punches should be located by means of this templet.

Do not stamp any necessary information on the top face of the blanking die, as it is generally removed when the die is ground. It is usually advisable to stamp whatever is necessary on the front edge of the die; but, if that is not convenient it should be put on the stripper plate. The bottom of the die should be ground level if good results are to be expected. In filing out the die, it is convenient to have a set of small "squares" which are set off from ninety degrees, an amount equal to the angle required on the die for clearance. These may be made from 1/16-inch sheet steel with the base ½ inch wide by 2 inches long, and the beam ⅛ wide by 1½ inch long, or they can be made to suit the requirements. It is generally found advisable to have these ranging from ½ degree to 2 degrees varying by ½ degrees. The number of degrees that these are set off from 90 should be marked on the various squares to designate them.

It is generally advisable to harden a blanking die at a low heat to prevent it from springing out of shape and cracking. The following is a solution which has been found to give very satisfactory results for this purpose. Into pure rain water mix enough salt to float a raw potato. To eight gallons of the brine, add one pint of oil of vitriol. After hardening the die in this solution it should be dipped in strong, hot soda water, which will keep it from rusting.

Points on Making Punches

When machining a punch which has inside corners, holes should be drilled in the corner close to the finished line, and as deep as the straight part of the punch extends. The size of the drill, of course, should correspond to the radius required on the punch. The punch should be beveled on the edge at an angle of about 45 degrees to a little below the finished line. This enables the punch to start centrally when shearing it into the die, and also simplifies the locating of it. This beveled portion can be ground off after the punch is hardened. When shearing the punch through the die, be sure that it stands perfectly square with the top face of the die. Care should be taken when shearing the punch through the die to see that it does not remove too much stock. If the die removes a nice curling chip from the punch it is not removing too much stock, but if the chip cracks and breaks as it is severed, it is obvious that it is removing too much stock, and before going any further the punch should be removed and reduced in size, at the point or points where the die was removing too much stock. It is advisable always to use oil on the punch when shearing it through the die.

Punches for piercing and blanking copper should be polished quite smooth, as copper clings tightly and is difficult to strip from the punch. If on the other hand the punch is left rough, the force necessary to strip the blank from the punch is very likely to bend it out of shape or to break the punch.

When making blanking or piercing punches for plain circular work, hold the punches by the shank in a punch bolster, and set this up to run true in the lathe. The outside diameter is then turned to the required size and the hole for the guide pin is also drilled. Making the punch in this way insures the guide pin being in the exact center of the punch.

Small perforating punches should be hardened their entire length, otherwise they will be upset or bent if thick metal is to be perforated. The punches should also be carefully examined after hardening and tempering, and those which have been bent or sprung in the hardening should be carefully straightened. Piercing punches in compound dies are steadied by the knock-out while operating on the stock. The punch is made a sliding fit in the knock-out, and the knock-out is also made a sliding fit in the die. When perforating thick metal where the strain on the press is great, a good method to reduce the pressure is to make each second punch lower than the preceding one an amount equal to the thickness of the stock. This, as can be seen, will reduce the pressure, as half the punches are through the stock before the remaining half operate. When heavy stock is being blanked or pierced, punches are not required to fit as snugly as when the metal is thin.

It is generally found after hardening small piercing punches, that although the holes in the punch holder are true with the die, the punches do not line up. This is because they have bent slightly in hardening. They can usually be brought into alignment by giving those that do not enter half a turn, but if this does not locate them correctly, they should be removed and straightened. When a large and a small piercing punch are too close together to allow both being set in the punch holder, the smaller punch is set in the larger one. and securely held in position.

Before transferring the outline of an intricate shaped die to the punch, it is good practice to coat the face of the blanking punch with solder; then machine the solder so that it is level. Coating the punch with solder enables one to obtain a much better outline than would be possible when scribing on the hard steel, and the very narrow and intricate parts can be laid out more easily. Another feature of the solder face is that if there are weak projections it eliminates the chance of breaking them when shearing the punch through the die. If 1/16 inch of solder is evenly placed on the punch, it allows the die to cut a perfect impression in the solder, which is a great help in milling the punch, as the milling cutter can be brought down until it just scrapes the solder, and the cut taken. At the completion of the milling operation the solder is removed.

In fitting the punch into the die, scrapers can generally be used to good advantage, as the points which are high can be reduced by scraping where it would be more difficult to file. These scrapers may be made in various shapes to suit the requirements. When piercing holes in a circular piece of work, the radius on the bottom face of the punch should be less than the radius on the piece, so that the outer edge of the punch will strike the metal first. If this precaution is not taken and the punch made the same or a greater radius than the piece, the work will be changed from its original shape.

Compound Dies

Compound dies are made without clearance, and the blanks are ejected by the knock-out as soon as the punch leaves the die. The piercing holes in the punch, however, should be taper reamed and larger at the top so that the piercings will pass up through the punch easily. The throwing out of the piercings from a compound die is aided by setting the die in an inclined press. If a double compound die is required to produce two blanks on one stroke of the press, care should be taken to see that the knock-outs are ground to the same height, and also that the blanking punches are perfectly level, so that both blanks will be flattened alike. The spring or rubber pad which operates the knock-out in the compound die should be adjusted tighter than necessary to insure the blanks being removed. The knock-out should just bring the blank to the surface of the die.

Guide Pins

Guide pins should be made slightly smaller than the hole in the blank and should be straight for the thickness of the stock, and then rounded off similar to the point of an acorn. The heads of all guide pins should be turned true with the shank. Care should be taken to see that the guide pins are also exactly in line with the piercings. If they are not in line they have a tendency to twitch the metal around, so that after a few blanks have been punched, they will be found to run off the strip. Precaution should be taken to see that the stock does not cramp between the guide pins and the stop, or between the guide pins and the back gage, because if this is neglected it will generally result in some broken punches. When the piercings are very small the punch should be provided with a spring guide pin, so that if the pin misses the pierced hole in the blank, it will spring back into the punch and nothing is spoiled except the blank. After having completed the die and punch, before taking them to the press, see that all guide pins when in the punch locate accurately in the piercing holes in the die, and also see that all the punches line up perfectly.

Making Small Round Piercing Dies

When a number of small round piercing dies of the same size are to be made, after having turned and bored them all to the same size, they can be taper reamed from the back very readily by holding them in a chuck which runs true, and using a taper reamer with a bushing located on it, this bushing acting as a stop. The piercing bushings can then be reamed out from the back to the exact size by using the bushing located on the reamer as a stop. Always provide clearance holes in the die bed under the piercing bushings for the piercings to drop out. These holes should be larger than the holes in the piercing bushings, so that the latter can easily be driven out.

Clearance Between Punches and Dies

The amount of clearance between a punch and die for blanking and perforating, or the difference between the size of the punch and die opening, is governed largely by the thickness of the stock to be operated upon. For thin material such as tin, for example, the punch should be a close sliding fit, as, otherwise, the punching will have ragged edges, but for heavier stock there should be some clearance,

CLEARANCES BETWEEN PUNCHES AND DIES FOR DIFFERENT MATERIALS

Thickness of Stock, Inches	Clearance, Inches			Thickness of Stock, Inches	Clearance, Inches		
	Brass, Soft Steel	Medium Rolled Steel	Hard Rolled Steel		Brass, Soft Steel	Medium Rolled Steel	Hard Rolled Steel
0.010	0.0005	0.0006	0.0007	0.120	0.0065	0.0072	0.0084
0.020	0.0010	0.0012	0.0014	0.140	0.0075	0.0084	0.0098
0.030	0.0015	0.0018	0.0021	0.160	0.0085	0.0096	0.0112
0.040	0.0020	0.0024	0.0028	0.180	0.0095	0.0108	0.0126
0.050	0.0025	0.0030	0.0035	0.200	0.0105	0.0120	0.0140
0.060	0.0030	0.0036	0.0042	0.220	0.0115	0.0132	0.0164
0.070	0.0035	0.0042	0.0049	0.240	0.0125	0.0144	0.0178
0.080	0.0045	0.0048	0.0056	0.260	0.0135	0.0156	0.0192
0.090	0.0050	0.0054	0.0063	0.280	0.0145	0.0168	0.0206
0.100	0.0055	0.0060	0.0070	0.300	0.0155	0.0178	0.0220

the amount depending upon the thickness of the material. The clearance between the punch and die when working heavy material lessens the danger of breaking the punch, and reduces the pressure required for the punching operation. To obtain the clearance between the punch and die, divide the thickness of the stock by a number or constant selected according to the following rules which apply to different materials: For soft steel and brass, divide the thickness of the stock by the constant 20; for medium rolled steel, divide by 16; for hard rolled steel, divide by 14.

Example: What would be the clearance between a punch and die to be used for perforating or blanking soft steel 0.050 inch thick?

$$\frac{\text{Thickness of stock}}{20} = \frac{0.050}{20} = 0.0025 \text{ inch.}$$

Whether this clearance is deducted from the diameter of the punch or added to the diameter of the die depends upon the nature of the work. If a blank of given size is required, the die is made to that size and the punch is made smaller. Inversely, when holes of a given size are required, the punch is made to correspond with the diameter wanted and the die is made larger. Therefore, for blanking to a given size, the clearance is deducted from the diameter of the punch, and for perforating, the clearance is added to the diameter of the die. To illustrate, suppose we want to blank hard rolled steel having a thickness of 0.0625 inch (No. 16 gage) to a diameter of 1 inch. What would be the sizes for the punch and die? The clearance equals $\frac{0.0625}{14} =$ 0.0044 inch. As this is a blanking operation, the die is made 1 inch. and the punch diameter equals $1 - 0.0044 = 0.9956$ inch.

A loose fitting punch will cut absolutely free from burrs up to a certain point, but if it is a little too loose or a little too tight, ragged edges will be left on the punchings as the result. A general rule which is sometimes used to determine the clearance is to allow a

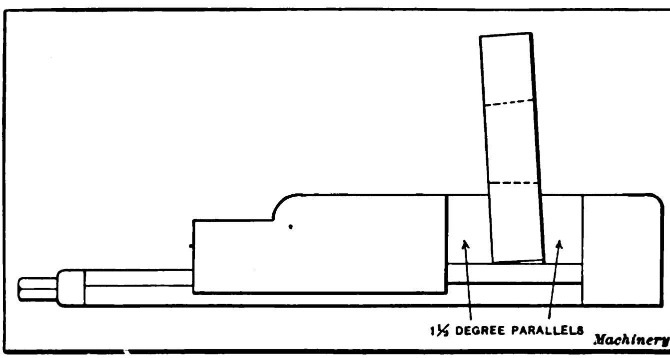


Fig. 1. Die held between 1¼-Degree Parallels for obtaining Clearance

clearance between the punch and die equal to 6 per cent of the thickness of the stock to be cut. For example, suppose a punch and die is required for cutting plain steel washers 0.040 inch thick. Then six per cent of the thickness of the stock equals $0.040 \times 0.06 = 0.0024$ inch, which would be the difference between the size of the punch and the die.

Angular Clearance for Dies

The amount of angular clearance ordinarily given a blanking die varies from one to two degrees, although dies that are to be used for producing a comparatively small number of blanks are sometimes given a clearance angle of four or five degrees to facilitate making the die quickly. When a large number of blanks are required, a clearance of about one degree is used. There are two methods of giving clearance to dies: In one case the clearance extends to the top face of the die; in the other, there is a space about ⅛ inch below the cutting edge which is left practically straight, or having a very small amount of clearance. For very soft metal, such as soft, thin brass, the first method is employed, but for harder material, such as hard brass, steel, etc., it is better to have a very shallow clearance for a short distance below the cutting edge. When a die is made in this way, thousands of blanks can be cut with little variation in their size, as grinding the die face will not enlarge the hole to any appreciable extent.

A common method of obtaining the required degree of clearance in a die when using an ordinary shaper is illustrated in Fig. 1. The die to be machined is held in the shaper vise by two 1½-degree parallels which hold the die in such a position that the desired angle of clearance is readily machined. These parallels are inexpensive and greatly facilitate work of this kind. When using a machine such as the Pratt & Whitney vertical shaper, the clearance can be obtained by simply setting the shaper ram to the required angle.

When Punch and Die should be Hardened

The blanking or cutting dies used on comparatively thin stock, such as tin, brass, aluminum, iron, steel, copper, zinc, etc., are ordinarily hardened and tempered to suit the work, and the punch is left quite soft, so that it can be "hammered up" to fit the die when worn. This practice is followed in some plants for all metals less than 1/16 inch thick which are not harder than iron or very mild steel. After the end of the punch has been upset by hammering, the punch and the die are oiled and forced together, which causes the hard die to shave the punch to a close fit. If the die is dull, it should be sharpened prior to this shearing operation. For some classes of work, the punch is made hard and the die soft. Both the punch and die should be hardened when they are to be used for blanking thick iron, steel, brass or other heavy metals.

Value of Annealing

Many diemakers overlook the importance of first roughing a die nearly to size and then carefully annealing it. There are internal strains set up in the bar of steel during its manufacture which are sure to cause distortion of the die or tool unless these strains are removed before the work is brought to its finished size. Some steel may be free from strains, but there is no way of determining beforehand whether the steel has "settled" or not; therefore, to guard against distortion, the careful diemaker will not take chances, but will anneal the piece after it has been roughed out, because annealing relieves these internal strains.

The following test illustrates the value of annealing before finishing: Four pieces of tool steel were cut from the same bar and the same amount of stock was removed from each piece, finishing them all over to exactly the same dimensions. They were then marked *A*, *B*, *C* and *D*. Pieces *A* and *B* were annealed after roughing, but pieces *C* and *D* were machined to size. The pyrometer was used to insure heating all the pieces to the same temperature of 1400 degrees F. The bath was clean water with a temperature of 68 degrees F. The pieces were heated separately in a muffle furnace and were allowed to remain in the bath exactly one minute, in each case. The result of this comparative test was as follows: The pieces *A* and *B* were slightly distorted, but the pieces *C* and *D* were distorted to such an extent that they were useless.

Points on Making Cluster Double-action Punches and Dies

Cluster double-action punches and dies have many advantages over the single construction, but they are open to the objection that extreme care has to be taken in laying out the punch-block. This type of punch and die is shown in Fig. 2. The holes in the die-block are

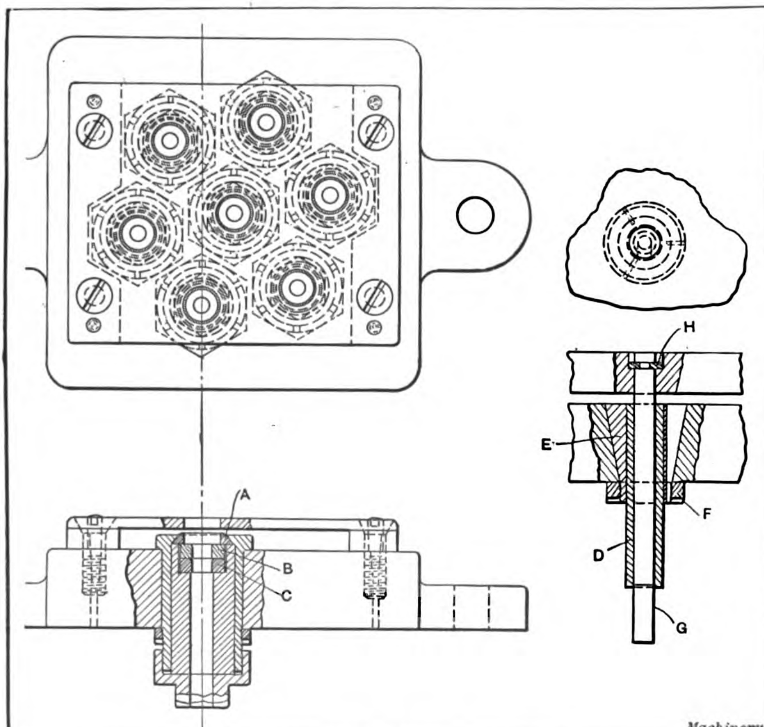


Fig. 2. Cluster Double-action Punches and Dies

reamed approximately 0.005 inch larger than the collets and are transferred to the die-block through bushings fitted into the punch-block when the two members are clamped together. If the holes for the die-holders are not laid out accurately, the tie or web between the blanked holes will be cut out as the metal feeds through, any error in spacing, of course, being multiplied as the work progresses. However, if the die-holder is properly laid out, it is possible to cut very close on scrap. When using such a die on thin metal, it has been found that the scrap averaged 18 per cent, while the estimated scrap was 18¼ per cent. These test runs were made on 0.017-inch metal. The difference between the actual and estimated scrap was due to the slight amount that the feed rolls squeezed the scrap back, making the webs slightly less than that estimated.

As a general rule, the punch- and die-block for this type of die is made from steel, and while this is not necessary as a matter of strength, it does away with the chances of striking a blow-hole in cast iron. The collets, sleeves and nuts, forming the members for holding the dies, are also made from tool steel hardened and ground. The blanking dies *A* are made from a high-carbon steel heated to the recalescent point, cooled in brine, at 62 degrees F., and then placed in an oil bath at 225 degrees F., after which they are ground. Each blanking die is good for approximately 1,000,000 blanks before grinding on the top face, which can be done, as a rule, about ten times, if

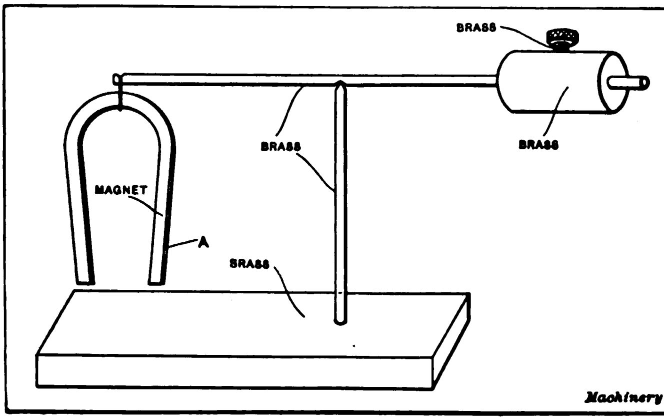


Fig. 3. Magnetic Device for determining Recalescent Point of Dies when heating for hardening

necessary on account of wear and not due to chipping. The blanking die is held in such a way that if the die is cracked from any cause, after it is ground to size, it still can be used without detriment to the blank. The sleeve holding it is tapered, and in this way as it is drawn up by the nut under the bolster, the die is securely held in place, and if cracked would be closed up.

The cupping dies *B* and *C* for the particular die illustrated were made from "Intra" steel, which was used because of the extremely hard surface obtained when it is heated to the proper temperature and "spouted." It is also extremely tough when heated in this way, and the combination of hardness and toughness is ideal for cupping dies. The small size of these dies makes it necessary to use a steel of great tensile strength, as well as one that will harden well, and "Intra" steel fills these requirements.

The cupping dies are heated to the recalescent point, which is found by using the testing fixture shown in Fig. 3. The die to be tested is placed under the magnet *A* from time to time, as the heating progresses, and when the point is reached where the steel has no attraction for the magnet, the heat is noted on a temperature pyrometer, and all dies made from this grade of steel are heated to that point. If a temperature pyrometer alone is used, without the magnet, readings are taken at stated intervals of approximately one minute apart, and then a chart is laid out by taking the readings as obtained from the pyrometer. This chart, if properly laid out, will show at the recalescent point a horizontal line. When the cupping dies have reached the proper temperature they are "spouted" with brine by holding them under a funnel which hardens the hole and leaves the outside circumference soft. They are then placed in oil, heated to 225 degrees F., and allowed to remain until they reach the temperature of the oil. One noticeable feature of cupping dies made from "Intra" steel is that they have a longer life—more cups per die—when the press is operated at from 125 to 135 R. P. M. than they do on lower speeds of from 90 to 100 R. P. M.; also the cups come square with less trouble.

In making the blanking punches and dies, care should be taken at all times to have the bottoms of the blanking punches and the tops of the cupping dies parallel. If they are not, it will be impossible to get a square cup, as the punch will bear harder on one side than on the other. In reaming out the hole in the cupping die, care should be taken to see that it is perfectly round and square with the top and bottom faces. A good method of determining if such a requirement has been obtained is to wring the plug gage into the die; this leaves a ring around the hole in the die parallel with the top face when the hole has been properly machined. That is to say, after swabbing out the die and cleaning the gage, a slight oil film is left on both parts; then when the gage is wrung into the die the liquid constituents of the oil are squeezed out, leaving a small carbon deposit. This should show heaviest just at the point where the drawing portion of the die commences to round off into the straight or sizing portion. On the lower or stripping die it is necessary to have the line show heaviest on the bottom, as a slight bell-mouth on the bottom will make the cup strip hard. If this line left by wringing the gage into the die is not parallel with the top face, the cup produced will not be perfectly straight, but will have an irregular top edge. This undesirable condition generally results from a chip clinging to the cutting edge of the reamer for a portion of a revolution when reaming out the die. It is also often caused by poor lapping, but more generally by reaming, as previously mentioned. If more attention were paid to this point there would be less trimming with its attendant scrap on re-draw work, as it is practically impossible to get a floating die to draw square unless it has a perfect "ring" bearing.

The blanking punches *D*, one of which is shown to the right in Fig. 2, are held in the punch-block by the split sleeve *E*, which, in turn, is drawn down by the nut *F*. This makes it possible for the punch *D* to slip up if more than one blank gets under it, which sometimes happens when a poor piece of metal gets into the press and the drawing punch *G* punches out the bottom of the cup instead of drawing it through the dies.

Both the blanking and drawing punches are made from high-carbon steel, heated slowly to the recalescent point in a muffle furnace and rolled around from time to time to get an even heat. They are then plunged in water that has previously been heated to 80 degrees F. This is done slowly with a tank which is so deep that the punch will turn black before being withdrawn. That is to say, the tank should have sufficient depth so that the punch when dipped straight will not touch the bottom before it has been cooled sufficiently to harden; it is also withdrawn straight from the tank. After hardening, the punches are then dipped in oil, heated to 225 degrees F., and allowed to remain in the tank for from ten to fifteen minutes. Afterwards they are ready for grinding.

The drawing punch is made with a taper on the end of from 0.004 to 0.005 inch to the inch of length, and is ground to this taper for approximately one inch. When the tapered ends of the punches have worn down below the required size, they are cut off on the end and re-ground, the slide of the press being lowered to compensate for the reduction in length. The upper ends of the drawing punches are held by slotted washers *H* which are fitted into counterbored holes in the punch-block.

The cluster double-action punches and dies shown in Fig. 2 are used in double-action crank and double-action cam presses, but for work using metal thinner than 1/32 inch, the cam press is preferable on account of the dwell which it is possible to obtain at the lower end of the stroke while the drawing punches are doing their work. With a strong, well designed and well built press, no trouble should be experienced in cutting with a minimum amount of scrap, when the tools and feeding device have once been properly adjusted.

CHAPTER II

MAKING ONE-PIECE ARMATURE DISK TOOLS

Armature disks are made from a grade of sheet iron about 0.025 inch thick called "electric" iron. This material is used because of its permeability (low resistance to an electric current) and though very soft, it is difficult to cut out, the wear on the dies being considerable. The shape of these armature disks, of which Fig. 4 is a good example, is such that it has been considered inadvisable by many manufacturers, to make the dies or punches solid because the thin strips of metal remaining are likely to warp in hardening and break, and if made solid, the repairing of them would be difficult if not impossible. The Robbins & Myers Co., Springfield, Ohio, well-known manufacturers of the "Standard" line of fans, motor and generators, make all types of armature and field punches and dies up to 10 inches in diameter from one solid piece of steel, and machine them to the shape required. This not only calls for good tool work, but it also demands particular care in hardening and subsequent operations.

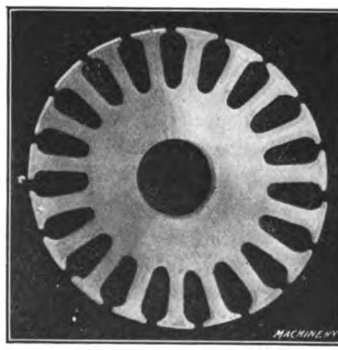


Fig. 4. Armature Disk

Construction of Solid Armature Disk Tools

The punch and die shown in Fig. 5 is not of the sub-press pattern, as is the usual practice followed in making sectional armature disk dies, but is of the plain blanking type of construction. The blanking die *G* is made from one solid piece of steel in which the required number of elongated slots are machined, as will be described later. The die fits in a counterbored seat in the die shoe *H* and is held in place by screws as shown.

The slitting punch *I* is made from a solid block of steel, which in this case is provided with a projection fitting in a recessed seat in the punch-holder *J*, to which it is held by screws. The punch *I* is also recessed to fit an additional plain blanking punch *K*, the latter cutting out a blank which is subsequently slit and made into a smaller sized armature disk *A*, Fig. 14. This method is used to economize in stock, and cut the scrap down to a minimum. The individual piercing punches *L* for the large armature disk *B*, Fig. 14, are driven into the punch-holder *J*, as illustrated. The prongs of the slitting punch *I* are formed by cutting a series of slots around the periphery of the blank and then shaping the individual prongs to the desired shape, as will be described later. The punch and die illustrated in Fig. 5 is the largest solid armature disk tool ever produced by the Robbins & Myers Co., and both the die and punch are made from solid pieces of "Ketos" non-shrinkable oil-hardening steel.

Making Solid Armature Disk Dies

Armature disk dies, as previously mentioned, are made solid up to 10 inches in diameter, and are cut from round bars of special non-shrinkable oil-hardened steel. The blank, after the center hole has been drilled, is placed on an arbor and turned on the external diameter

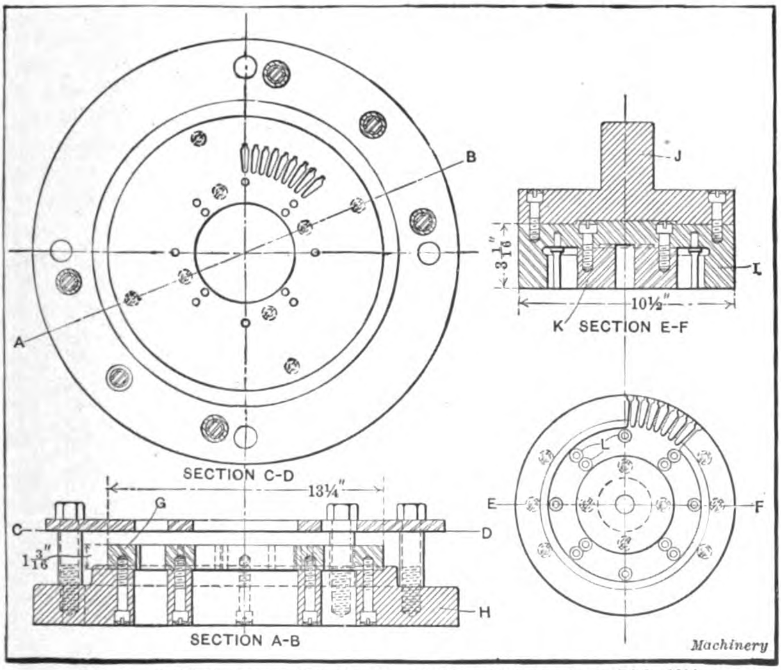


Fig. 5. Solid Armature disk Punch and Die which blanks a Disk $10\frac{1}{2}$ Inches in Diameter

in the lathe; it is then ready for working out the elongated slots which form the projections on the armature disks. The first step in this operation is to drill a series of equidistantly spaced holes entirely through the blank as illustrated in Fig. 6. The die block *A* in this case is driven onto a taper arbor which is held in the dividing head on the milling machine. A bushing type of drill chuck is then inserted in the spindle of the milling machine, carrying a drill of the required diameter. The internal ring of holes is usually drilled first, then the size of the drill is changed and an exterior ring of holes is drilled, these two rows of holes forming the approximate length of the slots. Following this, a series of holes is drilled so that they just break into each other, and thus remove the intervening webs.

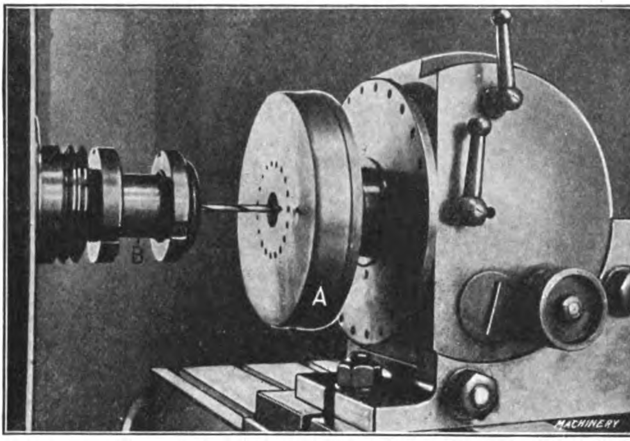


Fig. 6. Drilling Solid Armature Disk Dies in a Milling Machine

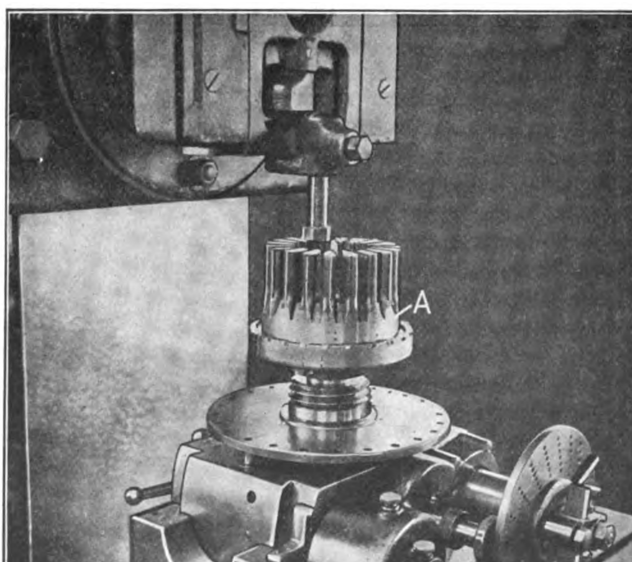


Fig. 7. Shaping Elongated Slots in a Solid Armature Disk Die, using a Slotting Attachment and Indexing and Dividing Head on a Milling Machine

The next step is to finish-form the elongated slots, this operation being accomplished in the manner shown in Fig. 7. The die *A*, as before, is mounted on a tapered arbor, which is held in the dividing head on the milling machine, while slotting tools of the proper shape are held in the slotting attachment. The dividing head is held perpendicular and the slotting attachment is also set square, so as to produce a straight hole. The clearance angle is produced in a filing machine as will be described later. The sides of the slots are machined first, after which the two arcs at each end of the oblong

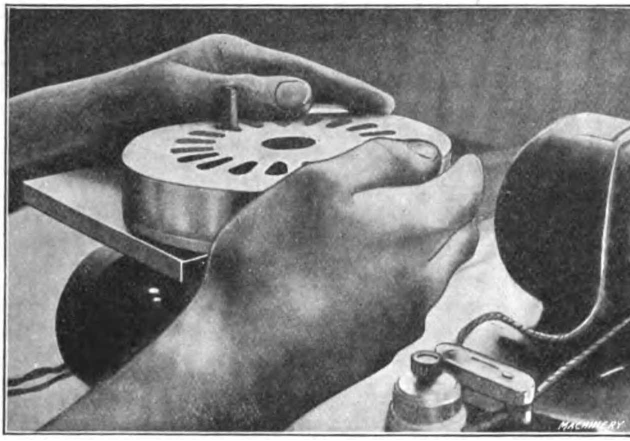


Fig. 8. The Final Machining Operations on a Solid Die—filing the Elongated Slots to the Proper Size and Shape

slots are machined. The outer arc has a slot cut in it. A tool of suitable shape is used to produce this slot after the arc has been finished and the slot cut to the desired length. The indexing attachment of the dividing head, of course, is used for spacing the holes correctly.

Finishing Operations on the Die Blank

After the elongated slots in the die have been machined to their approximate size, the final operation consists in filing them to the exact size. This is done in the small bench filing machine as illustrated in Fig. 8. It consists of a table that can be set to the desired angle, which carries a file of such shape as to conform with the slots in the die. This machine is driven by an individual motor as illustrated, and in addition to bringing the slots to the proper shape it also produces the correct clearance angle. The clearance angle on armature disk dies is 0.003 inch on a side, the die blank being 1⅛ inch thick. It is necessary, therefore, to tilt the table over from the vertical line to an angle of about 7½ minutes.

The die blank is hardened and drawn before the punch is made and fitted to it. For hardening, a regular gas burning muffle furnace is used. The blank is placed in this furnace and brought to a temperature varying from 1375 to 1400 degrees F. The heating is done gradually and uniformly until the tools show a dark red throughout, indicating a temperature of about 1100 degrees F., before the heat is raised to the hardening point—1375 to 1400 degrees F. The tools are then dipped into linseed oil and left to cool, after which the temper is drawn very slowly to 250 degrees F. to relieve the strain. The hardening of solid armature dies calls for considerable ingenuity on the part of the toolmaker, as the least amount of shrinkage or warpage in the die would unfit it for use, and as it is of the solid type it would be practically impossible to do anything with it if distorted in hardening. It is therefore evident that not only must a good brand of steel be used, but considerable care has to be exercised in order to obtain satisfactory results. However, it may be stated that the Robbins & Myers

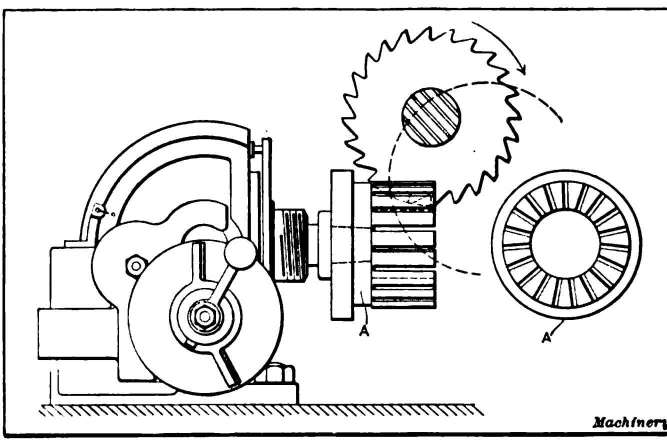


Fig. 9. Slitting a Solid Armature Disk Punch

Co. have been using this type of die for a considerable period, and they have not lost one tool during the past two years in the hardening operation.

Slotting Armature Disk Punches

The punch is made in a similar manner to the die in that it is cut off from a round bar of stock, drilled, turned and recessed in the lathe and is then slotted as illustrated in Fig. 9. The punch *A* in this case is driven onto a tapered arbor which is held in the dividing head of the milling machine and a slotting saw of the required thickness is used to form the individual members of the punch. Two cuts are taken; one cut is taken as indicated by the full lines in the illustration, after which the position of the cutter is changed (as shown by the dotted lines) and a second cut is taken. On some types of armature punches where the slot between the individual members of the punch or prong varies in width at the inner and outer extremities, slotting saws of different thicknesses are used in order to reduce the amount of machining on the sides of the members. When this is necessary, the saw is not inserted as illustrated in Fig. 9, but is raised slightly, and the second saw is also raised, the remaining web being machined out with a slotting attachment in the milling machine.

Finish-forming the Individual Members or Prongs

After the individual prongs of the armature punch have been formed by slotting, the next step is to form the inner and outer arcs. This is accomplished as illustrated in Figs. 10 and 11. In Fig. 10 the

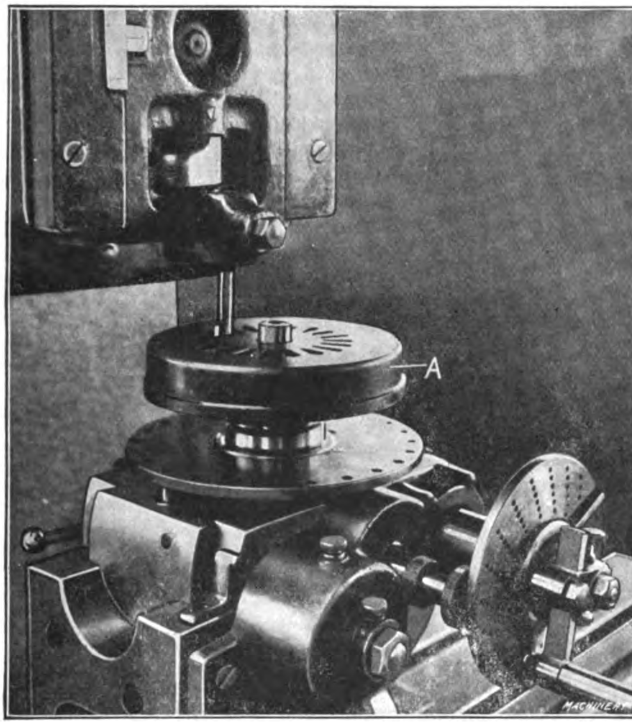


Fig. 10. Final Shaping Operation on the Inner Ends of the Punch Prongs, using a Slotting Attachment and a Dividing Head on the Milling Machine

punch *A* is set up in a vertical position, for machining the inner arc of the prongs. Here it can be seen that the dividing head is used for holding the punch, and the shaping tool is held in the slotting attachment of the milling machine. The shaping tool is so formed that it completes the arc on the inner edge of the prongs in one setting. The outer arc on the prongs is formed with the special milling cutter ***B***, as indicated in Fig. 11, with the punch *A* held in a horizontal instead of a vertical plane. The milling cutter, in addition to forming the arc, also produces the slight projections on the punch that cut out the ring that will be left in the armature disk, or in other words, continues the oblong slot to the circumference. The milling cutter illustrated completes this form of punch in one operation, and at the conclusion, with the exception of a slight touching up with the file, the punch is ready to be sheared into the die to obtain the final shape. The excess stock is filed away, and the punch sheared in several times until the shape has been produced for about ¼ inch. After this the punch is

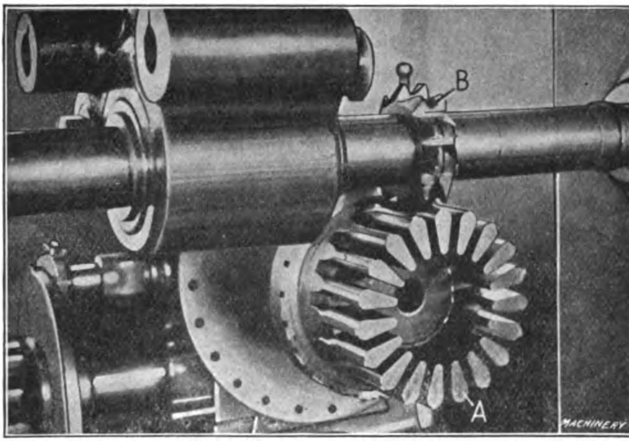


Fig. 11. Finishing the Outer Diameter of the Punch Prongs, using a Formed Milling Cutter

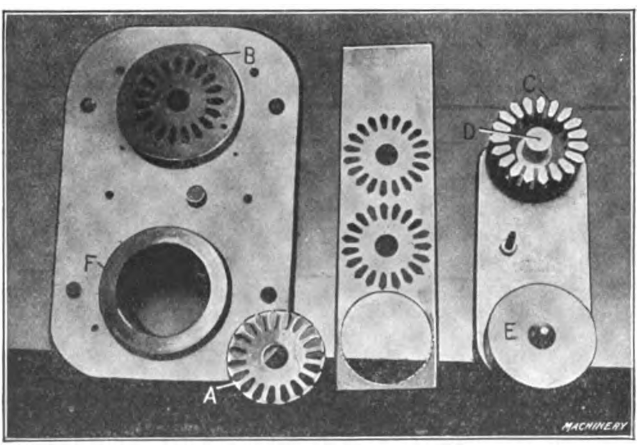


Fig. 12. Follow Type of Punch and Die for completing an Armature Disk in One Operation

taken back to the milling machine and the excess amount of stock removed as indicated in Figs. 10 and 11.

Different Types of Armature Disk Tools

Armature and field disks are made of several different shapes to conform with the motor or generator in which they are used. Fig. 12 shows a follow type of armature disk punch and die for producing the disk *A*. The sheet is first perforated by the solid die and punch *B* and *C*, respectively, and at the same time the hole is produced by the inserted punch *D*.

Owing to the relation of the blanking punch and die *E* and *F* to the perforating punch and die *C* and *B*, the punch press makes two strokes before a blank is cut out when starting a new sheet. The chief reason for laying out the perforating and blanking dies in this way is that it would be impossible to get them close enough unless made from the same piece of steel. Fig. 13 shows a follow type of die similar to Fig. 12, but of more interesting construction. These tools complete the armature disk *A* and slit and pierce the field disk *B* at each stroke of the press. The field disk *B* is blanked out in a separate operation. The perforating die *C* is made from one solid piece of steel, while the punches *D* and *E* are made from two solid rings of steel fastened by

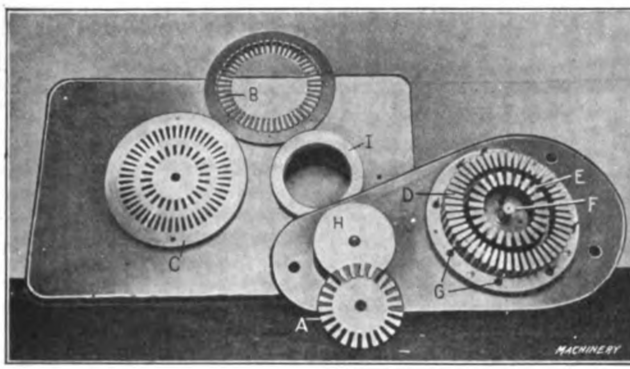


Fig. 13. Combination Follow Type of Punch and Die for completing an Armature Disk and slotting and piercing a Field Disk in One Operation

screws to the punch-holder. The punch *F* which pierces the center hole in the armature disk *A* is also an individual member. The piercing punches *G* for the field disk *B* are inserted around the outer periphery of the punch-holder, as shown. Punch *H* and die *I* blank out the armature disk *A*.

Another interesting example of solid punch and die work is shown in Fig. 14. This illustration shows the punch and die presented in detail in Fig. 5, and also gives some idea of the number of blanks and the character of operations performed by it. The small field disk *A* is only blanked out by these tools and is pierced and slit in a separate operation. The large armature disk *B* is slit by the solid punch *C* and die *D* and is pierced by the inserted punches *E*. the center hole being produced by the separate punch *F*. It is blanked out from the sheet in a separate operation. The field disk *G* is another piece which is produced from the same sheet as the other parts shown in this illustration, but it is completed in a separate operation. The portion of the sheet *H* shows where the disk *G* is obtained.

An armature disk set of tools differing slightly from those previously shown is illustrated in Fig. 15. These tools are used to produce

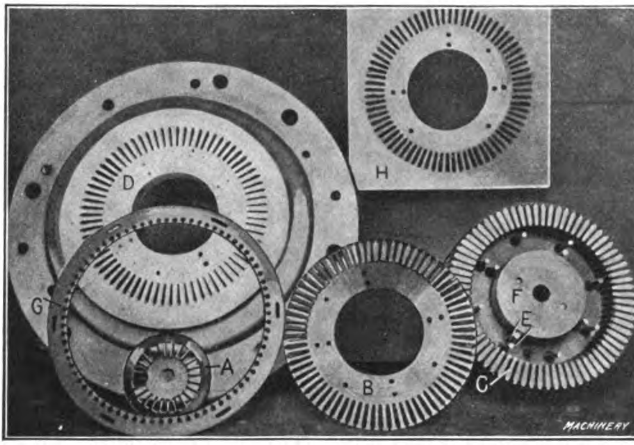


Fig. 14. Punch and Die for a Fan and Starter Field Disk and other Pieces made from Same Sheet

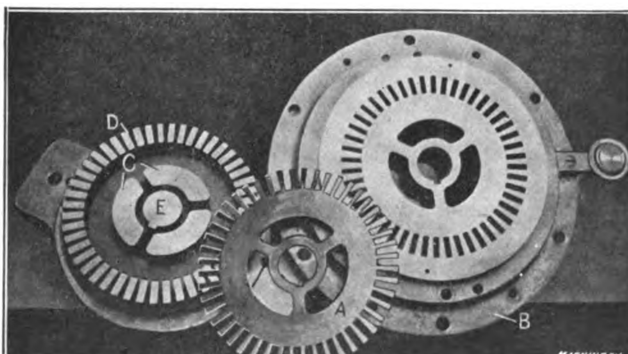


Fig. 15. Armature Disk Punch and Die of a Semi-solid Construction

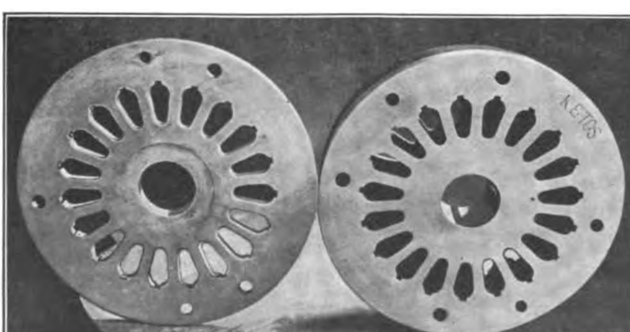


Fig. 16. Comparison of New and Old Armature Disk Dies. The Old Die has blanked 1,344,000 Armature Disks and has been ground down from 1 1/8 to 3/16 inch in Thickness

the armature disk *A* which is used in a 5 H. P. motor. The die *B* is one solid piece of steel machined out to the shape shown, while the punch is partly of segment construction. Punches *C* for producing the arms are made from three separate pieces of steel let into the main slitting punch *D*, which is made from one solid piece of steel. Punch *E* is also an individual member. This armature disk is blanked out in a separate operation.

Life of Solid Armature Disk Tools

One remarkable feature that is particularly noteworthy about these solid armature disk tools, and the steel used in making them, is their long life and the large number of blanks which can be produced between grinds. Fig. 16 shows two die blanks; the one to the right has never been used and is 1⅛ inch thick, whereas the one to the left has produced 1,344,000 blanks (16,480 blanks between grinds), has been ground eighty times, and reduced from 1⅛ to 3/16 inch in thickness. The solid punch also stands up satisfactorily and is ground an equal number of times. This is a rather unusual performance and is greatly in excess of what would be expected of the solid type of punches and dies as generally made. The clearance, as before mentioned, is only 0.003 inch on a side or 0.006 inch on the diameter of the elongated holes in the die. As the blank always retains the size of the punch—the scrap being the size of the die—the die can be worn down without affecting the character of the work produced by it.

CHAPTER III

THE MULTIPLE PLUNGER PRESS AND ITS TOOLS

The multiple plunger press is designed for producing, by means of a series of simultaneous operations, a complete article at every revolution of the press. It is constructed in various styles and sizes, the number of plungers ranging anywhere from three to eight. The most common type, however, and that most extensively used for the general run of small work, is the one shown in Fig. 17, which is a six-plunger machine. This machine can be used for such operations as blanking, cupping, piercing, forming, embossing, stamping, curling, bending, lettering, perforating, clipping, etc., and in fact almost any light operation that is performed on sheet metal. Of course this machine can be used when only three or more operations are required, by having the remaining plungers run idle.

The machine is driven by tight and loose pulleys, as shown to the left of the illustration, and is back-geared; the ratio of the gearing is 4½ to 1, the larger gear shown guarded to the left being on the upper camshaft. This camshaft *S* is made from a crucible steel forging, while the cams held on it are made of tool steel and hardened. In addition to operating the plungers, this camshaft, through the gearing shown at *G*, operates the roll feed, the reel used for holding the metal being shown at *H*. The upper camshaft *S* also drives, through bevel gears, the vertical crankshaft *I*, which actuates the transfer slide and the lower camshaft S_1.

The plungers *A*, *B*, *C*, *D*, *E*, and *F* are made from tool steel of square section, and work in scraped bearings. The lower ends of the plungers *B*, *C*, *D*, *E*, and *F*, are tapped out to receive the punch-holders, which are threaded into them. The blanking plunger *A* is bored out to receive a tapered split bushing into which the blanking punch is driven. The lower part of this split bushing is made square, so that by turning it around with a wrench it can be removed and the blanking punch driven out. The blanking punch can also be made to fit directly into the plunger, if so desired.

The blanking plunger *A* is set one-half revolution in advance of the other plungers, so that the blank after it is cut is carried by the transfer slide over the first cupping die before the plunger *B* descends. This is accomplished by changing the position of the cam controlling the operation of the blanking plunger on the upper camshaft *S* in relation to the other cams. The plungers are operated by horizontal "lifters" *L*, one lifter being provided for each plunger. These lifters are clamped to round rods *R* located at the rear of the press, and knee pieces connecting these rods to the plungers effect their operation. The usual form of wedge adjustment is provided for increasing the pressure of the plungers, the adjustment being effected by means of wedges which lower or raise the "bumpers" as desired.

The lower camshaft S_1 is provided with five cams M as shown, these being split and held to the shaft by screws, so that they may be shifted around on the camshaft to the position desired and then clamped. These cams operate the knock-up plungers into which the ejecting-pins are lightly driven, used in removing the work from the

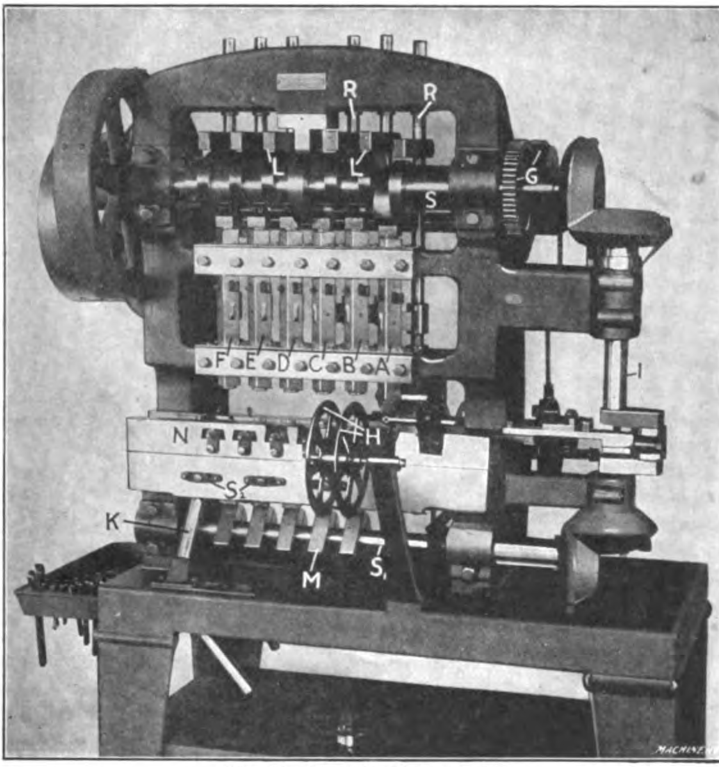


Fig. 17. Multiple Plunger Press

dies. The work is carried from one die to the other by means of a transfer slide actuated by the vertical crankshaft I.

The Transfer Slide and the Auxiliary Mechanism

The transfer slide, or "carrier" as it is sometimes called, is made of tool steel, and is a sliding fit in the die-bed N. This slide holds the fingers, which are used for carrying the work from one die to the other, and also holds the nest or set-edge used in carrying the blank from the plunger A to plunger B, where the blank is cupped.

A clear idea of the construction of a transfer slide, fingers and dies can be obtained by referring to Fig. 18, where a plan of the slide and a sectional elevation of the dies and punches for producing a one-

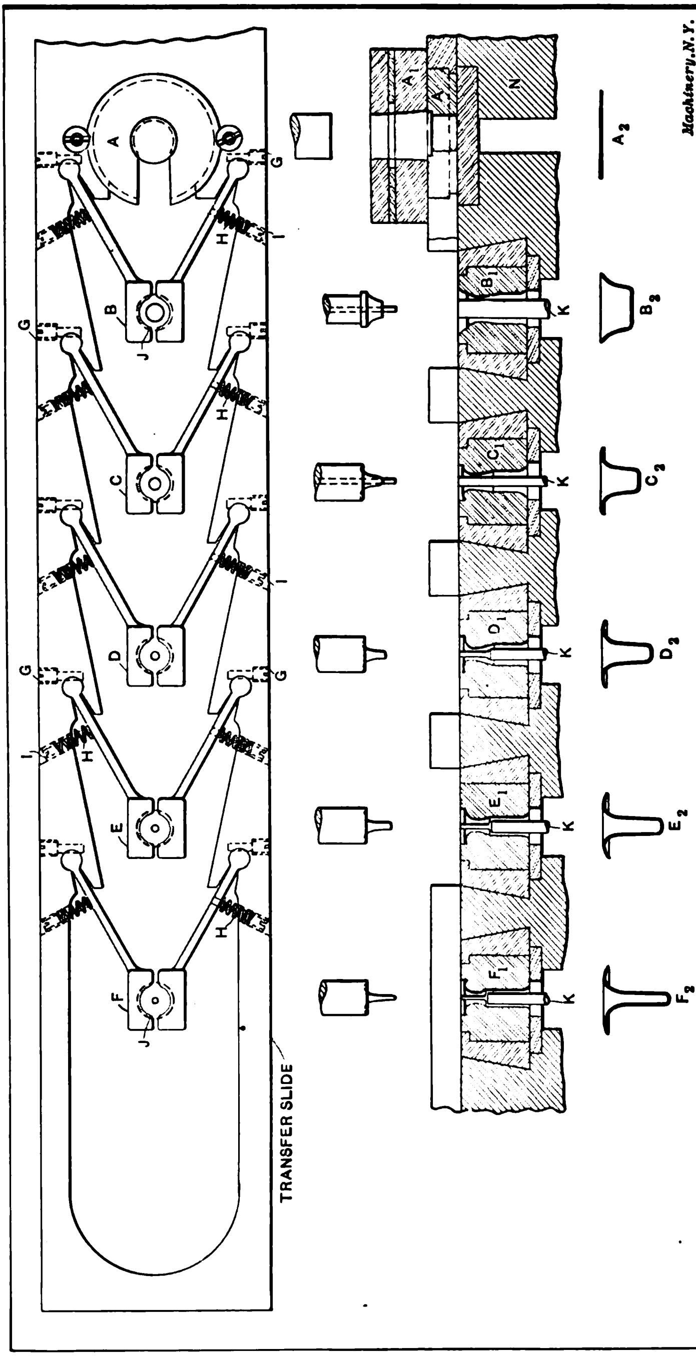


Fig. 18. Diagram illustrating the Construction of the Transfer Slide, Ejecting-pins and Dies, and also the Successive Operations on a One-piece Collar Button

piece collar button, are shown. The set-edge or nest is shown at A with the blank located in it. This nest may be removed and others substituted to suit the shape of the blank. It is cut out as shown, so that it will clear the first cupping punch, when the slide recedes.

The fingers B, C, D, E, and F, respectively, which are patented, are held in the transfer slide in smooth cylindrical bearings, the ends of the fingers being fitted into these bearings and held in place by screws G as shown. Each pair of fingers is actuated by coil springs H, which give them the desired tension on the blank, these springs being held in place by short pins driven into the fingers, and screws I located in the slide. The fingers are rounded at J, so that they will readily open when the slide recedes and the fingers slide past the punches. They are also rounded at the top and bottom as shown in Fig. 19, so that they will swing out of the way when they come in contact with the punch on the down-stroke or with the shell on the up-stroke.

The blanking die A_1 is of rectangular section, and is fastened by cap-screws and dowels (not shown) to the die-bed N, Fig. 18. The stock is placed on the reel H (see Fig. 17) and passes over a lubricating sponge-box, and from there over the top of the blanking die in the usual manner. A pair of ratchet rolls located at the rear of the press and operated by the gears G on the upper camshaft S draws the stock over the die, after which it is wound into compact form on a scrap-reel, also located at the rear of the press. The blanking punch forces the blank, after it has been cut, through the die and locates it in the nest A. After the blanking punch comes out of the nest A, the transfer slide advances, carrying the blank, and locates it over the cupping die B_1, when the punch forces it out of the nest into the die. The blank, after being operated on, is removed from the dies by ejectors K which, in turn, are actuated by the cams M on the lower camshaft S_1 (see Figs. 17 and 20). The ejecting-pins K which are lightly driven into the knock-up plungers, when not being forced down by the punches, are retained flush with the top face of the dies, by means of flat springs S_2, which are shown in Fig. 17 and in detail in Fig. 20. These springs fit over bronze plugs B, which bear against the knock-up plungers P. The bronze plugs B are provided with a teat T which fits in a slot cut in the plunger, thus preventing them from turning. The springs are held in position by cap-screws, and are provided with elongated holes, which fit over the reduced ends of the bronze plugs. The knock-up plungers are of square section on the lower end, and rounded so that they work freely on the lifting cams M. A hole H is drilled in the top of the plungers into which the ejecting-pins are lightly driven.

Operation of the Transfer Slide

In operation, as the stock is drawn by the feed-rolls over the blanking die, it is blanked, and the blank is forced through the blanking die A_1 into the nest A, Fig. 18. When in this position the transfer slide advances, and carries the blank from the die A_1 to the cupping die B_1. Here the slide dwells until the cupping punch descends, and forces the blank through the nest A into the die. The transfer slide now retreats before the punch has ascended out of the die, and for this reason it is necessary to cut out the nest as shown, so that it will slip by the punch. When necessary, the punch is reduced in diameter just above

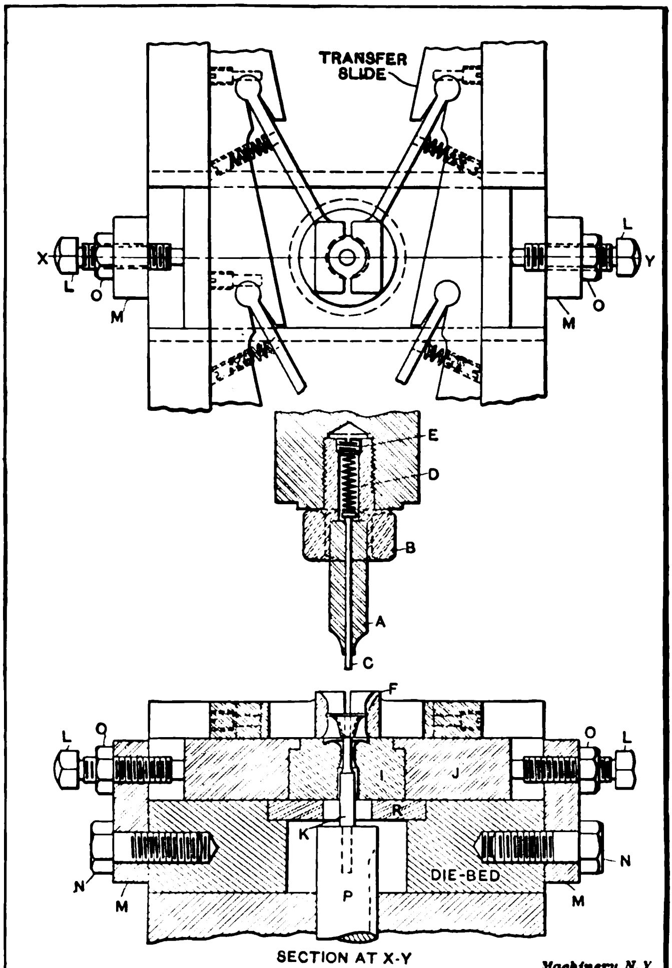


Fig. 19. Illustration showing the Construction of the Punches and Dies and the Manner in which they are held

the working part in order that the nest can slip past it. On the up-stroke of the plunger B (see Fig. 17), the ejecting-pin K, Fig. 18, which is held in the knock-up plunger P, Fig. 20, forces the cup out of the die B_1 into the fingers B; then as the slide again advances the finger B carries the cup to the die C_1, this order of operation being continued in a similar manner until the fingers F carry the finished piece to the last die F_1, after which it is forced out of the fingers and passes out of the chute K (Fig. 17) into a box. It can therefore be seen that the work is at all times under perfect control, the ejecting-pin K and the fingers working in unison.

After the work has been operated upon for the last time by the punch in plunger F, and when the operation is a clipping or re-drawing operation, the work readily drops into a box; otherwise, if some other operation is to be performed, the work is ejected by means of compressed air or some other simple ejecting device or fixture. The successive operations on the one-piece collar button are shown directly under the dies for producing them in Fig. 18, the operations being designated by the letters A_2 to F_2, inclusive.

Method of Holding the Punches and Dies

As previously stated, the cupping and stripping punches are held in punch-holders, which are screwed into threaded holes in the plungers. This is more clearly shown in Fig. 19, where the punch is shown held

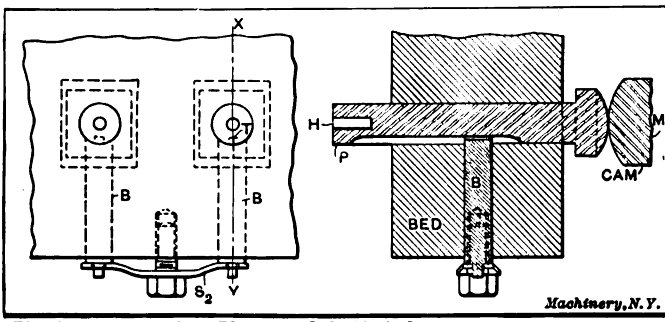


Fig. 20. The Knock-up Plunger and the Method of Operating and Retaining it

in the manner referred to. The punch shown here is the one located in plunger C, Fig. 17, and is used for performing the operation C_2 on the collar button shown in Fig. 18. The punch A (Fig. 19) is made of the desired shape and is driven into the holder B, this holder being provided with an octagon head and threaded on the upper end so that it can be screwed into the plunger. A push-pin C for the punch A, is operated by a coil spring D, which is retained in the holder B by a headless screw E. This push-pin, however, is not used on all of the punches, other types of stripping fixtures being employed. For this class of work, the fingers are shaped as shown at F, so that they hold the cup by the flange alone, not touching the body of the cup at all. This holds the cup effectively, as the ejector-pin K is always in the up-position, except when being forced down by the punch A, thus additionally supporting the cup while in the finger and preventing it from tripping. The manner in which the ejecting-pin K is held in the knock-up plunger P is also clearly shown in this illustration.

The die I is driven into a tool-steel die-holder J, this holder being counterbored as shown, so that the die fits up against the shoulder, preventing it from being drawn out. The die *I* rests on a hardened tool-steel washer *R* located in the die-bed, and which resists the thrust of the punches. The die-holder *J* is fitted in a dovetailed groove formed in the die-bed, and is retained in the desired position by means of set-screws *L* located in blocks *M*, which are held to the die-bed by means of cap-screws *N*. The set-screws *L* are provided with lock-nuts *O*, which lock the screws in the desired position.

These machines work so successfully that they require very little attention. In fact, they will sometimes run for weeks at a time without requiring any special attention beyond that of oiling, starting in a new coil of metal, and occasionally sharpening and polishing the punches and dies.

Tools for Multiple Plunger Presses

The multiple plunger press has become a most important factor in the economical manufacture of articles from sheet metal, and this type of press is now used for both large and small work; the presses for the large sizes of work are necessarily of stronger and more massive construction than those used for smaller work. The tools illustrated and described in the following are used for the smaller classes of work.

Before going into details concerning the construction of the punches and dies used in multiple plunger presses, it may be well to lay stress upon the fact that, preparatory to constructing the tools, one of the first things to do is to make sure that the construction of the press is such that the tools will not only be interchangeable in a given press, but also with the tools in other presses. In trying out a new set of tools, it is often found that better results are obtained by changing the sequence of some of the operations; for instance, if plunger No. 2 does the cupping, No. 3 the forming, No. 4 the piercing, etc., it often happens that some of these operations must be reversed, and if the tools are interchangeable, this can be done without any extra time being spent in altering the length of the punches, or in making new ejecting pins to fit the press. Moreover, if the tools for different presses are not interchangeable, they can only be set up and run in the press for which they were originally made; this means that some of these presses may frequently be out of use, simply because there are no orders for work which calls for the use of the tools that were made for the "dead" machine in question. On the other hand, there may be orders for work which must necessarily wait until another job has been run through on a given press that is in use, because the tools to be used were made for the press that is already in use, and are not interchangeable. This deplorable condition actually exists in some shops. The fact must be taken into consideration that the taper wedges used for adjusting the stroke of the plungers affords only 3/16 inch adjustment, and unless the presses are made so that the tools are interchangeable, the loss of time due to having "dead" machines is bound to occur again and again.

In adjusting a multiple plunger press to insure interchangeability, the first thing to do is to regulate the taper wedges used for adjusting the stroke of the plungers, so that they will all be in the same relation to each other. The press is then given a half turn, so that all the plungers except plunger No. 1 are down as far as they will go, so that the distance from the top of the die bed to the face of the respective plungers can readily be measured. It seems hardly necessary to say that this distance must measure the same in each case. The same can also be said of the face of the knock-up plungers which, when raised up as far as they will go, must all measure the same distance to the top of the die bed. The depth of the ejecting-pin holes in these plungers must also be the same, as, on small work, the ejecting pins rest on the bottom of these holes; and it is therefore essential that the depth of the respective holes be the same if the ejecting pins are to be interchangeable. It is also important to have the holes for the dies in the dovetail die-holder perfectly central

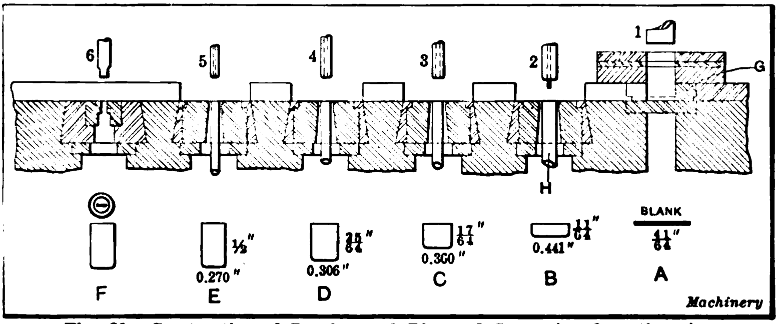


Fig. 21. Construction of Punches and Dies and Successive Operations in Drawing and Piercing Shell F

with the threaded holes in the plungers, and also bored out to fit plug standards, so that there will be interchangeability so far as the various dies and die-holders are concerned.

Examples of Shell Work done on Multiple Plunger Press

Fig. 21 shows a set of tools for a six-plunger press used in making the shell which is shown completed at *F*. The diameter of this shell is 0.270 inch, the length is ½ inch, and it has a small elongated slot pierced out of the bottom. The metal is first fed between the guide plates, where the round blank *A* is punched out and forced into the nest *G* in the transfer slide by the blanking punch in plunger No. 1; the nest is made to fit the blank tight enough to retain it. The blank is then carried under the drawing punch held in plunger No. 2 and drawn up into the shell shown at *B*. The punch is made small enough so that it will just draw up the shell and keep it from wrinkling, thereby preventing the metal from becoming too hard to be successfully worked in the following operations. After the shell is drawn up, it is ejected from the die by the ejecting pin *H* and then forced between the fingers in the transfer slide. These fingers hold the shell in place while it is being carried under plunger No. 3. As the shell *B* does not hug the punch tightly, no stripper is necessary; the push-pin prevents the shell from clinging to the punch. When the shell *B* comes under plunger No. 3, it is redrawn to the shape and size shown at *C*, care being taken to have the redrawing punch small enough so that it will not pinch the metal any harder than is absolutely necessary. The same can also be said with reference to the following drawing operations, except the one done under plunger No. 5, which draws the shell *E* hard. The last operation is piercing out the narrow slot in the bottom of the shell, which is done by the piercing punch held in plunger No. 6 and the piercing die shown directly underneath it. The finished shell is then pushed from the press into a pan or box by a push-finger held in the transfer slide. It will be seen that no ejecting pin is used in this operation, as the shell rests on the top of the piercing die while being pierced, and

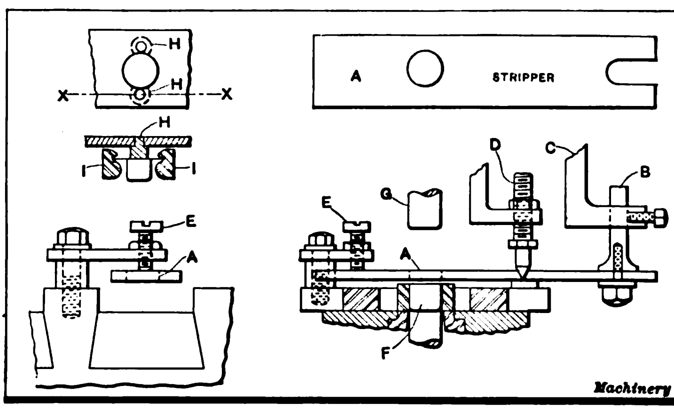


Fig. 22. Stationary Stripper and Method of securing it to the Press

therefore the knock-up plunger can be removed in order to allow the scrap punchings to escape. In stripping the shell from the punches in the third, fourth, fifth and sixth operations, stationary strippers similar to the one shown in Fig. 22 are used.

Stripping the Work from the Punches

For the punches and dies used in a multiple plunger press, two forms of strippers are generally used. One of these strippers is known as the stationary stripper, while the other is called a traveling stripper and is used in connection with a thimble for stripping the work from the punches. Fig. 22 shows the stationary stripper *A* held in position by the stud *B*, which, in turn, is held by a bracket *C* fastened to the rear of the press. The stripper has an elongated slot in one end to provide for adjustment. In addition to the stud *B*, the stripper is supported by the pointed screw *D* and the screw *E*, which are placed on each side of the hole used for stripping the shell *F* from the punch *G*. These screws, as well as the stud *B*, can be adjusted to different heights to accommodate different lengths of shells. The pointed end of the screw *D* rests in a small countersunk hole in the stripper; this not only helps to stiffen the stripper but also tends to prevent it from shifting endways. Fig. 22 illustrates the manner in which the stripper strips the shell shown directly underneath it. The device used for stripping flanged shells from the punch with a stationary stripper is shown in the upper left-hand view. Two short shouldered pins *H* strip the work from the punch, so that the flanged part of the shell can be readily grasped and retained in the circular grooves in the fingers *I*, as shown. These pins are made small and placed in the center of the open space between the fingers so that the projecting pins will clear the fingers and not interfere with their free action. The sectional view of this stripper is on the line *X–X*.

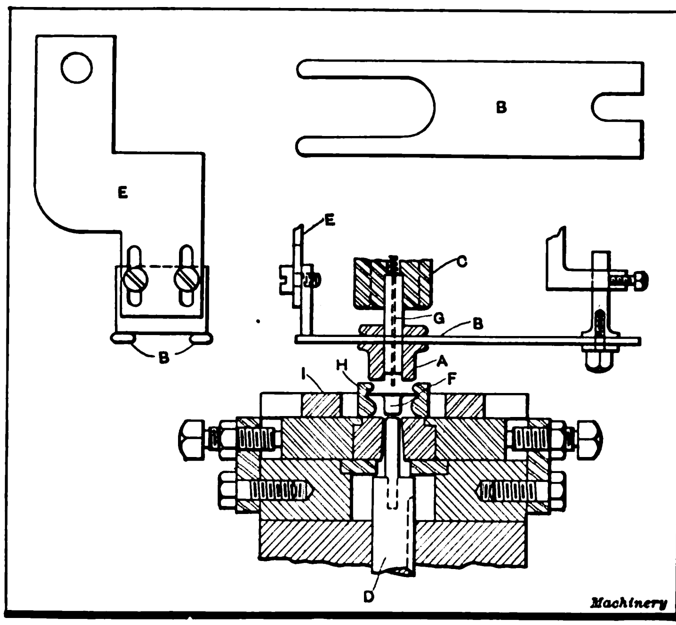


Fig. 23. The Use of a Traveling Stripper on a Multiple Plunger Press

Fig. 23 shows the manner in which a traveling stripper is used in the multiple plunger press for stripping the work from the punches. The punch is made a sliding fit in the stripping thimble *A*, which has a circular groove that engages in the forked part of the traveling stripper *B;* this thimble is also used in forming up flanged shells, as the face of the punch-holder *C* forces the thimble down on the flange and keeps it flat, thus preventing the work from getting out of shape. Making use of the stripper thimble in this manner does away with the necessity of using a solid shouldered punch; and as these thimbles can be used over and over again, they effect quite a saving. When in operation, the thimble is forced downward by the punch-holder; on the upward stroke of the press the traveling stripper, which acts in the capacity of a flat spring, forces the thimble upward with the assistance of the knock-up plunger *D*. When the fork of the stripper comes in contact with the adjustable stop *E*, as shown, it affords a substantial stripping arrangement for stripping the shell *F* from the punch. The stop *E* is fastened to the front of the press, and is made adjustable to allow for different lengths of shells, in order that the

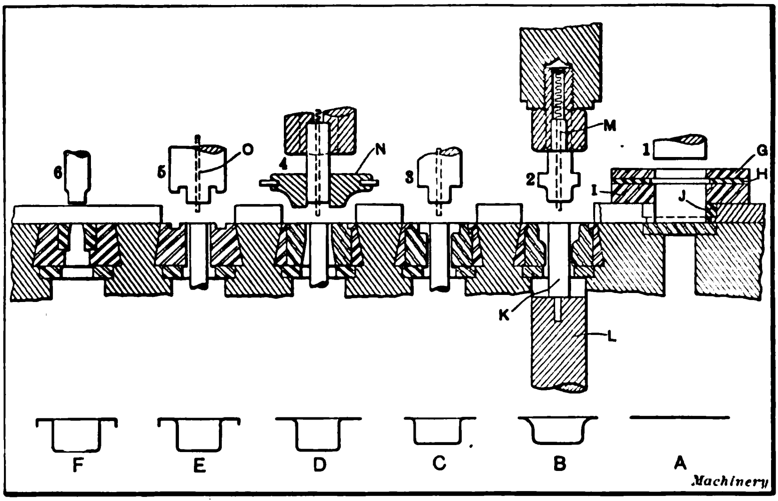


Fig. 24. Example of Flanged Work formed on Six-plunger Press

shells can be stripped from the punches at the right time on the upward stroke of the press. The punch is made slightly tapering so that the shells can be readily pushed off by the push-pin *G* and grasped by the fingers *H* in the transfer slide *I*.

Examples of Flanged Shell Work

Another interesting example of shell work, as performed on the multiple plunger press, is shown in Fig. 24. These tools complete the shell shown at *F* in six operations, their construction and operation being somewhat similar to the tools described in connection with Fig. 21. The metal is fed under stripper *G* in the usual way, and guided by the plates *H*; *I* is the blanking die and *J* the nest in the transfer slide for carrying the blank under plunger No. 2, where it is forced into the die and cupped up as shown at *B*. In this operation no blank-holder is used to prevent the blank from puckering while it is being drawn up. On the downward stroke of the press, the cupping punch forces the blank and the ejecting pin *K* downward. As the knock-up plunger *L* which holds the ejecting pin in place is held up by spring tension, the blank is prevented from shifting and is held central while

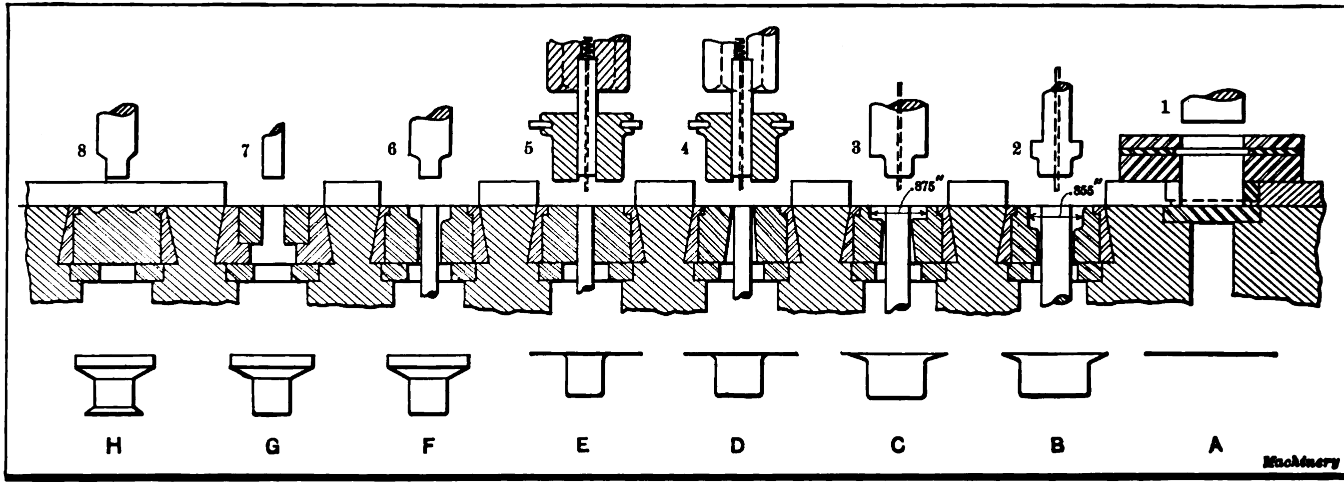


Fig. 25. Construction of Tools used to form Shell H on Eight-plunger Press

being cupped up. The blank is first partly cupped by the round corners shown on the top of the die, after which it is drawn up into the desired shape by the lower shoulders on the die. On the upward stroke of the press, the ejecting pin forces the cupped shell out of the die into the fingers of the transfer slide. No stripper is required, as the metal is not pinched hard by the punch, and the shell therefore does not hug the punch. The push-pin *M* merely prevents the shell from clinging to the punch on account of any settlement of oil in the bottom of the shell. In cupping up the shell in the manner previously described, it should be stated that a clean cut blank must be used which is free from all burrs, as otherwise the shell will pucker and wrinkle while being drawn into shape, inasmuch as no blank-holder is used.

After the shell is cupped, it is transferred under punch No. 3, where it is drawn up and flanged as shown at *C*.

Punch No. 4, with the aid of the thimble *N*, draws the barrel part of the shell smaller and longer, as shown at *D*, while punch No. 5 acts upon the flanged part of the shell only, and forms it into the shape shown at *E*. The teat of this punch is made a sliding fit in the barrel part of the shell and guides it into the die. As the shell does not hug the punch, no stripper is necessary; the push-pin *O* prevents the shell from remaining on the punch. The last operation is to pierce out the ¼-hole in the bottom of the shell, shown at *F;* this is done by punch No. 6, after which the finished shell is stripped from the piercing punch by a stationary stripper. The work is then either blown out of the way by compressed air, or pushed off the press by a push-finger, and drops into a box under the press.

Examples of Shell Work on Eight-plunger Press

Fig. 25 shows a most interesting set of tools for making the shell shown at *H* complete from sheet metal on an eight-plunger press. The tools shown are made and operated in the same manner as those already described and therefore require very little explanation. The illustrations show the progress of each operation very clearly, as the shell is carried from one punch to the other. The blank *A* is cut from the metal, carried under punch No. 2 and cupped up in the usual way. The cupped shell *B* is then transferred and gradually drawn up into a flanged shell as shown at *C*, *D* and *E*. In drawing up the shell to the form shown at *D* and *E*, the usual stripping thimbles are used in connection with traveling strippers. On the next operation, punch No. 6 cups the flanged part of the shell into the shape shown at *F*. The teat of punch No. 6 next engages the inside of the shell and forces it into the die. As the shell is drawn into the die, the flanged part is cupped up while being drawn over the corner of the die which is slightly rounded, after which it is formed into the desired shape by the beveled shoulder of the die. Punch No. 7 pierces the bottom of the shell; the shell is then stripped from the punch by the stationary stripper. On the last operation, the bottom end of the shell is flared outward, as shown at *H*, by being forced over the short tapered teat shown in the center of the die. The shell is then stripped from the punch and drops into a box under the press.

CHAPTER IV

SUB-PRESS DIE CONSTRUCTION

When constructing a blanking die, the class and quantity of work for which it is intended should determine to a great extent the cost of the tool and the degree of accuracy necessary. Where only a limited number of blanks are required and a variation of a few thousandths is allowable, a die can often be made very cheaply that is good enough; for instance, in the manufacture of cheap jewelry where only a few thousand blanks of a certain kind are wanted, a die of cheap steel, three-eighths thick, soldered to a plate and run with a soft punch, meets all the requirements. On the other hand, on a class of work where accuracy is the essential feature and the die is in constant use until worn out, the best of material and workmanship is necessary. In shops where this class of work is handled, the sub-press die is usually depended upon to produce it. A die of this type is shown in Fig. 26. Dies built upon this principle have been extensively used in nearly all the watch factories in this country for several years, and are constantly growing in favor in most shops where high-grade dies are used. It is true that the first cost of a die of this kind is considerable, but the long life of the tool and the excellence of its work make it a profitable investment.

Arrangement of a Typical Sub-press Die

A brief description of a sub-press die for producing the blank shown at *A* (Fig. 26) follows: The upper half of the casting or cylinder *B* is shouldered onto the base *C* to which it is attached by screws *D;* it is also doweled in position by the two pins *E*. The plunger *F* runs in a casing of babbitt shown at *G*, the wear in which is taken up when necessary by screwing down the tightening nut *H*, which forces the babbitt down and in at the same time, as the cylinder is bored on a slight taper. The plunger has three semi-circular grooves milled along its length to prevent its turning. Attached to the plunger is the die *I*, which cuts the outside of the blank, and the small punches *J* which are held in the back-plate *K* and supported by the shedder *L* which is backed up by the heavy spring *M*. The tension on this spring is obtained by screwing down screw *N* which has a small hole running through it to allow the air to escape. The center piece *O* and the three pins *P* placed between the spring and shedder, supply the tension necessary to operate the latter. The hardened disk *Q* is pressed into the plunger behind the back-plate, as indicated, to take the thrust of the small punches. The base *C* is recessed to receive the base of the larger punch *R* which has three openings for the three small punches *J*, clearance being provided to allow the scrap punchings to pass through. The stripper in the lower member is

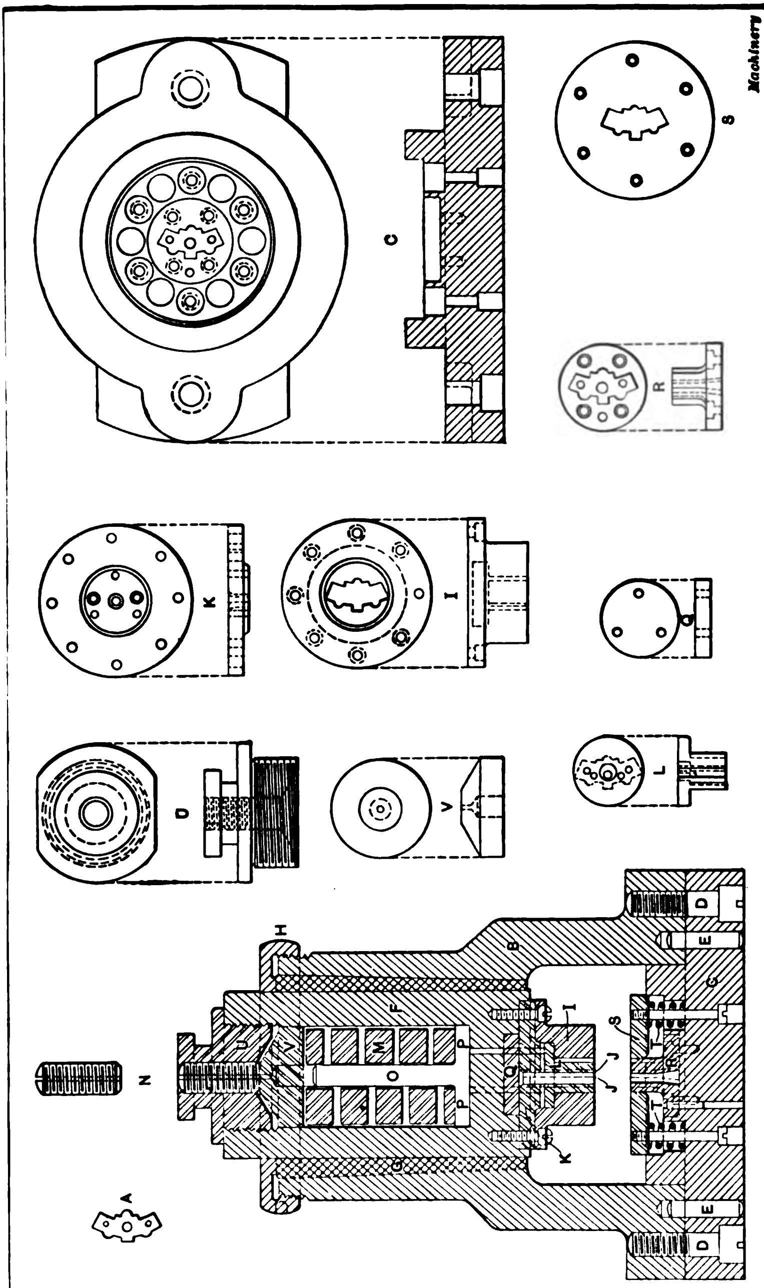


Fig. 26. Sub-press Die and Detail Views of Principal Parts

shown at *S*, the resistance from the springs *T* doing the work. The most important parts are also shown in detail and are marked with corresponding reference letters.

In operation the plunger descends with the ram of the press and the stock caught between the two flat surfaces is held firmly in position at the time it is struck, thereby preventing any creeping or distortion of metal during the blanking. The outside of the blank and the pierced holes are cut simultaneously. Upon the return stroke of the ram, the tension from the small springs *T* forces the stripper *S* back over the punch *R* which still has the blank pressed firmly against its face by the shedder *L*, forcing the blank back into the scrap which is left smooth and flat, a feature which is appreciated wherever the reel-feed is used.

Advantages of the Sub-press Die

The many advantages of this type of die over the open die are apparent to anyone seeing it in use. The fact that the sub-press is a self-contained tool, being in nowise dependent upon the power press in which it is run, and the consequent ease with which the die can be set, means a great saving in time, as all that is necessary is to attach the cap *U* to a T-slot in the gate of the ram, clamp the base to the bed of the power press, and adjust the stroke. Not only is it a time-saver, but it also possesses another distinct advantage in that it does not necessitate a careful lining up of punch and die, as dies of this kind form an independent unit and are always in perfect alignment.

Another point in favor of the sub-press is the fact that owing to the small punches being supported nearly their entire length, it is possible to pierce smaller holes in comparatively thick stock, than can be accomplished with any other die; it is not unusual to successfully punch holes in stock considerably over twice the diameter of the punch. A narrower bridge can also be left between blanks and a much better blank obtained than with any other form of die. The blanks are not only free from burrs, but they are always of a uniform size, the die being straight instead of having clearance, as in the case in the open die (where the blanks have to pass through) so that the first blank punched is an exact duplicate of the one produced when the die is worn out, which, obviously, means a longer life for the die.

Points on Sub-press Die Construction

In constructing the sub-press dies shown in Fig. 26, the sub-press stand should not be slighted, as upon its construction depends in no small measure the proper working of the die. If the stands are well made, they can be used indefinitely for different dies, owing to the means provided to adjust for wear. It is a disputed point whether the plunger should be babbitted before or after the punch and die are fitted. Some prefer to make the punch and die first, enter the punch into the die attached to the plunger, and pour the babbitt, but it is generally conceded that the better way is to babbitt the plunger first; in fact, most manufacturers at the present time buy them already fitted up from one of the several companies manufacturing them for the trade. One advantage in having the plunger babbitted first is that it can be run continuously for a day or so to secure a good bearing, the large nut being set up occasionally. In this "working out," the plunger is sure to creep a trifle, probably caused by the babbitt not flowing evenly and, obviously, it is much better for this change to take place before the alignment of the punch and die. In recessing the cylinder to receive the base, the proper way is to place the plunger on the centers of the lathe with the cylinder attached and recess and face out on the bottom, using the plunger for a mandrel. With this method (which is applicable when the plunger is babbitted first) one has the assurance of knowing that the plunger is exactly central and in a vertical position with the base.

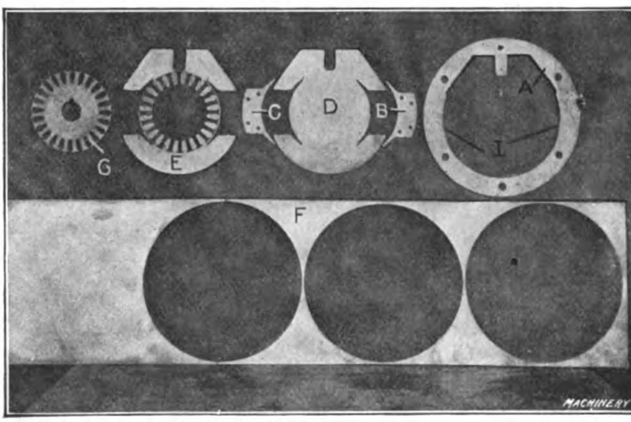


Fig. 27. Field, Pole and Disk Punchings and the Stock from which they are made

In milling the three grooves in the plunger, it is well to space them unevenly, as it will then be impossible to insert it in any but its proper position. In locating the holes in the backplate and shedder, a round master plate is usually used, thus insuring greater accuracy. This master plate can also be used for duplicating the die, if, at any time, this should be necessary. In boring the holes in the master plate, they should be made a trifle larger than the largest hole in the work, which gives clearance for the boring tool to pass through. When boring the back-plate, it should be set perfectly central with the master plate and then be fastened with a drop of soft solder on opposite sides. Having done this, a taper pin is inserted in the center of the faceplate of the bench lathe, and turned up on the end that projects, to the size of the holes in the master plate. One of the holes in the master plate is then wrung onto the pin, after which the master plate is clamped to the faceplate and one of the holes bored. The work is then located for boring the remaining holes by shifting the master plate in the usual manner. The holes should be left small, so as to correct the error from hardening, by grinding.

When grinding, the work is placed upon the master plate in the same manner and position as when boring, the grinding being done by means of a steel lap several thousandths smaller than the hole, the enlarged end of which is charged with diamond dust. In separating the die from the master plate, the best way to remove the solder is to turn it off with a lathe tool before the work is removed from the faceplate.

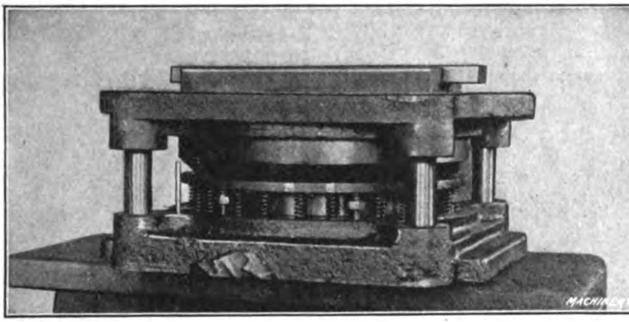


Fig. 28. Assembled Punch and Die for the Field and Pole Punchings

When making the die *I*, great care must be exercised, as the die is straight and the templet must be worked through without any clearance; this allows an even sliding fit for the shedder. In case

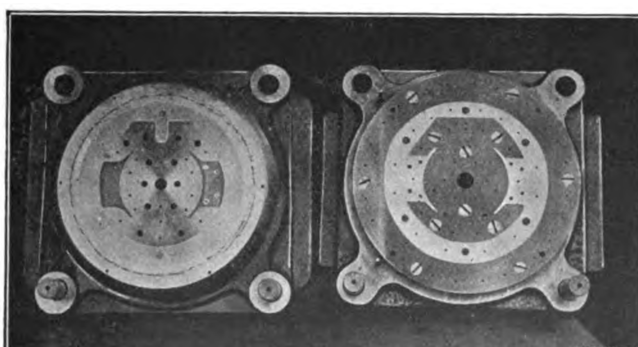


Fig. 29. Field and Pole Die taken apart

it is impossible to avoid a little clearance, it can sometimes be corrected in the lapping operation, after hardening.

Construction of Sectional Sub-press Dies

The methods of making two interesting sectional sub-press dies that are used in the manufacture of armature disks and field and pole punchings are described in the following: Fig. 27 shows the punchings and also the 0.025 inch sheet steel from which they are made. Fig. 29 shows the assembled punch and die used for making the field and pole punchings, and Fig. 32 shows the assembled punch and die for blanking and notching the armature disks. The other illustrations show parts of these punches and dies from which the construction will readily be understood. The parts *A*, *B*, *C* and *D* are produced at one stroke of the press. The parts *E* and *F* are scrap; and the disk *G* is stamped from the piece *D* in a subsequent operation.

The assembled punch and die for making the parts *A*, *B*, *C* and *D* is illustrated in Fig. 28, and Fig. 29 shows this punch and die taken apart in order that a better idea of the construction may be obtained. In Fig. 30 the lower half of the die is shown with the strippers

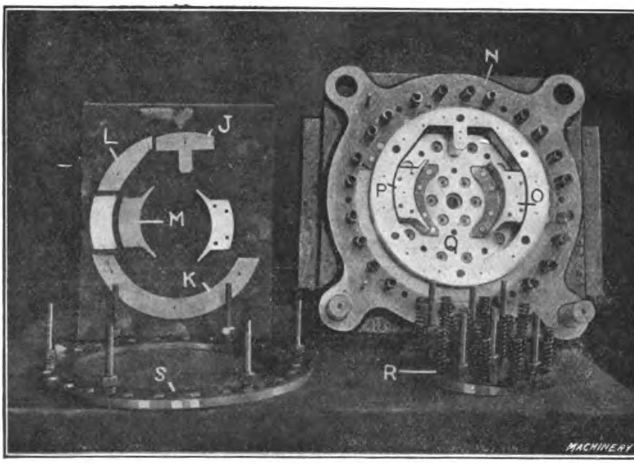


Fig. 30. Lower Half of Die with Strippers removed; also Templets for the Punch Sections

removed. This illustration also shows the templets for the field and pole punches and the templet drill jig used for drilling the pole punches. The punch for making the field is made of six sections, comprising one each of parts shown at *J* and *K* in Fig. 30 and two each of parts *L* and *M*. These sections have flanges on the outside, fastened to a tool steel ring 5/8 inch thick, fillister-head screws and dowel pins being used for this purpose. The ring and flanges are ground to fit into a recess in die-holder *N*. The pole punches *O* and *P* are made 1/8 inch higher than the cutting edge of the field punch and have a flange on the inside. They are screwed and doweled onto a tool steel plate *Q*, 5/8 inch in thickness, this plate being a sliding fit in the ring on which the sections of the field punch are mounted. Both the ring and plate are doweled to the die-holder *N* and held in position by fillister-head screws which extend through from the back of the die-holder.

To facilitate grinding the die when it becomes dull, the screws holding the field punch plate are loosened and the field punch raised to the level of the pole punches, four adjusting screws being provided for this purpose. The dies for the round holes in the field and poles are bushed in the punch sections. This makes replacement an easy matter and the scrap from the holes is allowed to pass down through the die-holder. The spring plate strippers are shown at *R* and *S*. They are held in position by flat-headed screws which have nuts in counterbored holes in the back of the die-holder. Dowel pins are put into the holes to keep the nuts from turning, the method being clearly shown in Fig. 33. Short springs and nuts shown in Fig. 30 are used to prevent the screws from loosening up when the die is in operation.

Fig. 31 shows the upper half of the die used for producing the field and pole punchings. In this illustration the outside die ring, the solid stripper, the knockouts, and the templets for the sections of the punch are clearly shown. The punch is composed of one each of sections *T*,

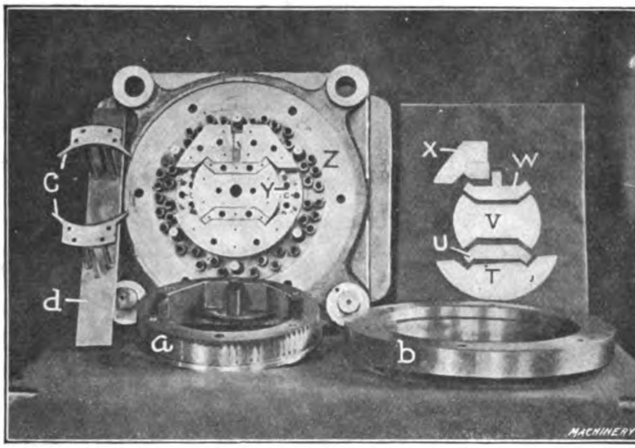


Fig. 31. Upper Half of Die, Solid Stripper, Outside Die Ring, and Templets for Sections

U, *V* and *W* and two of section *X*. These sections are doweled onto a tool steel plate *Y*, the plate and ⅛ inch at the bottom of the sections being ground on the outside to fit a circular recess in the holder *Z*, to which the plate is held by dowel pins and fillister-head screws. The solid stripper *a* is made of tool steel with two hardened dovetailed sections inserted. These sections sever the pole punchings from the field at the points marked *I* in Fig. 27. The springs shown in the die-holder *Z*, Fig. 31, take the thrust of the cut, and as the pole punches are ⅛ inch higher than the field punches—as previously explained—the pole punchings are blanked before the field punchings. The stripper serves as a support for the punches which pierce the small holes in the field, constitutes the cutting edge for the pole dies and also acts as an ejector for the field punching shown at *A* in Fig. 27. The die ring *b* is recessed into the holder *Z*; and the flange on the bottom of the stripper *a*, which fits into a recess in the blanking ring *b*, keeps the cutting edge flush with the rest of the die. As *a* is ground to a close sliding fit with the inside of the die ring and the outside of the sectional pieces on the plate *Y*, perfect alignment is always maintained. The knock-outs *c*, for ejecting the pole punchings *B* and *C* in Fig. 27, are fastened to the bar *d*, which is worked automatically by the punch press.

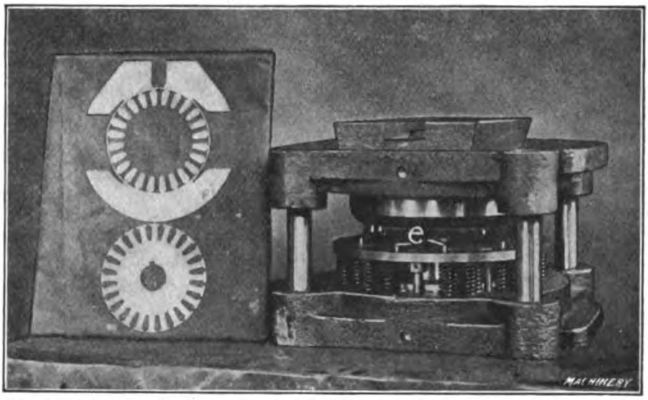


Fig. 32. Assembled Punch and Die for blanking and notching Armature Disks

All cutting members of this die are hardened and accurately ground so that there is no variation in the size of the blanks. A tolerance of 0.002 inch is allowed, but the dies are made to maintain the maximum size. The punches are made 0.003 inch smaller than the die, thus affording a cutting clearance of 0.0015 inch. A run of from 35,000 to 40,000 blanks is obtained between grindings, the number of pieces produced varying according to the grade of steel from which the work is being produced. Counting the three separate punchings produced at each stroke, this would mean a total production of from 105,000 to 120,000 finished blanks. The height of the punch and die above the holders is 1¾ inch. This affords 1⅜ inch of wearing surface, which corresponds to a total production of from 4,007,500 to 4,580,000 blanks, after which the strippers and flanges can be reduced in thickness to give at least ⅛ inch more of wearing surface.

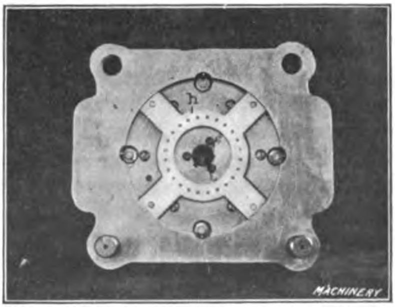


Fig. 33. Back of Lower Half of Die showing Method of securing Strippers

Figure 32 shows the assembled die which is used for blanking and notching the armature disks, and also one of the finished disks and the scrap left in making it. It will be seen that the disks are produced from the scrap formed by the die used for making the field and pole punchings, this scrap being shown at *D* in Fig. 27. The blank for the armature disk is located on the die by means of a nest of spring pins which are shown at *e* in Fig. 32. The spring stripper plate is recessed to allow the operator to handle the blanks quickly with a pair of pliers. Fig. 34 shows the die taken apart, the lower half being shown at the right-hand side of the illustration. This part of the die is made up of sections having a flange on the bottom, the

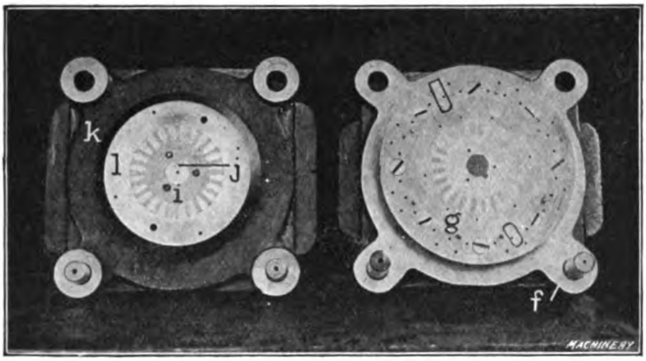
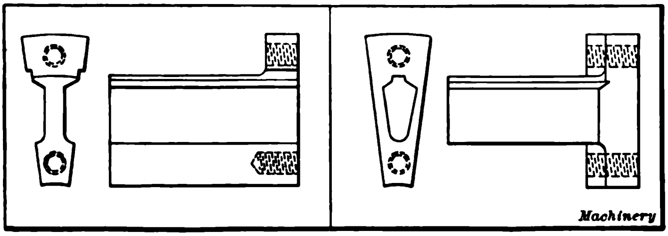


Fig. 34. Upper and Lower Halves of Die shown in Fig. 32

design of one section being shown in detail in Fig. 35. These sections are accurately fitted together and built around a tool steel plug which is bushed to receive the center hole and keyway die. The assembled sections are fitted into a recess in a tool steel plate and securely fastened by means of screws and dowel pins. The plate itself is held in a recess in the die-holder *f*, and the scrap from the center hole goes down through the die.



Figs. 35 and 36. Design of Sections for the Punch and Die shown in Fig. 34

The part marked *g* is a spring stripper plate; the strippers for the slots are made separate and they are a close sliding fit in the slots, thus helping to support the die sections. Studs threaded on one end are screwed into the bottom of the strippers and the opposite ends of these studs pass through the die-holder and are secured in the ring shown at *h* in Fig. 33. This ring is fastened to the stripper plate *g* (Fig. 34) by means of four flat-headed screws and the springs under the plate *g* operate all of the strippers. One of the punches for the upper part of the die, shown at the left-hand side in Fig. 34, is illustrated in detail in Fig. 36. These punches have a flange on the bottom and are accurately fitted together at the correct angle to obtain accurate spacing and alignment with the lower die sections. The punches are assembled on a tool steel plate and ground on the outside to a snug fit in a tool steel ring which constitutes the cutting edge for the outside diameter of the blank. The knock-out *i* in Fig. 34 is ½ inch thick; it is made a sliding fit on the slot punches and is connected by three studs to a plate in the head block. This knock-out is worked automatically by the press. The punch for making the keyway is dovetailed into the center hole punch *j*, the shank of which is made a driving fit in the holder *k*. The sections of these dies are milled to size so that no filing or fitting is necessary after the parts have left the milling machine. The final finish is obtained by grinding between the joints and this grinding is only necessary when the steel has expanded in the hardening process, the expansion never amounting to more than from 0.001 to 0.002 inch. The outside cutting edge of the die sections is ground to the correct diameter to give a clearance of 0.0015 inch between them and the ring *l* in Fig. 34. The center die and punch and the ring *l* are ground all over, the punches being 0.0015 inch smaller than the dies. The center die *j* has a tapered hole through it which allows the scrap to drop down.

The average number of pieces produced in this die between grindings is 35,000 and at least 1½ inch of the die can be used up. This corresponds to a total production of 4,375,000 blanks. This number of blanks produced from sectional dies is not unusual and some dies have stood up under this rate of production without requiring any repairs during a period of three or four years. The stock used is Crucible Steel Co.'s 1.25 per cent carbon steel which is hardened so that it cannot be scratched with a file. The first cost of the sectional dies is considered by many to be higher than that of solid dies, but considering the life of the dies, they may be cheaper in the end, especially if the number of parts to be produced is large enough to warrant the increase in first cost.

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