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NUMBER 45

DROP FORGING

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CHAPTER I

THE DROP FORGING PLANT

The design and equipment of the drop forge and hardening departments—adjuncts most important to the modern manufacturing plant—are subjects frequently entirely neglected in preliminary design, and almost invariably slighted in erection. While this fact is due, without doubt, to conservatism, it is not to be denied that in few places will careful design or small investment show greater beneficial results in finished product, or quicker returns from the amount of money expended. To install an elaborately equipped tool shop, and a hardening department consisting only of a few coal and gas fires and tubs of fresh water, indicates, to the writer's mind, lack of proper thought, and is, to say the least, inconsistent. It is the object of the present chapter to illustrate and describe a type of each department, indicative of what constitutes best modern practice, together with discussion bearing on such departments in general.

The drop forge and hardening departments being of the same general type, should preferably be combined under one roof. In a building for this purpose, ventilation is of greater importance than light. A good form of building is from 60 to 70 feet wide by about 20 feet high under the trusses, with roof pitched not less than 30 degrees, and a ventilating monitor at least 15 feet wide extending the entire length of the building. Windows throughout should be of the American type, with sliding sashes.

In the hardening room, all windows should be protected from excessive light by slat shutters or louvres, the slats being set at 45 degrees and about 3 inches apart, adjustable for about 1 foot at the top. This arrangement gives a subdued light, enabling the hardener to distinguish his color with a greater degree of accuracy. The slight adjustment at the top is sufficient to keep the interior light even, regardless of the outside conditions. One 16 candlepower light hung 7 feet from the floor should be provided for every 150 square feet of floor space in this department. Fig. 1 shows the plan of a building as primarily laid out as a part of a large manufacturing plant.

Location of Die-sinking Department

The die-sinking and inspecting departments are set in the end of the building, both to insure better light, and to be further away from the jar of the larger drop-hammers. The jar in a department so located is insufficient to materially affect the quality of the work, provided the partitions are of brick and extend well below the floor line. The rough stock for dies is to be brought in at the door near the end of the building, planed up and dovetailed in 10-foot lengths, and rough sawed to size desired in a Thompson hacksaw. The finished dies are to be stored in a fireproof vault assigned to them, on racks with shelves 8 inches wide, the dies being stored face out, one half above the other. Thirty-inch passageways, being sufficiently wide to admit single trucks, are allowed between the racks.

Board and Steam Drop-hammers—Helve and Trip Hammers

In a moderate sized shop at least, it is good policy to install comparatively large drop hammers on account of their broader range of utility. General practice is to install board drops with no size smaller than 400 pounds, and to install steam drops where the work requires sizes larger than 1,000 pounds. The steam drop in large sizes has the advantage of being able to break down its own work, but on small parts many forgings are spoiled by catching in the quick stroke.

In Fig. 1, the larger board drops have been set in conjunction with a helve hammer, so arranged that it may break down for two of them. This result may be obtained equally well by setting the helve hammer between two drops and faced the same way, but with the anvil block set about 3 feet in front of the base line of the drop hammers, thus permitting the blacksmith to swing his stock directly from one to the other.

The larger hammers are set nearest the main cross passageways to make possible less travel for the larger stock and finished product. The forgings are, of course, hot trimmed in the trimming presses and by sprue cutters set in conjunction with each hammer, but before going to the machine shop they are accurately trimmed to the size required for their reception into their various jigs and fixtures, in the presses of the cold trimming department.

The two trip hammers are used in conjunction with tool dressing and general work. The two blacksmith forges near the die-sinking department are used for general work during the day, and for night and overtime work when the main shop is not running. They are blown from an overhead blower, motor-driven, and are hung from the trusses, their exhausts being taken out through the roof. With the exception of these two fires the use of fuel oil is universal throughout the entire shop. This subject will be further discussed later. Both the forge and hardening departments should be in general charge of one man whose office is centrally located between them, but each should have a separate sub-foreman.

Lay-out of the Hardening Department

The general layout of the hardening department is self-explanatory, but the details may require explanation. In front of the small open fires, lead pots, etc., with 45 inches clear space, is set a row of brine and whale-oil tanks, alternating, one of each kind being sufficient for two fires.

These regular brine tanks are built of 2½-inch Southern pine, and elliptical in shape, being 30 inches wide, 4 feet long, and 30 inches deep, with a capacity of 120 gallons. The brine is circulated through these tanks, entering at the bottom through a 1¼-inch brass pipe controlled by a gate valve, and overflowing at the top through a 4-inch

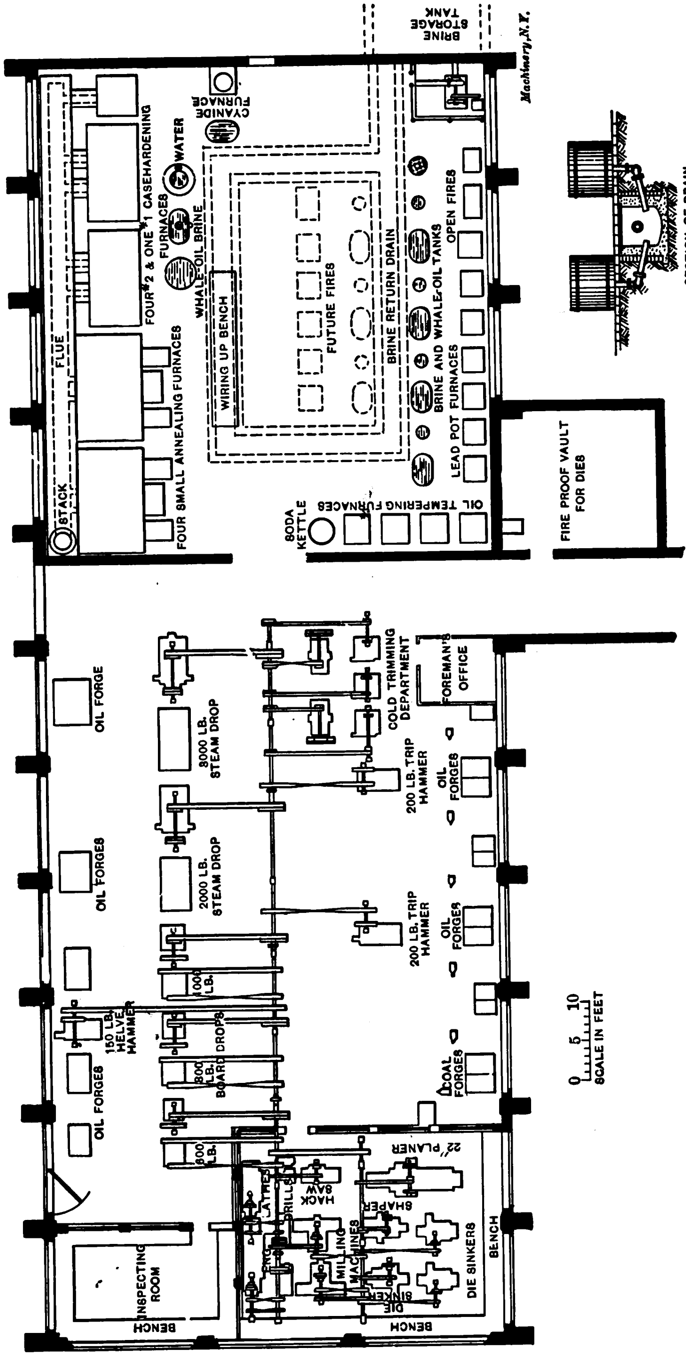


Fig. 1. Layout of Drop-forge and Hardening Shop

cast iron soil pipe. The required rate of circulation for each tank to keep the brine sufficiently cool for best results in hardening, is 50 gallons per minute.

Centrally located in front of the No. 2 casehardening furnaces is a brine tank of the same size as described above, a vertical section of which tank is shown in Fig. 2. Brine is admitted through the 4-inch brass pipe in the center of the tank. This pipe extends within 6 inches of the brine level, and is readily removable by hand, being loosely screwed into the coupling at the bottom. The brine entering through this pipe under pressure, forms a dome above the main level, which dome is used for the purpose of dipping the face of the drop-hammer dies, after which the dies are reheated slightly and plunged all over. By using this method of dipping the face, every corner and crevice of the die is struck at once, thereby preventing unequal cooling and cracking. As the inlet pipe is readily removable, the utility of the tank as applied to general hardening is in no way limited. One

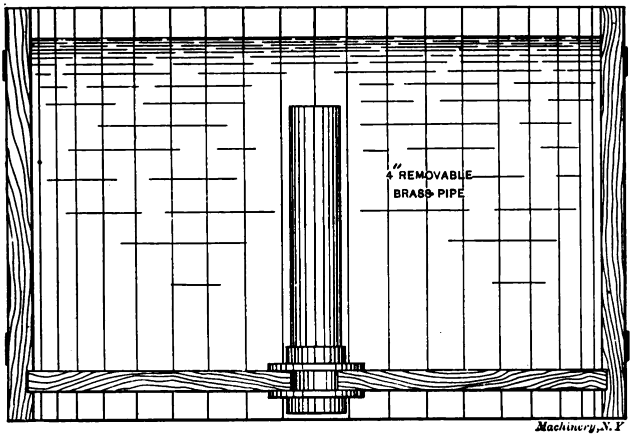


Fig. 2. Section of Brine Tank

hundred and fifty gallons per minute should be temporarily available for this tank. A 5-inch cast iron soil pipe takes care of the overflow.

A 4-foot diameter whale-oil tank, one regular brine tank, and a portable fresh water tank complete the equipment required for the casehardening furnaces. These tanks are served by crane. The portable fresh water tank is 30 inches diameter by 30 inches deep, and when not elsewhere in use is set in a concreted depression in the floor, 4 feet diameter by 6 inches deep, which depression is drained through a screen by a 4-inch tile drain. The chief use of this tank is for water-marking screws and other small parts. The tank is drained at the bottom through a 2-inch spigot. A large part of the black bone used is caught by the screen in the depression, from which it may readily be shoveled out. Even with this precaution, however, it is desirable that the drain run with as steep a pitch as possible direct to a catch-basin, both to prevent stoppage and to facilitate cleaning out, should stoppage occur. The drain will surely give trouble if laid with many turns. On opposite sides of this tank are lugs or hooks to receive poles by which two men carry the tank about the job, wherever its use is required.

In front of the open fires is a special brine tank used for hardening cutters, reamers, etc. A section of this special tank is shown in Fig. 3. The brine is admitted at the bottom through a 2-inch brass inlet pipe, and spurts in through a large number of ⅛-inch holes drilled in the 12-inch cast iron inner tank. The combined areas of these small holes is designed to be about 20 per cent in excess of the area of the inlet pipe. A 4-inch cast iron soil pipe takes care of the overflow. The advantage claimed for this tank is that the brine spurting through the small holes on all sides strikes all the teeth or flutes of the cutter or reamer at the same time, thus tending to prevent cracking.

A 5-inch by 4-inch centrifugal circulating pump set in the pit in the

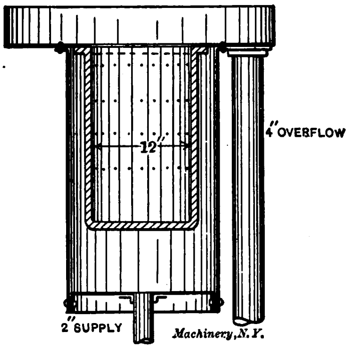


Fig. 3. Section of Special Brine Tank

corner of the building, and driven by a 15-horse-power motor, supplies the brine system. The required pressure which must be kept on this system to secure good efficiency is 15 pounds per square inch. The pump is set sufficiently low to be always primed from the storage tank built in the ground outside the building. That the brine may be kept sufficiently cool in the summer months, this storage tank must have a capacity equivalent to a fifteen minutes' supply for the entire system when all tanks are in operation at full capacity. The brine overflow from all service tanks is returned by gravity to the storage tank through the drain shown in Fig. 1.

The regular oil tanks are 20 inches diameter by 2 feet deep inside, but the shell is made 30 inches high to bring their tops at the same level as the brine tanks. The cooling apparatus consists of a coil of ½-inch brass pipe through which a part of the factory service water is circulated. The large 4-foot oil tank is of the same depth and is cooled through a 1-inch brass coil. It is not necessary to keep the oil as cool as the brine. A 2-inch by 3-inch belt-driven centrifugal pump supplies the circulating water. Certain concerns cool their oil by circulating it through a series of trombone coils placed in the monitor of the hardening room, but the practice has never appealed to the writer. The expense necessitated is comparatively great, the oil makes hard work for the pump, and the main heat from the building must pass out around these coils if so placed.

Advantages of Fuel Oil

Having in a general way described the equipment of each department, let us return to the question of fuel. The primary considerations controlling the efficiency of such departments are undoubtedly the ease of regulation and heating capacity of their fires. It is in this regard, even more than in the reduction of fuel cost, that the greatest economy is attained by the use of fuel oil. The reasons are obvious. The blacksmith's time may be given entirely to his work in hand, since once the valves are properly adjusted they require little or no

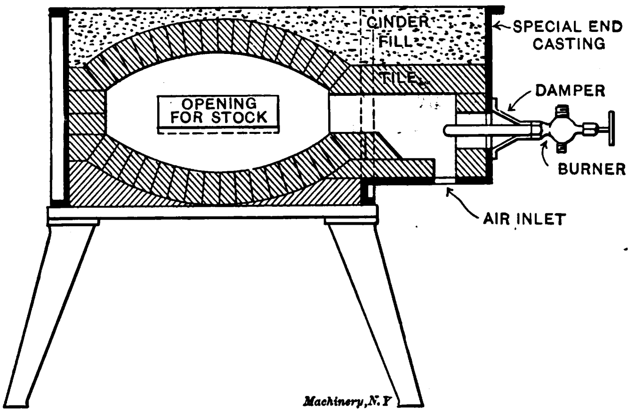


Fig. 4. Common Blast Forge Refitted to use Fuel Oil

attention and an even heat is assured. No labor is required to bring coal to or take ashes from the forge, and when no work is being done no fuel is required. If the flame is run a little on the yellow there is absolutely no scale. The cleanliness of the fire renders it especially adapted to such work as welding, etc. For the departments under discussion, the writer prefers an air-pressure system to those using steam, his preference being chiefly due to the fact that these departments are generally somewhat isolated from the source of steam supply. Of the air-pressure systems, those using the lowest pressures consistent with best efficiency are evidently the most desirable. Excellent systems are now on the market using from 8 to 16 ounces pressure. These systems require, however, furnaces of rather special design, the most efficient having ample combustion or mixing chambers in which the oil spray is combined with a primary air supply and volatilized before being admitted to the main chamber, where the stock is to be heated. In a plant where the installation is to be of entirely new forges, a carefully selected system of this type is ideal. In many cases, however, it may not be thought desirable to entirely discard such equipment of coal-burning forges as may be on hand. Where such is the case, but small outlay is required to make the necessary alterations to permit them being used in conjunction with a moderately low-pressure system. By this the writer means a pressure of about 2 pounds per square inch, which can, of course, be readily discharged by

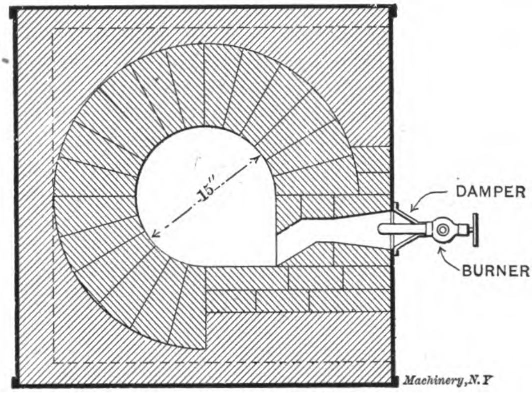


Fig. 5. Horizontal Section, Refitted Lead Pot Furnace

the ordinary "high-pressure blower," without requiring the installation of an air compressor, as is of course necessary with a system using from 15 to 18 pounds pressure.

Refitted Coal Forges and Furnaces for Fuel Oil

In refitting coal forges and furnaces to use fuel oil, it is desirable as far as possible to give the spray a whirling motion which tends to

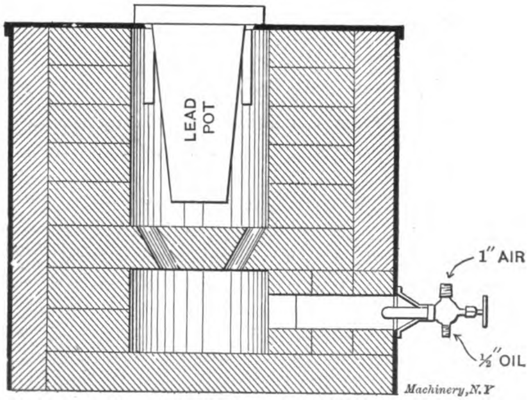


Fig. 6. Vertical Section, Refitted Lead Pot Furnace

more completely vaporize the oil, and also makes a much less noisy fire than is the case where the oil strikes against flat surfaces. In the latter case, where the oil strikes flat against the white-hot tile, it causes what appears to be a series of rapid explosions sufficiently loud in a large shop to be a source of annoyance.

In Fig. 4 is shown a method of refitting a common blast forge. Common arched firebrick and skewbacks are used and a few special tiles which may readily be ground to form on the common grindstone. Common red brick may be used as backing. A special casting is required, the end of which may be made to bolt onto the original side castings. In very large sizes it is sometimes advisable to install a burner at each end of the forge, which arrangement is very satisfactory and gives an intense heat at the center of the fire box.

Figs. 5 and 6 show horizontal and vertical sections of the common form of lead pot furnace refitted. Either wedge or cupola brick may be used. Two courses from the bottom tile, and forming the top of the mixing chamber, is a tile through which are drilled at an angle, six 1½-inch holes. For this operation a common star drill may, with care, be used. In the top two courses, four bricks in each are omitted

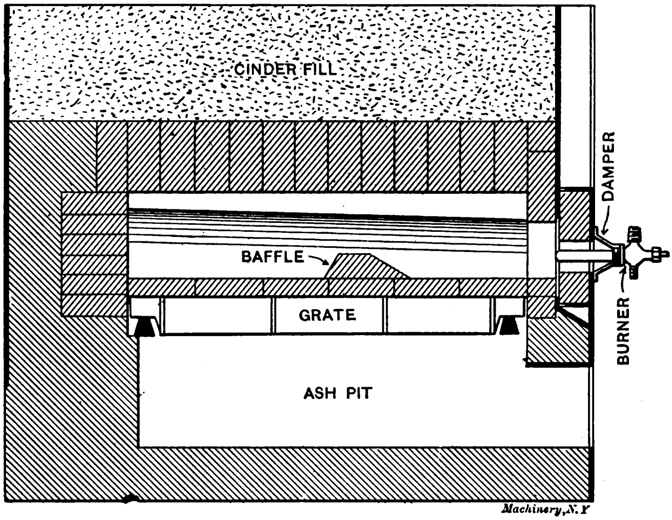


Fig. 7. Longitudinal Section, Refitted Casehardening Furnace

at 45 degrees for vents. As before, the firebrick is backed up with common red brick.

Figs. 7 and 8 show cross and longitudinal sections of a refitted No. 2 Brown & Sharpe casehardening furnace. In this case the coal grates are left in place and simply paved with firebrick laid on their sides. A 3-inch fire tile, ground to form shown, is centrally located in the firebox to act as a baffle. If the furnace is to be set up new for use of fuel oil, it is desirable that the bridge wall be sloped as shown, to leave an opening at the back of 2 inches over the wall, and 4 inches at the front. The reason for this construction is to counteract the tendency of the heat to drive to the back of the oven. This tendency exists, but is not marked, and in cases where the furnace is already set up it hardly pays to rebuild the bridge wall. A special fire door casting, designed to take the burner, must take the place of the former vertical sliding door. These few examples will give a general idea of the changes necessary to remodel an installation of coal fires.

Arrangement of Piping

In the two departments under discussion, the oil is supplied to all furnaces through a 1¼-inch wrought iron main, making a complete closed loop around each department in order to keep the pressure even. A 1-inch steam pipe must be laid with it to keep the oil from congealing in cold weather. These two pipes should be laid preferably in the ground itself and not in a trench, and should never be laid above the floor, the reason being that the gases from all petroleum distillates are heavier than air, and will run to the low parts of the floor or the trench. These gases, though not themselves explosive, may become so if confined with a large proportion of air.

The air piping should preferably be suspended overhead with outlets

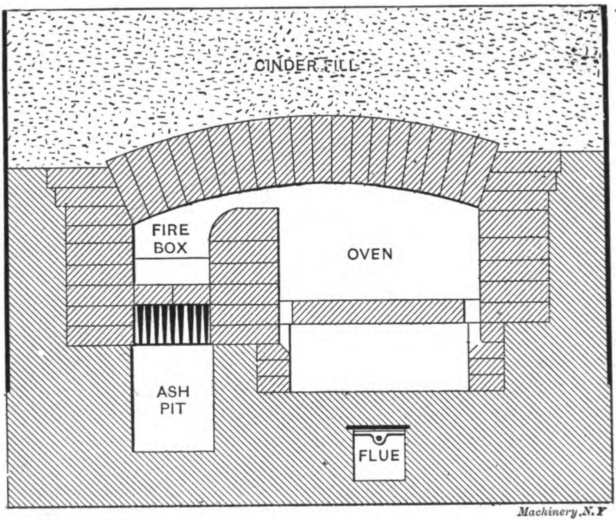


Fig. 8. Cross-section, Refitted Casehardening Furnace

looking down into the risers from the oil mains. The speed of the air in these pipes should not exceed 15 feet per second in the first installation, which will permit of about 30 per cent increase, due to growth, without the speed becoming excessive. A rule-of-thumb measurement sometimes used is that the area of the air pipe shall equal six times the area of the jet, but the foregoing method is much the safer one for computation. To facilitate calculations, the following notes may prove of interest:

At 2 pounds pressure there will be required at the blower roughly about 1,000 cubic feet of free air per minute per gallon of oil burned.

Blast forges burn per day of ten hours approximately 0.15 gallons of oil per square inch of horizontal area of firebox.

Open fires for hardening, as above, 0.025 gallon.

Lead pots, oil tempering, casehardening and annealing furnaces, 0.05 gallon.

About 10 H. P. is required to transmit 1,000 cubic feet free air against 2 pounds pressure.

From the foregoing, a close estimate of the size of the required blower and the horsepower required to drive it may be obtained. Included in this estimate must be a figure on the amount of air required to blow the drop-hammer dies. The blow-pipes required are one 1½-inch pipe with flattened nozzle for each small drop and trip hammer, and two of the same size for the larger drop hammers. As the use of these blow-pipes is rather intermittent, this figure is generally in the nature of an off-hand estimate, based on the judgment of the engineer.

CHAPTER II

DROP AND STAMPED FORGINGS

The employment of drop forgings and stampings increases constantly and rapidly. Several firms are now equipped wholly for this class of work, and supply enormous numbers of forgings to the metal working trades. Drop forgings or stampings bear the same relation to the work of the blacksmith shop that machine-molded castings bear to that of the foundry. In each case the skilled labor of the craftsman is dispensed with, yet good wages are earned by men working by the piece. In each case the cheaper product has the advantage of much greater accuracy, and uniformity in shapes and dimensions. The numbers turned out from the dies or stamps, as from the molding machines, are often twenty or thirty times as great as those which can be produced by hand by skilled men. In each case, too, the question of machining is often inseparable from that of the methods of production adopted, because accuracy of shape, and uniformity of dimensions in forgings and castings alike are favorable to the most economical machining, since allowances which are either insufficient or excessive for the machines are equally undesirable and troublesome. The smith working at the anvil, even with the aids afforded by templets and gages, is unable to produce two pieces, to say nothing of twenty intricate and elaborate pieces, absolutely alike, unless at an enormous expenditure of time. It is cheaper therefore, and is the practice to "leave plenty on" to insure that the work shall "finish" all over when machined, otherwise the final corrections would occupy much more time than the actual formative work of the forging. But forgings which are stamped, all come out exactly alike from the dies, without any extra care or time spent on the part of the workman.

The accuracy of stampings, however, is further advantageous in the fact that a considerable amount of machining is often avoided altogether. The smooth, glossy, polished and accurate surfaces left from the dies are often good enough for handles, levers, webs, and bossed parts. Or, if they are required to be bright for good appearance, then a polished surface imparted by an emery wheel and buff are sufficient, without any machining in the lathe, shaper, or milling machine. Punched holes may be simply lapped, instead of being drilled and reamed, the locations of the holes being fixed with accuracy by the dies.

Development of Stamping Processes

The history of die stamping goes back fifty years or more in the Black Country, and Birmingham district, England. In the blacksmith shops a limited amount of work had been done previously in dies for as long a period, but only or chiefly as a device for imparting a final finish to work which had been already prepared and nearly completed at the anvil. This practice arose out of the fact that only in this way was uniformity in a number of similar forgings economically possible. Such uniformity could only be produced on the anvil with flatters and

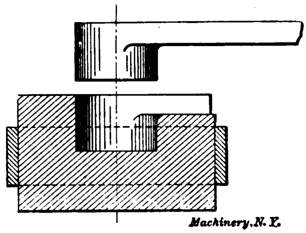
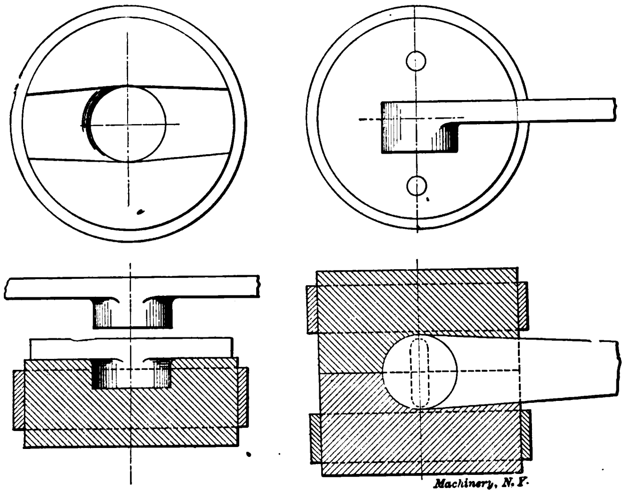


Fig. 9. Die Used for Correcting or Finishing Levers

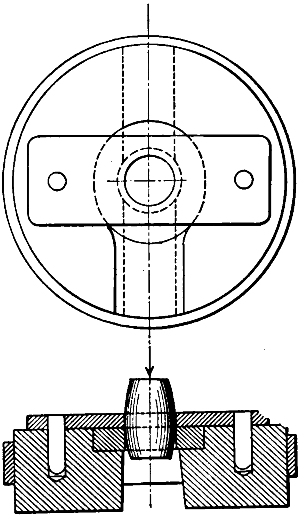
swages, at the sacrifice of much time and labor. Hence, long before the practice of *producing* forgings by stamping existed in the blacksmith shops, the practice had grown of *correcting* and *finishing* anvil-made forgings in dies under the power hammer. The dies were often of a sectional form, as they are still to-day when heavy forgings are in question. Thus, a die or pair of dies would include a boss only,



Figs. 10 and 11. Other Examples of Dies Used for Finishing, but not for Rough Forging, Bossed Levers

on a lever, Figs. 9, 10 and 11, the lever ends standing out beyond the dies; or a die would be used to punch a hole, and correct the boss at the same time, Fig. 12. Lever ends, either forked or solid, are suitable objects for finishing in this way. So are the ends of connecting-rods, Fig. 13, the eyes of the tie rods, and the bridles or loops of slide valves. In the old practice, as to a large extent now, these were made of wrought iron, bent, and welded. These operations were done at the anvil, and the correction and finish done at another heat in the dies. These dies were and are made of cast iron from a pattern. Later, cast steel has been often used with a view either to increase the strength, or to lessen the weight.

Even on the anvil, in little shops where there was not as yet a steam hammer, the old Oliver-hammer was utilized in finishing the heads of bolts in dies, and the writer remembers seeing these in operation. And on the anvil, little devices were rigged up for finishing bosses. and punching holes, the type of which was the spring swage, Fig. 14,



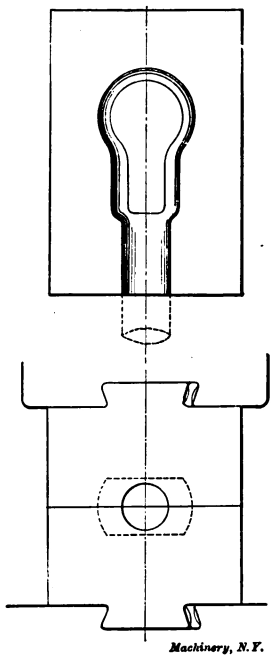


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Fig. 12. Die used for Punching Hole through Boss, Correcting Shape of Boss at Same Time

Fig. 13. Die for Finishing the End of a Connecting Rod

the jaws of which were fashioned independently of aid from the machine shop, by a process of *typing*, or *hubbing*, from a dummy, or a duplicate forging. Very many simple forms can be and are done in this way still as a legitimate and suitable method. Light swages are used on the anvil, just as the heavier ones are operated under the steam or drop hammer.

The sectional dies are used very extensively now in the blacksmith shop for the purpose of final correction and finishing only. But along with the use of these, there has grown the practice of stamping wholly, either as a sub-department of the shop, or carried on in a distinct shop. Generally, however, the merely corrective dies are used for the heavier forgings, and the regular stamps for the smaller class, as in Figs. 15 to 18. To make the larger forgings entirely by stamping operations would often require heavier hammers and appliances than most shops are equipped with, and the numbers wanted of the large forgings might not be sufficient to render heavier installation remunerative. But a heavy forging may be corrected in dies when it would

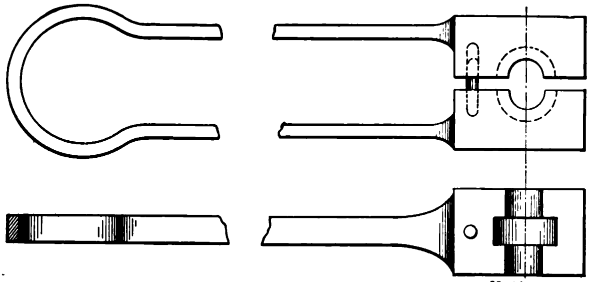


Fig. 14. Device for Shaping Bosses on Work, made on the Principle of the Spring Swage

not be practicable to produce it entirely from a rude lump. Among work of this kind may be instanced large tie-rod eyes, large bossed levers, Figs. 9 and 10, rings, cranks, and such like. Some of these are too long to be embraced wholly in a single die. A long two- or

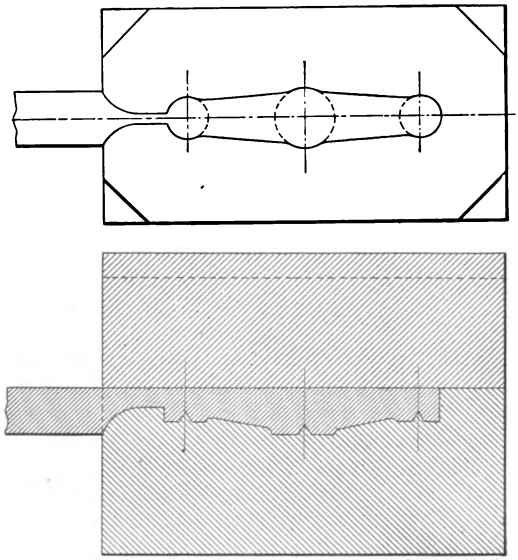


Fig. 15. Example of Forging Die Forming Center Holes in the Bosses of the Work

three-bossed lever, for example, is then corrected only on its bosses, and for an inch or two away therefrom. A pillar for a handrailing would have its bossed portions corrected separately, and the body corrected by swaging at the anvil, or in other dies.

Materials Used for Dies

The number of similar forgings required is often insufficient to justify a large outlay for cut steel dies. But dies made in cast iron are not costly, and therefore they are frequently made when only half a dozen or a dozen of similar articles are required. They may, of course, be kept for future use, and should be, when a job is likely to be repeated, but, apart from that, a very small number of forgings will pay the cost of cast dies.

The growth of stamping has been gradual and natural. The mere

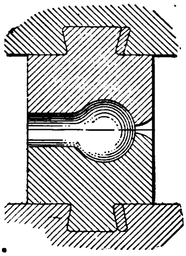


Fig. 16. Type of Die Forming the End of a Ball Crank

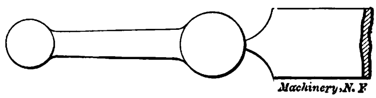


Fig. 17. Forging Made in Dies From a Bar

fact of having cast dies lying by from previous jobs has been the cause of their utilization for pieces of work which might not otherwise have been thought to justify the expense of new dies. But being in stock, slight and unimportant alterations in some dimensions in new jobs would often render the dies available. In this way the beginnings of standardization arose. For as the dies began to accumulate,

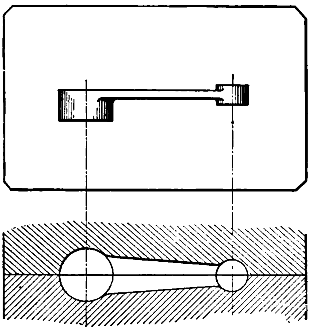


Fig. 18. Dies for a Lever with Hubs at Both Ends

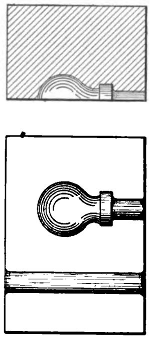


Fig. 19. Dies for Forging an Eye Bolt

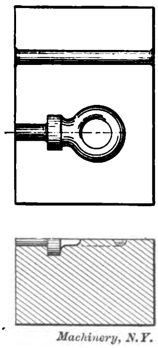


Fig. 20. Dies for Finishing the Eye Bolt

one pair or set was made to do duty for work for which it was not originally intended. Thus, the difference of half a ton or a ton of crane power was not allowed to involve the making of minute differences in the forged work for the cranes, but one standard set was used for both. So in engine and pump work the same standard sets came to be used for powers and sizes of mechanisms that were not very dissimilar, and when a difference of 1/8 inch, or so, in dimensions could make no possible difference in the proper operation or strength of the forged details.

Principles of Drop Forging and Stamping

Comparatively few articles can be produced in one pair of dies, and those are chiefly circular forms, the diameters of which at different sections do not vary greatly. If they do vary, some preliminary reduction or "breaking down" is necessary. And if a portion of the article takes the form of an eye, or a boss, three or four successive operations may be necessary to produce the forging, as in the eye-bolt produced in Figs. 19 and 20. The die maker has then to settle how the work shall be done, whether in one or more pairs of dies, and whether

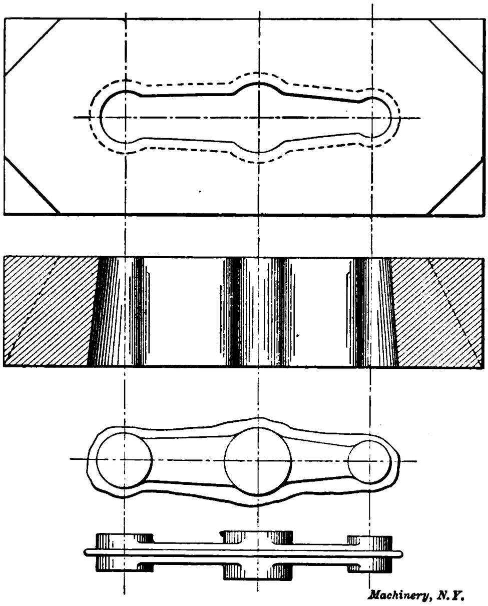
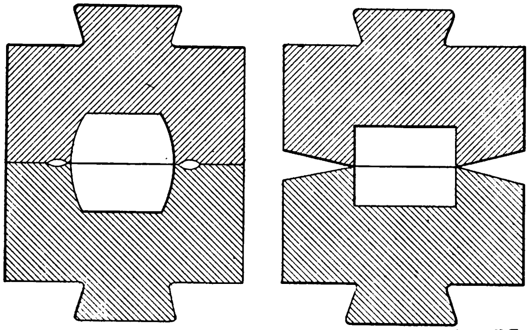


Fig. 21. Stripping Die for Removing Fin Produced by Forging Process, and Work for which it is Used

under one hammer or two. As a rule, to which there are exceptions, it is desirable to do all the work at a single heat. Then, if several operations are required they must be done either in one set of dies, or in separate dies. For small forgings it is easy to get three or four recesses in one pair of dies, for roughing down, for formation, and for cutting off, or nicking for breaking off. In larger pieces it is necessary to have two hammers adjacent, so that the stamper can use them both without walking away from either. But a few hammers are made double headed, with two anvils, and tups to facilitate such work. When two heats are necessary, then it may be convenient to perform the earlier operations on a large number of similar pieces, and then change the dies for the subsequent work. This, perhaps, is more often done in the regular machine shops than in the drop forging works, in which the work is divided between two adjacent hammers.

Though the smith working at the anvil endeavors to gage by a very rough mental estimation the amount of material which is required for a forging, in order to lessen labor, the stamper may be comparatively indifferent to that consideration. He will not, of course, have much excess of metal if it can be avoided, yet he is much in the same position as the anvil smith who has a steam or drop hammer available adjacent to the anvil. The power hammer is often resorted to for roughing down an odd lump quickly, in place of taking a smaller section, which would involve the alternative of upsetting, or of welding. The shapeless lump is simply roughed down rapidly in far less time than would be occupied in fullering on the anvil, or in performing the alternative operations of upsetting, or welding. In this way, too, very many odds and ends, cropped from iron or steel bars are utilized, which would otherwise go to swell the scrap heap.

The case of stamping is analogous. Though forgings having con-

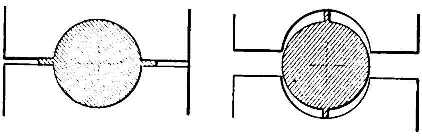


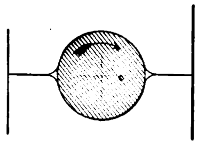
Figs. 22 and 23. Dies Provided with Space for Receiving the Fin

siderable differences in cross-sectional areas, are, as a general rule, broken down in one or more operations, preliminary to finishing, yet a great deal of work is done without this step-by-step process. A cubical lump is taken and put into the dies and reduced. A large amount of fin being squeezed out in the process, this is removed in an adjacent stripping die, Fig. 21, and the forging put back, and finished in the first, or in another, recess, followed sometimes by a final stripping. This heavy reduction is only possible, first, because the lump is raised to a high temperature, and second, because the mechanical work done on it maintains the heat until the reduction is completed. At the anvil, two or three heats would often be required to accomplish the same amount of work which is done in one heat in dies.

Removal of Fin Produced in Drop-Forging

The formation of fin, it will be noted, is peculiar to stamping; it does not occur in anvil work. Sometimes dies are cut like Figs. 22 and 23 to receive the fin. In Fig. 22, a wide and shallow groove is cut all around the recess to receive the fin. In Fig. 23, the faces are sloped away with the same object. Work which is of cylindrical form does not necessarily involve the formation of permanent fin, because it can be rotated, as the reduction is going on, and such excess of metal which is equeezed out laterally is removed at once when a partial rotation is given to the piece, as in Figs. 24 and 25. In Fig. 24 the fin is shown squeezed out; in Fig. 25 it is being driven into the forging



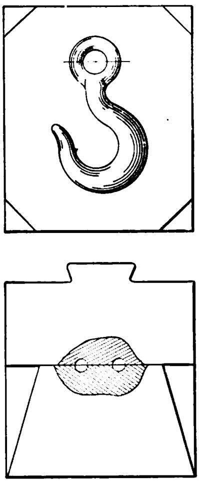


Machinery, N.Y.

Figs. 24 and 25. Showing How Fin Produced on Round Work is forged into the Bar by Rotating it

Fig. 26. Die with Rounded Edges to Receive Fin

again. Such being the case, Fig. 26 is the shape given to circular dies in cases where the circular form is not hampered by the proximity of shapes which would interfere with rotation. When the work can be rotated, the result is a fine, smooth, polished surface, which in many classes of work renders any subsequent machining unnecessary, or, if finish is essential, a little grinding may suffice. In some forgings a



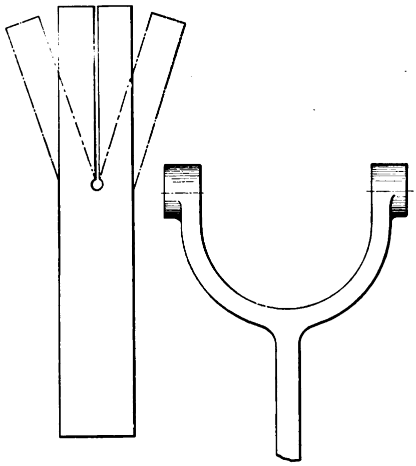


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Fig. 27. Dies for Crane Hook

Fig. 28. Fork Lever and Wrought Iron Bar from which it is made

portion only, a stem or shank, can be so treated, the remainder consisting of an eye, or a flattened portion, or a square shape.

Difference Between Treatment of Steel and Wrought Iron

In the blacksmith shop, wrought iron is still used as extensively as steel for common forgings. But many forms when made of wrought iron must not be stamped from a solid lump because of the loss of strength which occurs across the grain. Large thin rings and curves of light section should always be bent. But if these are made of steel, no such reason exists, because steel has practically no difference in strength with or across the direction of rolling. The partial substitution of steel for wrought iron has therefore been favorable to the development of stamping. Many jobs are now stamped from a solid

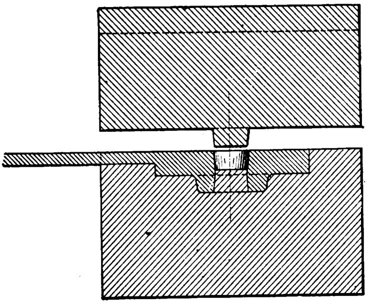


Fig. 29. Dies for a Circular Loose Hub

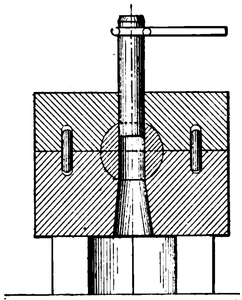


Fig. 30. Punching a Small Hole through the work in the Dies

bar, or lump of steel, which were formerly made from wrought iron by bending and welding. Hence, while wrought iron is still extensively used for anvil-made forgings, steel is employed much more for stampings. The crane hook, Fig. 27, when made of wrought iron, is always bent from bar before being finished in the dies. Made from

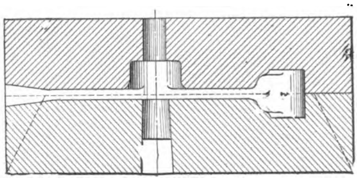


Fig. 31. Dies for Punching Holes Through Bosses

Fig. 32. Holes Punched by Punches Integral with Die

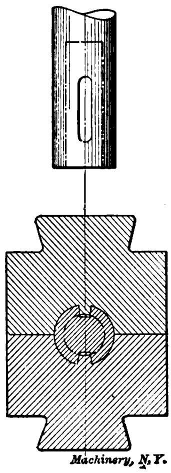


Fig. 33. Method of Forging the Slots in Collets

steel, it is stamped from a solid lump. For the forked end, Fig. 28, if made of wrought iron, a bar is split, and opened out, and bent over a form, and finished in dies. When made of steel, it may be stamped from a solid mass. The flange, Fig. 29, is stamped in steel from a solid chunk, handled by a porter bar temporarily.

Work with Holes Forged Through It

The old method of punching holes is that shown in Fig. 12, in which the punch is guided by a plate doweled on the body of the die. This is suitable for large holes. Frequently, for small holes, the punch is separate, and driven through a hole in an upper die as in Fig. 30; in Fig 31, a hole without its punch is shown. But punches are also often included solidly in the die, as in Fig. 34, half in top, and half in bottom, and not quite meeting at the center. In a shallow boss the punch may be in one half of the die only, as for a forging like Fig. 32. The metal becomes squeezed into the boss, and is improved by consolidation. Often, when holes are left to be drilled, the centers are stamped by small conical projections in the dies which serve as accurate guides for the driller. Sometimes holes are punched only through a portion of the metal, Fig. 33, when the central part has to be bored out subsequently, as indicated by the dotted lines.

Methods of Applying Impact or Pressure on Dies

Formerly all die work was done with hammer blows. As the demand grew for an extension of the system to heavier forgings, and to

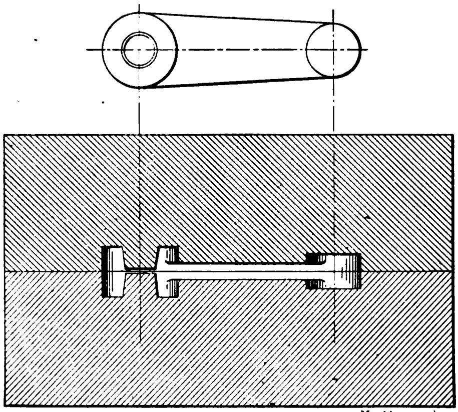


Fig. 34. Construction of Die for Forging a Hole through a Boss

articles involving the bending of plates and sheets, the steam and drop hammers were not able to deal so well with these. The demand was met by the presses, which are actuated by hydraulic power or by gears, cranks, and toggle levers. These will easily deal with dies and articles several feet in length, many of which are too intricate to be dealt with by hammers, even if their dimensions did not set a limit to such treatment. They are practicable on the hydraulic presses, because two rams can be utilized, one acting in the vertical, the other in the horizontal direction, so working at right angles with each other. This is utilized for bending, welding, and punching, for closing up joints, for dealing with undercut designs, and with hollow spaces formed by bending and welding, or by stamping. Typical of much work of this class is the die and punch used for stamping the rings for uptakes of vertical boilers and the man-hole and mud-hole seatings for boilers, Fig. 35, from a plain piece of steel plate. Fig. 36 shows the dies for forging a crank by pressure. A large amount of work of this kind is done in the railway car shops.

Stamped forgings thus diverge into two great groups, according as they are produced by hammer blows, or by gradual pressure. Broadly, the first group includes articles of small and medium dimensions, the latter those of a massive character, and all large work done in plates. This is now a generally accepted division, and one which harmonizes with the difference in hammer blows delivered on comparatively small masses, and of pressure on thicker bodies. Where mass is the condition present, slow pressure is more penetrating than impact, just as it is in large shafts and forgings. Moreover, the blows delivered

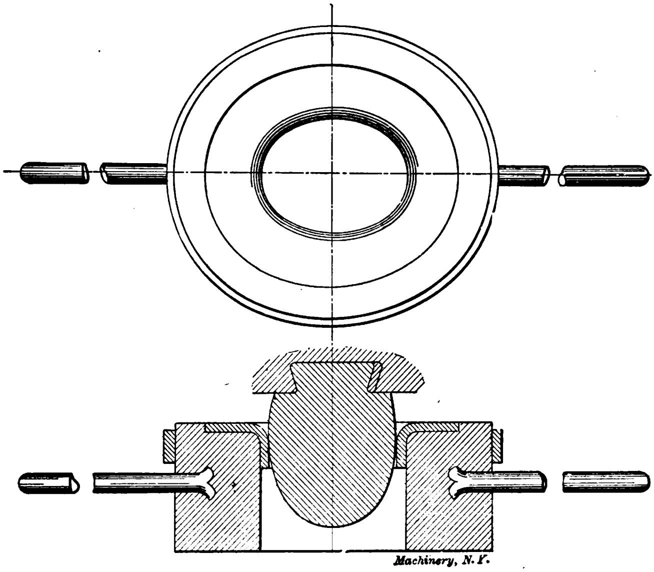


Fig. 35. Die Used for Forging and Bending Man-hole Seatings

from a very heavy hammer are destructive to dies, and if they are made massive enough to withstand these blows, then they are too heavy for convenient handling. Massive dies are, of course, required to resist pressure, but that is not nearly so destructive as the violent, incessant jarring action of a hammer.

Methods Used for Making Dies

The stamps or dies used are as varied in their details and cost as the forgings themselves are. A great advantage of stamping dies is, that like machine molding, they are as readily adaptable to the demands for a very few identical articles, say ten or a dozen, as to hundreds or thousands. But the amount of work put into the dies, and the patterns and the materials used for them have to bear a definite relation to the number of pieces required. Hence, we have at extremes, dies of cast iron made cheaply, and these of mild steel cut out with care and hardened. Except in name and function, the examples at each extreme have little in common. They are not made in the same way, and the periods of their service are much less in the first than in the second case.

The cast dies are molded from suitable patterns. They may have to be cleaned up a little by the machinist. As they are liable to fracture, unless made very massive, they are frequently encircled with bands of wrought iron, shrunk on, as in Figs. 9 and 12. They are, when small, lifted with circular tongs, Fig. 37, or by the hands, but larger dies have handles cast in for lifting them, Fig. 35. Or, alternatively, holes are cast for the insertion of rods for the same purpose. Some cast dies will endure long service, others fracture soon. Dies of cast steel are stronger, but are more liable to inaccuracy.

Dies of forged steel are marked out on their faces, and recessed

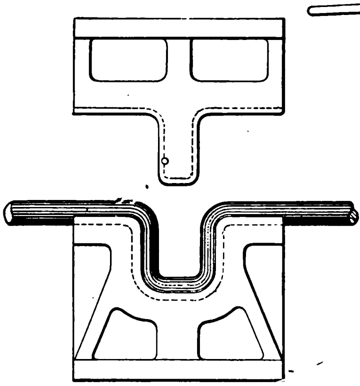


Fig. 36. Die for Forging Crank

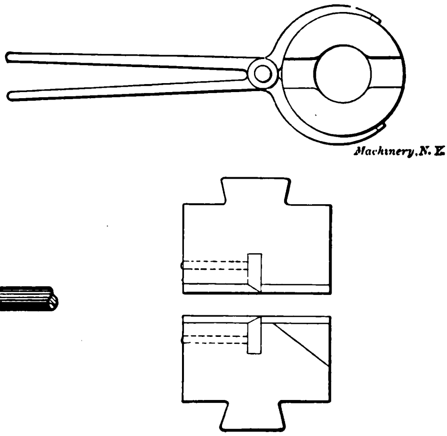


Fig. 37 Tongs for Holding Dies, and Cutters for Nicking the Stock, Fitted at the End of Dies

by various machine tools, and by hand work. All the aids afforded by machine tools are utilized, as boring, slotting, milling, and shaping. But often very much is left for the chisel and file to complete. There are several special machines designed wholly or chiefly for the use of die sinkers, but much can be done by the ordinary tools in the shops. Templets are used to check the progress of the work, including those of sheet metal for local sections, and those which represent the actual forgings which have to be stamped. These are made of lead, or tin, or a first sample forging is prepared. Contact is insured by the transference of red lead from the templet to the recesses which are being cut.

Reference has been made to the typing or hubbing process. It bears an essential resemblance to the operation of stamping medals and coins by a hard blow. Only the operation is reversed, the die itself being produced by stamping it, while white hot, from a cold forging.

It has the advantage of being cheaper than cutting dies, and in circular outlines is accurate enough, but is not well adapted for intricate shapes. The spring swages are frequently made in this way. In obtaining circular shapes thus, the hub or type is rotated between each successive blow, so correcting any inaccuracies that might form. The edges are of necessity produced with a slight convexity, Fig. 26. But this is an advantage in producing circular forgings which are rotated in the dies. It is not necessary to have complete circles in such a case, because metal squeezed out laterally, and what would soon form a fin, becomes obliterated by the next blow when the rotation into a new position takes place.

In one of the illustrations, Fig. 11, dowels are shown, which are inserted to serve as guides to secure the alignment of top and bottom dies. These are only used when the dies are not attached in any way to the anvil below, and tup above, as is often the practice in heavy dies. But generally the dies are secured by dovetails and keys, as in Fig. 13. In some cases locating screws are used on the anvil for dies cut at the corners, like Figs. 21 and 27, and the dovetail is only on the tup. The locating screws permit of making slight adjustments.

Forgings are often included in their dies, and are knocked out by a kicker device, or are pried out, or pushed out. Often a porter bar is used, generally the plain length of the bar from which the forgings are being stamped, as in Figs. 15 and 17. Then the forging is easily nicked off by reducing at the neck as shown, or a pair of cutters is fitted at the end of the dies, as in the lower part of Fig. 37.

The foregoing is an outline of the methods of drop forging in use, from which it is seen that the practice is devisible into three great groups; that done under hammers, and that in presses, and a further subdivision between the methods of the geneıal shops, and the drop forgers who work for the trade.

CHAPTER III

MAKING DROP FORGING DIES

Drop forging dies are made of 0.45 to 0.60 carbon steel, and are, usually, from 5 to 8 inches thick. At *A*, Fig. 38, is given a general idea of their appearance when finished. The dies are marked *T* and *B* (top and bottom) to prevent their getting mixed up in the laying out. The front and left-hand sides are squared up, and from these sides the center lines of the impressions are laid out and the dies set up when ready for use. The edger, or breaking down impression, is on the right-hand side of the die. It is used for breaking down the rough heated stock into something like the shape required, before it goes into the finishing die. The heaviest part of the forging is always nearest the front. In deep dies, shapes which show parallel sides on the drawing, are given from 5 to 7 degrees taper on each side, to prevent the forging from sticking in the die. For machining the forging 1/32 inch is usually allowed, and for shrinkage 0.012 to 0.015 per inch. When the dies are finished a specimen casting of lead is made in them for ascertaining whether or not they will give the desired result.

The round portion of the impression is sunk first. Swinging the die blank in a lathe, when there is much stock to remove, is a convenient method. In some shops a cast-iron bolster, for the lathe faceplates, is used. This bolster has a web on its back, which fits the slot in the faceplate. The face of the bolster has a dovetail slot, which is identical with those in the hammer, and is at right angles to the web on the back. By this means a circle is quickly trued up. When the round portion is under 1½ inches in diameter, a profiling machine is better adapted for the work, using the half-round cutter shown at *C*, Fig. 38, to finish with, after roughing out the stock with a two-lipped cutter similar to that shown at *D*. The half-round cutter is very useful, being strong, easily made, and is easily ground by hand. The one illustrated at *C* leaves a point in the center of the impression, for spotting the center of the boss on the forging.

A die for forging a ball is sunk with a two-lipped spherical cutter. If there is to be a large hole drilled in the forging a plug is left, when sinking, or is afterward inserted in the die to lighten the forging at that point, and is shown at *E*. This plug should have a taper of 15 degrees on each side, and the top well rounded. In making the dies for forging the piece illustrated at *E*, the round portion *F* can be machined out after the part *H* is sunk. This may be done with a spherical cutter. A special attachment for the die-sinker may be used, by means of which a cutter can be sunk to its center in the work. The cutter is held in the fixture on a short arbor between half-round centers, around which the cutter is rotated by means of a rawhide gear. The teeth of the gear engage the back of the teeth of the cutter. This is only used for finishing. Parts *K* could be done with this device. It saves time, makes an accurate, clean job and does work that would have to be typed out, *i.e.*, sunk by hand. Some circular impressions are sunk in the milling machine, using one long half-center, and a forming cutter with a small shank, a groove being first cut to clear the shank.

The parts *K* would, however, have to be typed in most shops. A type is a hardened steel template, of the size and form that the impression is to be, with the top left soft to prevent the steel from flying when struck with a hammer. Portions of the die that cannot be machined, owing to their irregular shape, or the lack of shop facilities, must be sunk by hand. This requires especial skill with the hammer and chisel,

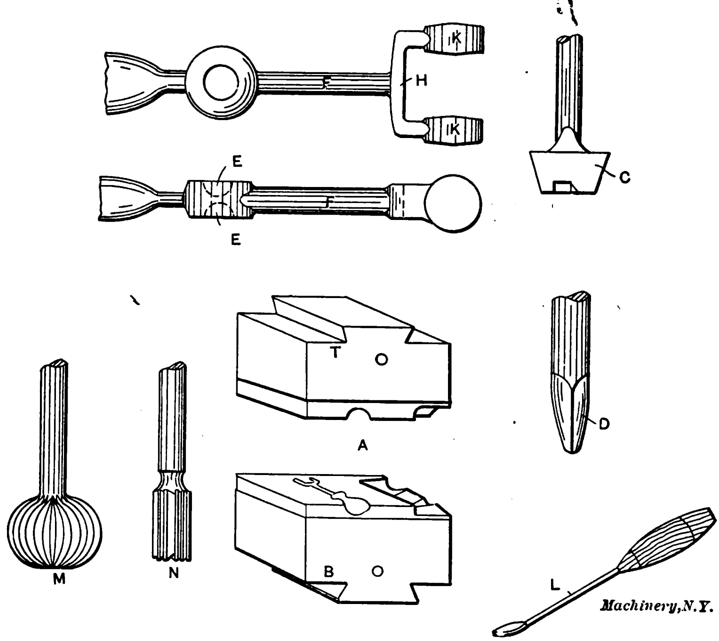


Fig. 38. Tools and Methods for Making Drop Forging Dies

scrapers and gravers, as well as a good eye. The chisels must be ground to the proper angle on the cutting edge, for chipping the curved surfaces and awkward corners. Scrapers may be made of various shapes, to suit the requirements of the work. One of the most useful is the three-cornered scraper, with two edges rounded; the third, being the cutting edge, is left sharp and is curved toward the point. Another handy scraper is shown at *L*, Fig. 38. It is leaf or heart-shaped, and is convenient for getting at small curves and corners, especially those at the bottom of the impression. The type is covered with a thin coating of Prussian blue, or red lead, and driven into the die from time to time, as the work progresses, and the high places worked down until the correct form is produced.

For the fillets and small corners, a graver or scraper is made from

Stubb's steel drill rod, of the desired radius. To save room in the tool-box, a 3/16 or 1/4-inch rod may be threaded on one end, and these scrapers fitted to it. A hole is drilled in the cutting end to save time in grinding. The scrapers leave small ridges in the work, which are filed out with rifflers, or bent files. Some impressions are polished with a soft pine block and powdered emery, but this is not the usual practice. When the impressions are worked out to the lines, a lead casting is taken to see where they need matching or evening up. The lead is tested for size, and if all right, a half-lead is taken from the top die, to be used as a template in laying out the trimming dies, that is, in shops where sheet metal templates are not used. If the lead is overheated, or is heated too often, it will not flow freely and chills before the impression is filled. Powdering the impression with chalk causes the lead to flow freer.

The edger, or breaking down form, on the right of the die, is made from 1/16 to 3/16 inch smaller than the horizontal cross-section of the forging, and has no abrupt shoulders or curves. The idea is to get the heated stock smaller in width than the finishing impression, so that the bottom of the impression strikes the stock first, and spreads it to the sides, filling the die. Cast-iron dies are also used for breaking down heavy work.

The flash, which is a recess 0.015 to 0.025 inch in depth, and about ⅞ inch wide, milled around the outline of each impression, allows the surplus stock to escape from the die. This surplus is afterward trimmed off in the trimming dies. The top die, also, has a groove about 1/16 inch in depth, milled around the impression, ¼ inch from the edge. The gate for clearing the stock tapers gradually toward the front from the impression so as not to weaken the die at that point.

In dies for making small forgings in large quantities there are several impressions sunk, one of which is used for a rougher, and should be about 1/32 inch narrower and deeper than the finishing impression. Some dies have to be interlocked when difficult shapes are to be forged, that is, the faces have to be shaped to suit the offset in the forging. Care must be taken to have the interlocking parts high enough so that the dies will not glance off when striking the stock, and make an imperfect forging. When the face of the dies is curved, special cutters are made, similar to those at *M* and *N* for surfacing and flashing. As a guide for machining curved impressions, some mechanics transfer the lines to the side of the die blank and lay out the curve there, then clamp a surface gage to the profiling machine, and with the needle set to the face of the cutter, work out the stock by following the lines with the needle point. Dies for forging gears, or similar work, are finished with a broach having the teeth machined in it, which is then driven into the die.

CHAPTER IV

DROP FORGING DIES IN AN AUTOMOBILE SHOP

The making of drop forging dies, together with the hardening process through which they are put, is a trade in itself, though closely allied to tool and die making as understood in the big shops of to-day. Each branch of shop work presents its individual problems, and a tool- and die-maker, though skilled in other lines, cannot go into a forging shop and make drop forge dies without special instruction and training.

In drop forge die work, as in other kinds of tool work, there are various grades of accuracy and finish required. Some forgings must come from the hammer practically finished to size, while others are made large enough to allow considerable machining. Where only a few pieces of a rough nature are required, little skill is needed in the

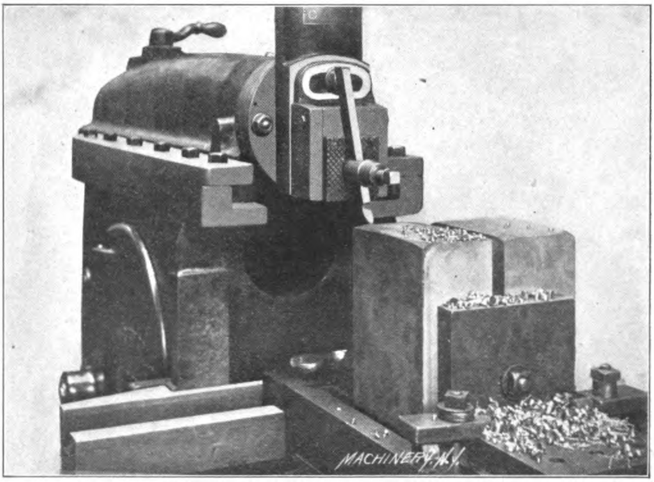


Fig. 39. Planing a Die-block on a Shaper

making or maintenance of the dies, but where small accurate parts are to be made in large quantities, special tools for both hand and machine use, and trained, skillful die-makers are needed, as well as a careful selection of the steel used.

Materials for, and Life of, Drop Forging Dies

Steel, cast into blocks, is not suitable for this work, as flaws or blowholes are likely to develop where least expected or desired, so as a general rule, forged blocks of open hearth crucible steel are used. These blocks are either purchased ready forged, in various sizes, from the steel manufacturers, or are forged in the shop where they are used, the former plan being the usual one.

A rough estimate as to the average life of a drop forging die, used for medium-sized work on Bessemer steel, was given by a foreman of long experience, as about forty thousand pieces. Some dies might be broken immediately when put in operation, while others might stand for a hundred thousand pieces or even more.

Automobile Shop Drop Forging Practice

In preparing the present chapter, the photographs and data were obtained in the factory of Thomas B. Jeffery & Co., Kenosha, Wis., the manufacturers of the famous "Rambler" automobile. This company's drop forging department is comparable to those of the big concerns that make a specialty of drop forgings, and consists of a well-lighted, finely-equipped tool-room, used only for drop forge die work, a thoroughly up-to-date hardening plant, and a big building full

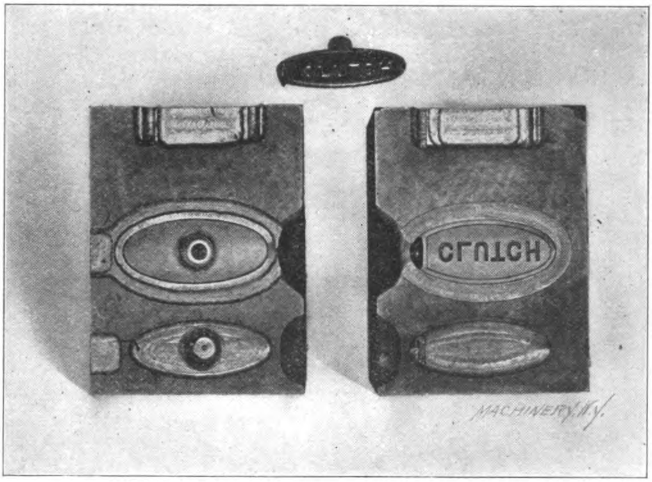


Fig. 40. A Pair of Typical Drop Forging Dies and Their Work

of steam hammers, punch presses, heating furnaces and every appliance necessary for first-class work.

The greater part of the drop forgings made here are of Bessemer bar steel, though some of the more particular automobile fittings are made of special grades of tool steel. All of the drop forging dies are of the highest class, calling for the best die-making skill, and necessitating a great deal of hand work in addition to the most accurate machining.

Making a Die

In the original outlining of a set of drop forging dies, the measurements for the forming cavities may be taken from a blue-print supplied by the drafting-room, or they may be taken from a piece already made—possibly a forging or a lead casting obtained from some former set of dies, or perhaps a piece made up for a model. Sometimes a sheet metal templet is made to assist in obtaining the desired shape of the die cavities, while in other cases, only the outline scribed on the coppered surface together with the necessary measurements, is needed. The size and outline of the forging to be made, as well as the accuracy required, govern the method of procedure.

The die blocks, which, as already stated, are forged of open hearth crucible steel, are first placed in a shaper and carefully surfaced off to the required dimensions, as shown in Fig. 39. These blocks are made

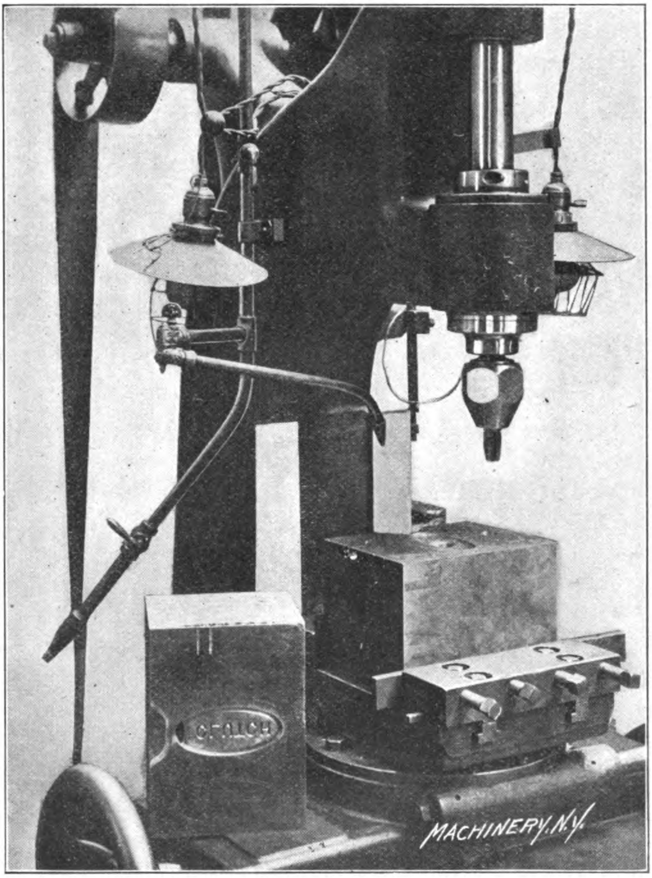


Fig. 41. Profiling Machine much Used in Die-sinking

over-size, so that enough of the surface can be machined off to insure good, sound metal to work on. The outlines for the breaking-down or roughing, the finishing, and sometimes the bending forms are then laid off on the coppered faces, and the cavities roughed out on the drill press or lathe as the case may require, or on the profiling machine, as shown in Fig. 41.

The same set of dies shown in this engraving is shown still further roughed out in Fig. 40. The shape of the forging to be made in this set is shown at the top of the illustration, and it is a foot pedal for a clutch lever. The channel for the fin, or "flash," which is formed in the finishing operation, is plainly shown in the middle cavities.

The letters, C L U T C H, were first lightly stamped on the metal with special steel letters to get the outline; then they were chiseled out, and finally finished by driving in the steel letters to smooth up the roughness caused by chiseling.

Fig. 42. Finishing the Die Shown in Fig. 40 on the Profiling Machine

Fig. 42 shows the final cuts being taken on the breaking-down part of this die, the rest of the work consisting of scraping, gouging and chiseling.

Tools Employed in Making Dies

For the hand work, the die block is held in a special "ball vise" which is shown in Fig. 43. A vise of this type is the handiest device imaginable for heavy die work. This illustration also shows the breaking-down part of the die a little more plainly than the previous examples.

Fig. 44 shows a few of the tools, scrapers, and rifflers used in the

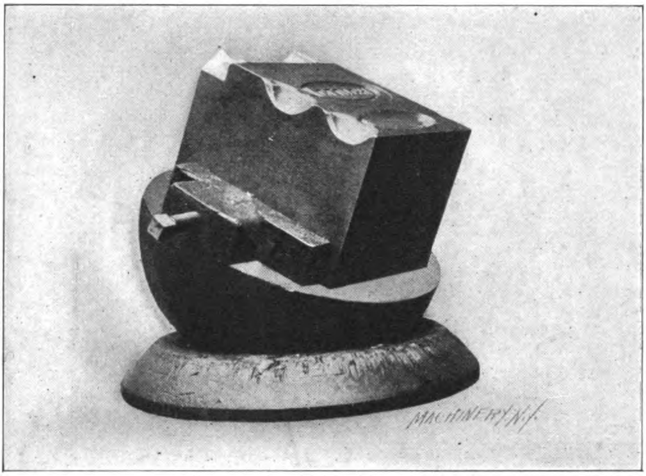


Fig. 43. Special "Ball Vise" Used in Sinking Drop Forging Dies

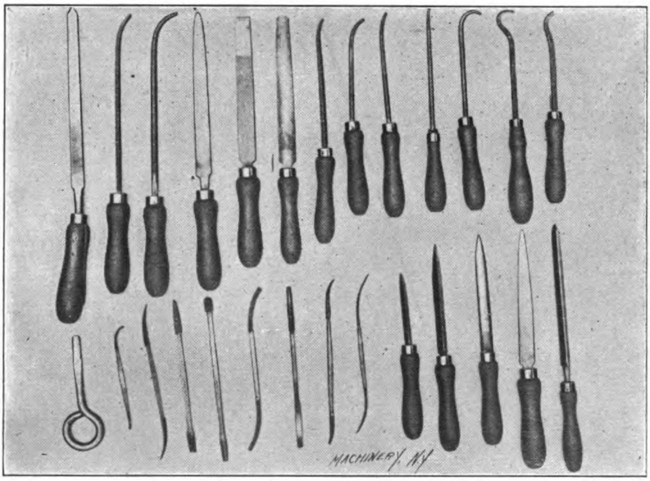


Fig. 44. Scrapers, Files, Rifflers and Other Tools used by Die-sinkers

finishing work. These are mostly made of old files and are ground or bent to suit the needs of particular cases.

In Fig. 45 are some of the milling tools that have been made especially for this work. Only twenty-four of them are shown, though several hundred of all shapes and sizes are in stock. Another set of special cutters is shown in Fig. 46. Two of these have a single inserted blade or "fly-cutter" held in place by a set-screw, and are very useful tools for some kinds of work.

The tools shown in Fig. 47 are known as "types," and are used in scraping out cylindrical cavities to size. These types are turned to the proper size, and when used are smeared with lead and rocked back and

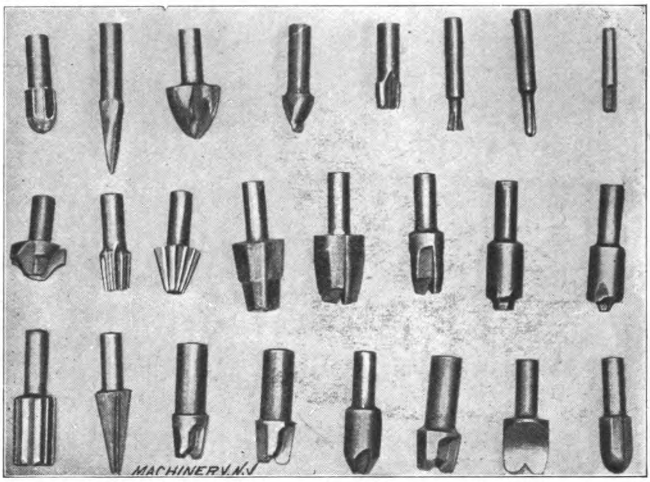


Fig. 45. A Few Milling Tools used in Die-sinking

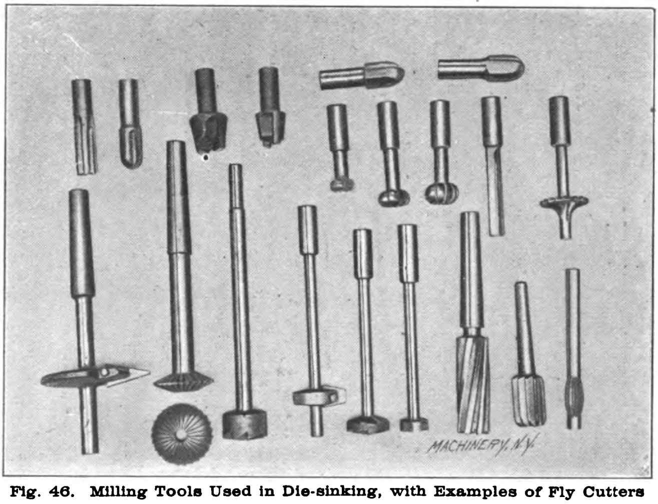


Fig. 46. Milling Tools Used in Die-sinking, with Examples of Fly Cutters

forth in the partly finished cavity. The metal is then scraped away wherever the lead shows. For cylindrical work, these types are indispensable tools.

The tools shown in Fig. 48 were made by one of the expert die sinkers in the Jeffery shop. The tool shown at the right is used to scribe an outline from a forging. It consists of a hardened steel blade, with a point on one end, set into a flat steel block in such a way that it is free to move up and down to a limited extent. The rivet shown on the side passes through a short slot in the blade. When in use, a flat spring on the top edge of the tool presses the point down onto the

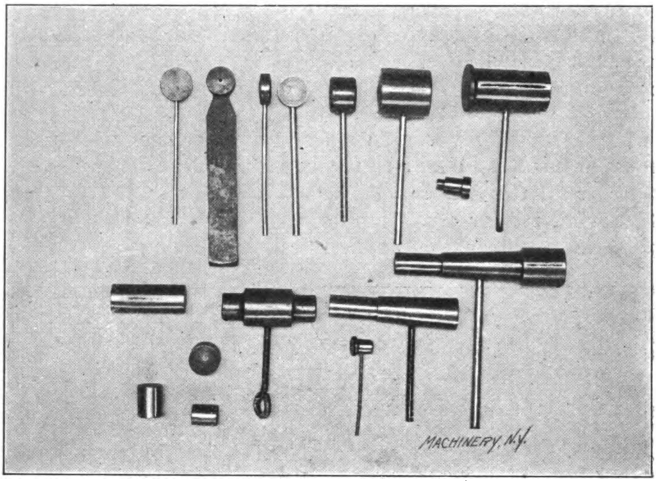


Fig. 47. "Typing" Tools Used by Die-sinkers to Form Circular Cavities

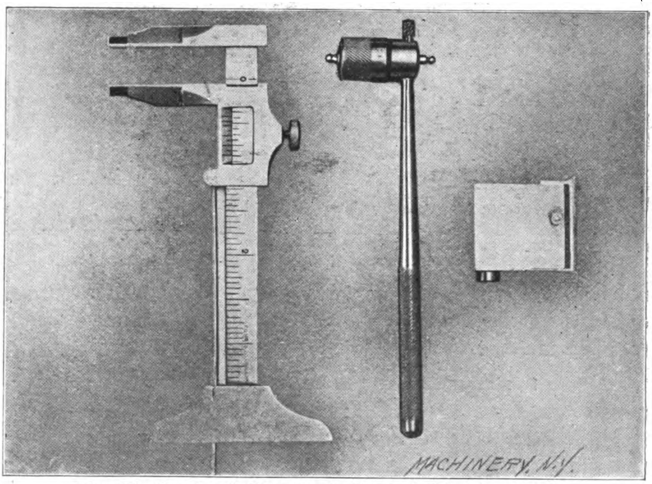


Fig. 48. Vernier Caliper Depth Gage, Inside Micrometer, and Scribing Block

coppered surface, causing a mark wherever moved. To use this tool, it is held on edge with the point down and the edge of the hardened blade in contact with the forging. The steel block keeps the blade perpendicular, and by keeping the edge of the blade in contact with the forging while scribing, a correct outline is obtained, which could not be done with an ordinary scriber on account of the working outline being considerably above the die face.

The middle tool shown in Fig. 48 is a one-inch inside micrometer, which was made by the die-sinker because he could not buy one small enough for the purpose. The other tool is a regular stock caliper square, to which has been added a depth gage. The gage is so made that the rod projects the same distance that the capiler jaws are apart. The usefulness and convenience of this tool are at once apparent to a tool-maker.

The Lead Casting or Proof

After the mechanical work on a set of dies is done, a lead casting of the cavity is made and sent to the superintendent to be passed upon. If it is correct, the dies are hardened and sent to the forging shop, but if it is off size or shape, or for any reason not satisfactory, suitable changes are made, and another lead impression taken and passed

Fig. 49. Samples of Lead Castings or Proofs Taken from Drop Forging Dies for Testing the Accuracy of Outline

upon as before. Fig. 49 shows a number of these lead castings which are kept in the tool-room for reference, and they often save considerable trouble when making duplicate dies.

Staking Tools Used for Repairing Dies

After a set of dies has been in use for some time, the dies are likely to develop cracks or drawing seams which cause ridges and rough spots on the forgings. These cracks are closed up by hammering first on one side and then on the other with a hammer and what are called "staking" tools, which are simply specially shaped, tempered steel punches made of chisel steel stock. Some of these staking tools are shown in Fig. 50.

Examples of Drop Forging Dies

One-half of a die set, showing the breaking-down and finishing forms, is illustrated in Fig. 51. In this illustration the method of leaving a ridge around the finishing form and cutting a channel for the fin is very plainly shown. This method is followed in all of the drop forge dies made in the Jeffery shop. Fig. 52 shows a more complicated die. In this, both edging and flatting breaking-down die forms are shown. In using this die, the hot bar from which the forging is being

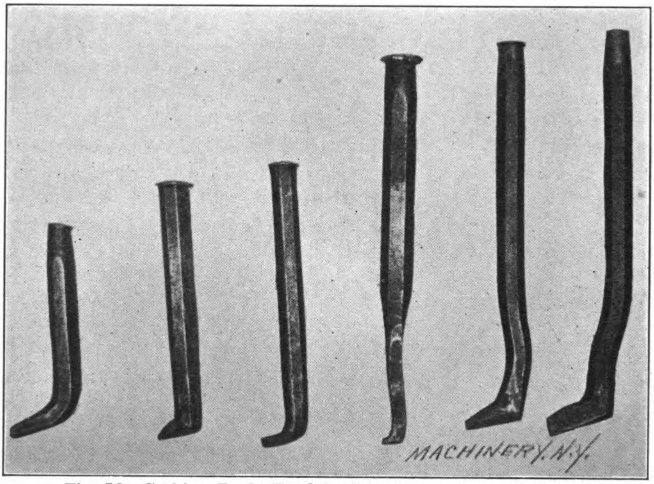


Fig. 50. Staking Tools Used for Repairing Worn and Cracked Drop Forging Dies

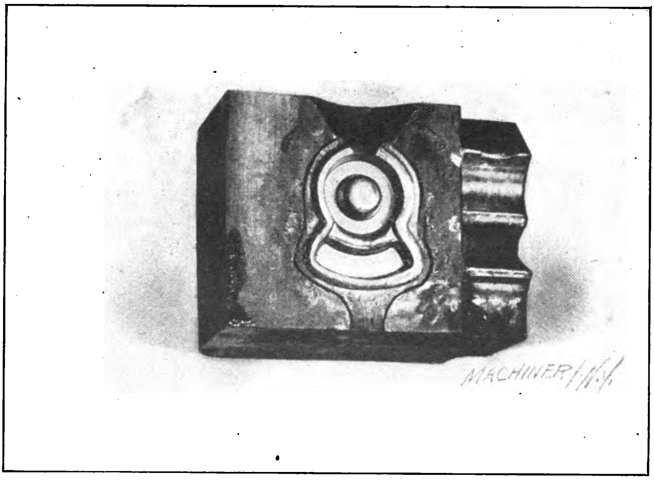


Fig. 51. An Example of Drop Forging Die Showing Breaking-Down Die at the Right

made, is alternately swung from one to the other form, it being held edgewise in one and flat in the other, and given a blow or two until sufficiently reduced for the finishing form, after which it is cut off from the bar by a shear fastened to the hammer at one side of the die block.

In Fig. 53 the roughing or breaking-down die is shown and also a bending form, the bar being roughed into shape, and then bent and finished. Of course, in these last two illustrations it is understood that the cuts show only one-half of the set, the other half correspond-

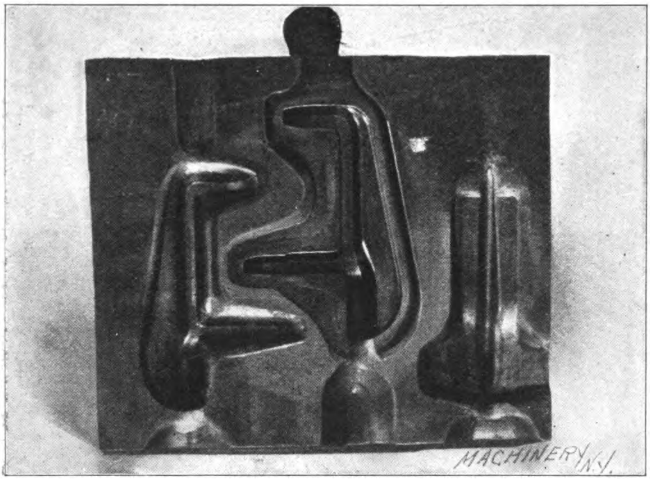


Fig. 52. Drop Forging Die Showing both Edging and Flatting Breaking-down Dies

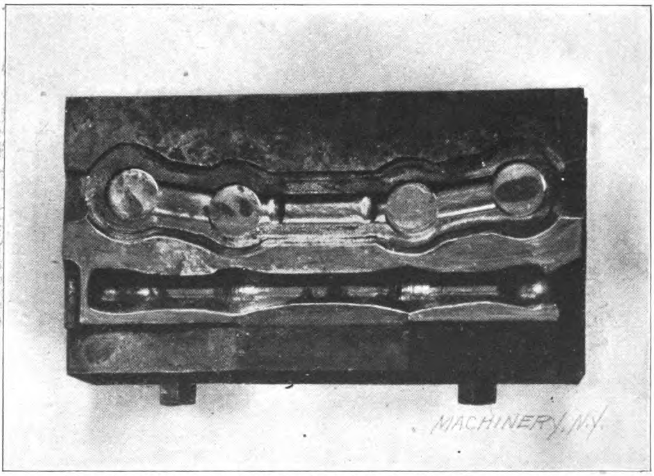


Fig. 53. Drop Forging Die Showing Bending Form in Front

ing in shape to the one shown in such a way as to produce the desired shape. To better illustrate this for the benefit of those not familiar with this class of work, both halves of a set of dies are shown in Figs. 54 and 55. These show the complete forging and bending parts for this particular piece. The end of the finishing form also shows a place where one of the types illustrated in Fig. 47 was used when first working out the cavity.

Trimming Dies

Some of the forgings are of such shape that the fin of flash formed is easily ground or machined off, while others are put through a trim-

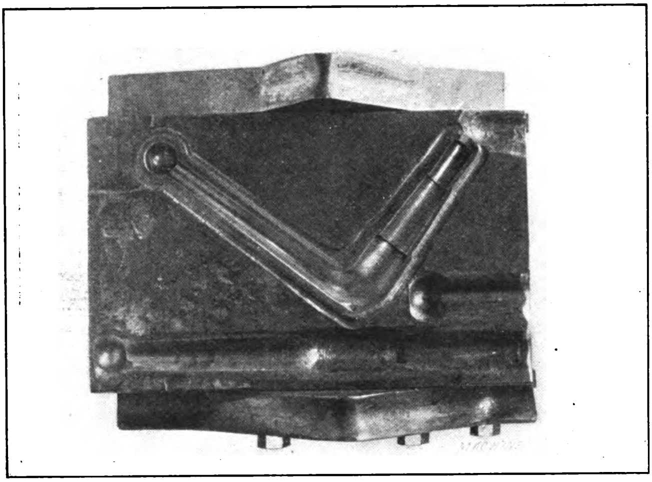


Fig. 54. Drop Forging Die and Bending Die for Steering Gear Part

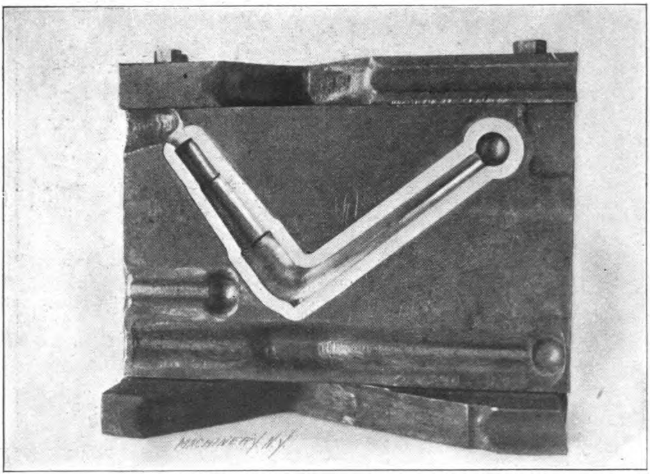


Fig. 55. Mating Die to Die in Fig. 54

ming die. These trimming dies are about the same as the trimming dies used for other classes of work, and so need little comment. Fig. 56 shows a set of forging and trimming dies used for making "Rambler" wrenches. The breaking-down form is very plainly shown as is also the finishing cavity. The trimming punch is at one side, while the trimming die in the middle is shown made up of four separate parts. This is done because the die parts that shear out the wrench slots wear or break sooner than the rest of the die, and when made this way they are easily replaced without necessitating a wholly new die, which would be the case if made solid.

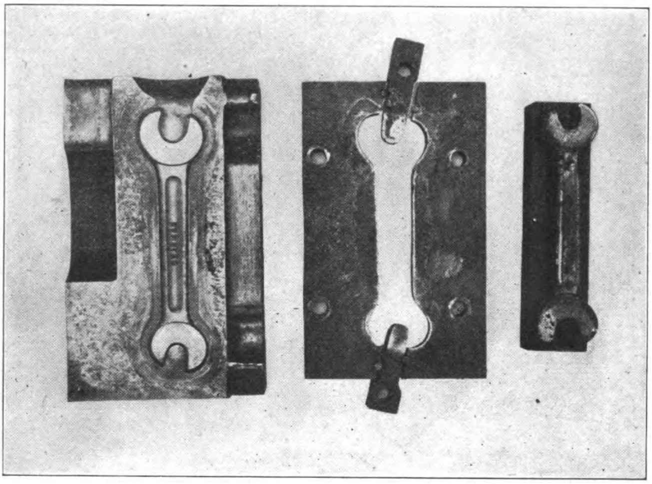


Fig. 56. Drop Forging Die for Wrench and Trimming Die for Same

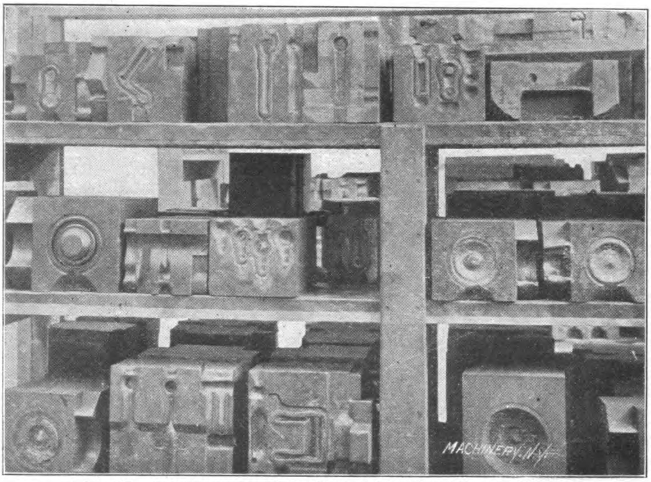


Fig. 57. A Few Examples of Drop Forging Dies in Storage

Fig. 57 shows a number of dies on the storage shelves, only one-half of each set being shown, the other half of each set being back of the one visible. The trimming dies which are in constant use are kept conveniently near the presses in the forge room. Both the trimming and forging dies are stored on heavy shelves close to where they are used, thus saving the unnecessary "toting" that is practiced in so many shops.

Heating Furnaces

The heating furnaces in a forging shop must be set near the hammers, and Fig. 58 shows how the oil furnaces are placed, so that little

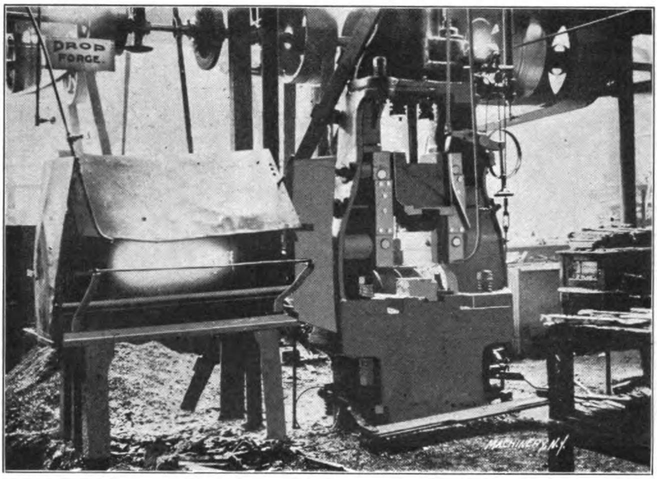


Fig. 58. Oil Heating Furnace and Drop Hammer

Fig. 59. Brown & Sharpe Heating and Annealing Furnaces

time is lost getting the heated metal to the hammers. Fig. 59 is an illustration of two of the big Brown & Sharpe furnaces in the hardening room. For small work several smaller furnaces are used, but those shown are used for large work, and are said to be the best obtainable.

Hardening Drop Forging Dies

In hardening drop forge dies only the face is hardened. The die is heated and placed face down in a tank of water on a sort of spider support, and a stream of water pours upward onto it. Fig. 60 shows

Fig. 60. Hardening the Face of a Drop Forging Die

how this is done. In the illustration a round piercing die is being hardened, so the water appears to be boiling up through the center, which would not be the case were it a solid block like a forging die. Large special shaped tongs make the handling of the heavy steel blocks of the drop forge dies comparatively easy.

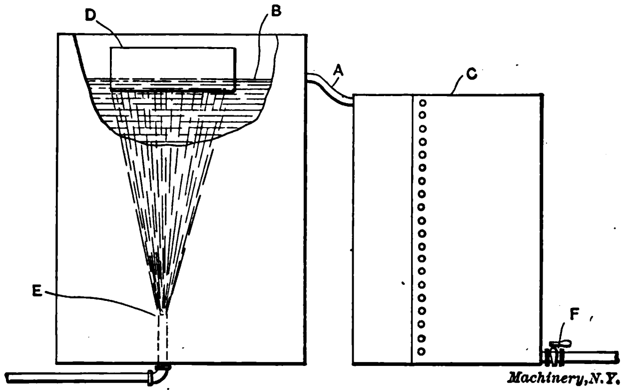


Fig. 61. Arrangement of Brine Tank for Hardening

On the subject of hardening drop forging dies, Mr. J. F. Sallows has contributed the following to MACHINERY.

Uneven heating and uneven cooling, with consequent uneven contraction, is the cause of so many drop forging dies cracking in hardening. There is no necessity for this trouble if the dies are properly handled.

If drop forging dies are made from machine steel, they should be packed in No. 1 raw bone and fine wood charcoal, three parts charcoal being used for each two parts raw bone. They are then heated in an oven for eight hours, at a temperature of 1,600 degrees F., and are then dipped the same as described in the following for tool steel. When the dies are made of tool steel, the heating of the dies in an open furnace, even if covered with coke, is very injurious to the steel, as the

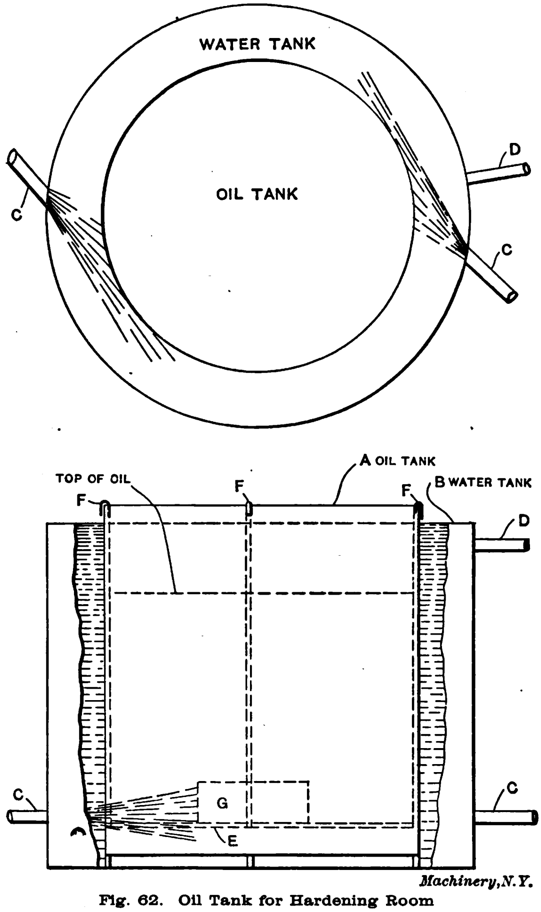


Fig. 62. Oil Tank for Hardening Room

carbon is removed from the surface of the steel, and the dies will not harden on the outside, but will be harder further in. This does not matter so much with tools that are to be ground to size after hardening, but it is a poor practice with any kind of tool-steel tools. Tool-steel dies should be packed in fine wood charcoal in a box large enough to allow plenty of charcoal between the die and the box walls, say about two inches or more. Seal the cover on tightly with asbestos cement, place the box containing the die in the furnace, and, if a pyrometer is attached to the furnace, hold the furnace at about 1,500 degrees F., leaving the die in for at least four hours. For a small die, shorter time will be sufficient, but a die weighing 50 pounds or more should be allowed four hours to heat slowly and uniformly. Then, instead of immersing the whole die in a tank of cold, clear water, have two tanks, a large one and a smaller one, as shown in Fig. 61. An overflow pipe or hose *A* from the water line *B* in the large tank should connect it with the small tank *C*. When ready to dip the die *D*, place the face only in the water. Plenty of salt should be well dissolved in the water, about 4 pounds to the gallon; this extracts the heat from the die quicker than clear water, and prevents steam formation on the face of the die. A water pipe *E* should be carried in at the center of the large tank at the bottom, and should be supplied with water at fairly high pressure. When placing the die in the bath, open the valve of the pipe *E*, thus forcing the cold solution against the face of the die, while the warm water passes into the smaller tank. The solution collecting in the smaller tank, when cool enough, can be used for smaller tools, and, when so desired, can be run off by outlet *F*. Another bath, in an oil tank, inside of a water tank, as shown in Fig. 62, should be provided. The size of the tanks must be determined by the size of the dies to be hardened. Fish oil should be used in this latter tank, and the tank should have two water inlets *C*, at opposite sides of the tank, and so arranged as to allow water to flow around all sides of the oil tank as indicated in the plan view. Pipe *D* is the overflow. A coarse mesh sieve *E* is suspended in the oil tank, and held by rods *F*. The oil tank should have four legs about 6 inches long, to allow water underneath the tank. When the die face has been cooled in the salt water solution, remove the die quickly to the oil tank, and lower it until it rests on the sieve (see *G*, Fig. 62). Let the die remain in this position until cold. It requires no further attention than removal from the oil. Dies hardened in this manner will not crack.

CHAPTER V

FOUNDATIONS FOR DROP HAMMERS

The concrete foundations for drop hammers, described in the following, are used in the Pratt & Whitney Co.'s shops at Hartford, Conn. The blacksmith shop is located on what one might say is the second floor of the building, there being a basement about 11 feet high under the blacksmith shop, which is used as a stock-room and where the case-hardening furnaces are located. The foundations for the drop hammers in the blacksmith shop must therefore be carried down clear through the basement, and then down approximately another 11 feet to hard pan. The construction of these concrete foundations is shown in Fig. 63. At *A* is shown a cast iron base-plate, into which the base of the drop hammer sets. This plate is bolted to the concrete column by four 1¼-inch anchor bolts. Between the cast iron plate and the top of the column a double layer of wood and also a thick layer of tar paper are interposed, the purpose of which will be referred to later. The column, as shown, reaches nearly up to the ceiling of the basement, *C* being the floor line of the blacksmith shop. At *D* is shown a line representing the floor of the basement. As will be seen, reinforcements have been placed around the concrete column in the form of heavy planks *B*, having one-inch bolts through the concrete to clamp them up against the concrete surface. It has been found later, however, that this reinforcement was not necessary, and that the foundations would have served their purpose fully as well had the column been left plain all the way down.

The installation of these concrete foundations, as compared with the wooden foundations previously used, has proved to be a very economical move. While previously, with hammers working on wooden foundations, it was not possible to make certain medium-sized drop forgings on anything but a 200-pound hammer, since these foundations were put in, it has proved possible to make them on a 100-pound hammer, and, at the same time, the rapidity of completing the drop forgings has been increased, so that a saving in time of 20 per cent has resulted in the making of these forgings. Other elements of saving in comparing the making of these forgings on a 200- or a 100-pound hammer are that the tools cost more for a larger machine, and it consumes a great deal more power. The reason why there is a saving in the making of these forgings, even in regard to the time consumed, is because the strokes, even on a smaller hammer, can now be made shorter, so that a greater number can be struck in the same time, the blows, however, having an equally good, or better, effect, on account of the solid foundations under the base of the hammer. In the case of drop hammers, where the hammer was previously raised three feet, it is now not necessary to raise it more than two feet, in order to accomplish the same results.

When the foundations were first put in, the cast iron plate *A*, already mentioned, was laid directly on a surface of cement, three inches thick, placed on the top of the concrete foundations. The cast iron base-plate, of course, was not finished on the bottom, but was more or less rough. The cement itself did not have a perfectly plane surface, and it was

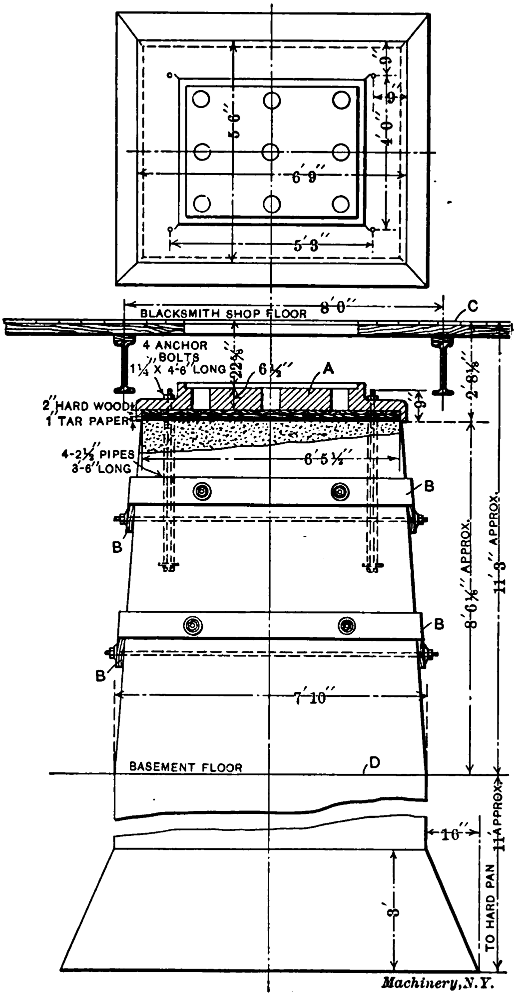
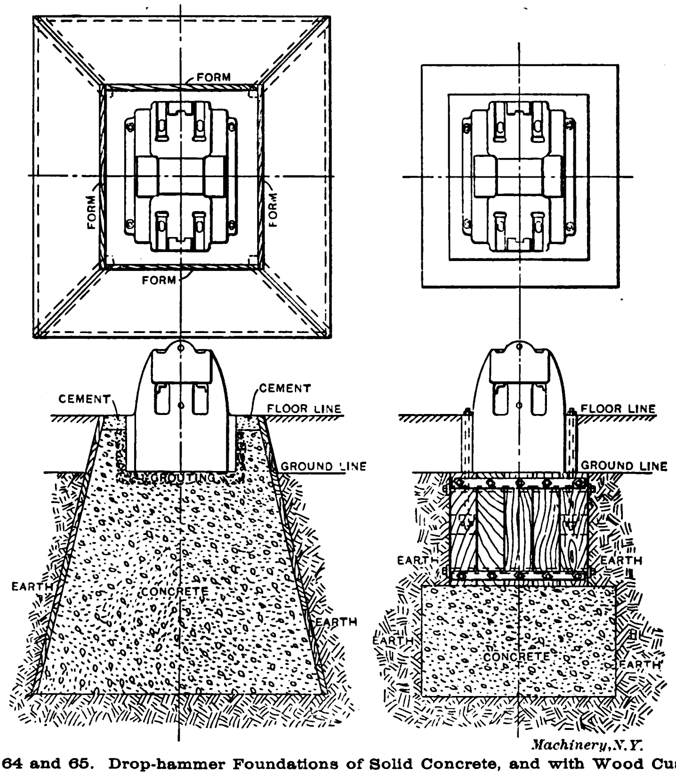


Fig. 63. Concrete Foundations for Drop Hammers in the Pratt & Whitney Co.'s Blacksmith Shop

found that, after the hammer had been used for some time, the top layer of the cement would be ground to powder, on account of the rough surfaces coming in contact, constantly cutting and grinding the surface of the cement. In order to prevent this, a layer of tar paper, one inch thick, was first placed on the top of the concrete foundation, and on top of this, two layers of hard wood, each one inch thick, were laid diagonally, the cast iron base-plate being placed directly on the hard wood, after which the anchor bolts were tightened down, clamping the base-plate tightly against the wood and the tar paper, and consequently pressing the latter firmly against the top of the concrete. The tar paper would fill in all crevices and rough places on the top of the concrete, and the impact of the hammer blows would be distributed equally over the whole surface. After this improvement had been made, no more troubles were experienced with the top of the concrete being pulverized by the blows of the hammer.



Figs. 64 and 65. Drop-hammer Foundations of Solid Concrete, and with Wood Cushion

At first it was feared that these solid foundations, having practically no springing action whatever, would cause trouble in regard to the dies, so that a greater cost would be incurred in regard to the replacing of broken dies, but this apprehension proved to have no foundation; the dies seem to stand up fully as well as with the old wooden foundations.

The concrete used for these foundations is what is known as 1—3—5 mixture. This mixture consists of one bag of cement, one barrel of heaped sand, and two barrels of stone.

The E. W. Bliss Co., Brooklyn, N. Y., builder of drop forge hammers, has given out the following information regarding the construction of drop-hammer foundations.

The endurance and effectiveness of drop-hammers depend in no small degree upon the proper ratio between the weight of the base and the weight of the hammer. It has been demonstrated that 12 to 1 is decidedly better than a smaller ratio, and that the best results are obtained with a ratio of 15 to 1 or 16 to 1 with all parts made in proportion; the extra cost of the heavier machine being more than compensated for by the larger quantity and better quality of the finished product and by the comparative freedom from breakdowns.

For the successful operation of drop-hammers, it is very essential to have a good foundation. Both of the types illustrated in Figs. 64 and 65 have been found to give good results. The wood cushion foundation, as shown in Fig. 65, is used where the bottom is not good and where the jarring of the surrounding buildings is objectionable. The solid concrete foundation shown in Fig. 64 is recommended as best when it can be used, as it is like a continuation of the base on the hammer, and therefore makes the drop more efficient. In deciding the depth of foundation of either of the above types, care should be taken to determine the best point to stop the excavation. Bed rock is the best bottom, cement gravel next best, and a strata of sand or clay, say 4 feet thick, and in its original and undisturbed condition, also makes a good bottom. The trouble with sand or clay is that on account of the heat of a drop forge shop drying the soil, and the continual jar, they are apt to shift, provided they get an outlet into other adjacent excavations. By spreading the bottom of the foundation the desired result is sometimes obtained without going very deep, but for any size of drop-hammer the concrete should not be less than 4 feet thick, whether a wood cushion is used or not.