to use it to the best purpose of which it was capable; call in the aid of a second, and he might as well be put to strike at once. There is no great difficulty in this; the smith, once he has got his work on the anvil, seldom requires to hold it there with both hands; one therefore being free, the management of the machine by a single lever, would come quite within his powers; a simple treadle too, might lend its aid under peculiar circumstances. From the varying angles at which the blows could be delivered at pleasure, the use of all kinds of dies and swages would become easy, while the most complex small welds could be shut with an ease and certainty unattainable by the use of any hammer striking only straight up-and-down blows.

As to the power to be employed we are disposed to give the preference to steam without hesitation. No hammer can possibly be made to run at high speed by the aid of gravity alone. In order to use compressed air, a piston and cylinder are requisite, and a certain amount of valve gearing is indispensable; and these things being provided once, the piston may just as well be put in motion by steam, as by the aid of belts and gearing. We do not wish to be understood as generally condemning compressed air hammers; on the contrary, we consider them admirably adapted to certain situations, such as forges at a great distance from a boiler; but, as a rule, we prefer steam. It may perhaps be urged that there is no need for such little hammers as we have just spoken of--that the work which they would perform is too insignificant to require the aid of machinery; but this is not true. It is in the performance of some of the most apparently trivial operations that the aid of machinery has been called in with the greatest advantage; and while hundreds, nay thousands of tuns of small forgings have to be made annually, there will always be a field open for the introduction of the proper modification of the steam hammer to make them.—*Mechanics Magazine.*

DIE ENGRAVING, SINKING AND MULTIPLYING.

BY J. NEWTON, OF THE ROYAL MINT.

It is more than probable that, with the exception of those who may be practically engaged in the above-named arts, very few persons are acquainted with the modern method of preparing dies, whether for the stamping of coins or the striking of medals. The general belief shared, as we have reason to know, by many scientific men, is, that each individual die used for either of these purposes must first be engraved by the skillful hand of an artist, and that therefore, at her Majesty's Mint, where, in addition to the coins of the realm, all our naval and military medals are struck, a numerous staff of engravers is constantly employed in the preparation of new dies. This is a very reasonable supposition ; but as it is also a very erroneous one, it is intended to explain in as popular a way as the subject will admit, the system of die manufacturing as actually carried on at that establishment. It will be found that the processes employed in the conversion of bars of steel as they come from the molds and mills of Sheffield into coining and metal dies are to the full as interesting as those exercised in any other branch of manufacturing and inustrial art.

The melting of wrought or bar steel, intended for conversion into cast-steel, is effected in small crucibles formed of clay and plumbago, and which are capable of holding about 30 lbs. weight each of the metal to be acted upon. Ten or twelve of these are placed in furnaces very similar to those used in ordinary brass foundries. After the crucibles have been brought by the concentrated action of a coke fire to a white heat, they are charged with pieces of bar steel reduced to a particular degree of softness, and weigh about a pound each. When the crucibles are thus loaded, lids of clay are placed ov them, the furnaces are filled with coke, and the covers of the furnaces are put down. The intense heat thus generated soon reduces the contents of the crucibles to a liquid state, and induces an ebullition of the metal, resembling somewhat the boiling process in the case of ordinary fluids. When the furnaces require feeding with fresh coke, the lids of the crucibles are also removed, and the workmen are enabled to judge as to how far the process is matured. Usually in about three hours the molten metal is ready for "teeming." The subsidence of the ebullition, and the dazzling brilliancy of the metal are proofs of the successful completion of the fiery ordeal, and it is then forthwith poured into ingot molds of the shape and size required. When cold, the resulting ingots are removed, and are in fit condition for the market and the rolling mills or the workshop. Those which are intended for conversion into dies are first elongated into bars, of which we shall have to speak hereafter. Without further preface let us now proceed to deal with the manufacture of cast-steel dies as practiced at her Majesty's Mint. The whole of those which are used there—and in these days of incessant money-making their name is "legion"—are produced within its own walls.

Rectangular bars of the finest cast-steel which Sheffield can furnish, and varying in size in accordance with the respective denominations of coin in the British series alone are used in the Mint. There are two substantial reasons for employing highly refined steel in die making. The first is that the elaborate engraving and fine lines of the artist, as placed on an original die, may be satisfactorily copied, and the second that due resistance may be gained by the perfect homogeneity and toughness of the metal to the rapidly-repeated and heavy thuds of the coining presses. Constant practice has made the officers and workmen of the department excellent judges of the peculiar mechanical and chemical properties which should distinguish the steel they use. They are consequently not very liable to error in selecting it. It is not essential, perhaps, to explain minutely the peculiarities which distinguish good die steel; but it may be said that that which exhibits, when broken or fractured, a moderately fine grain which is of uniform texture, and when polished is free from spot or blemish is the best. Let it be imagined for illustration, that a coinage of florins is required to be struck and issued from the mint, and that the entire duty of engraving, sinking and multiplying a number of dies for the purpose has to be performed. Then, if we succeed in making the operation understood, our readers will have obtained information as to the manufacture of dies generally, for all pass through similar processes. The engraver will have received his instructions from the master of the mint. Let us therefore visit his *atelier* and watch his movements. Having selected with especial care the bar to be first used, tested portions of it with rigorous severity, and thus assured himself of its perfect fitness, the artist will cause it to be sent to the mint. After one end of the bar is heated to redness in an ordinary forge, two pieces are cut off it of the size required. The resulting blocks are then again heated and swaged into round form. It may be suggested that the bars of cast-steel might as well be made round before reaching the hands of the die forgers, and that this would save the labor of hammering the blocks into round shape afterwards. The smith's labor, however, is not labor lost, for it gives a density and tensile strength to the embryo dies which they would not otherwise possess, and hence they are eventually found more durable. It will be well to explain, too, that the blocks are not rounded longitudinally with the bar from which they are cut, but transversely; that is to say, the sides of the bar form the tops and bottoms of the dies, The grain of the steel is thus made to pass across the dies, and not vertically through them. They are thus rendered less liable to splitting while under the press.

The two rounded blocks are next annealed to the fullest extent possible, and this is done by placing them in a wrought-iron pot, covering them with animal charcoal and depositing the whole for twenty-four hours in an oven heated by coke; they are afterwards withdrawn, removed from the pot, and allowed to cool gradually. Next they are taken to the lathe and one end of each is turned. That which is intended to become the "matrix" die (of which more anon) is made perfectly flat and smooth, and it is upon this prepared surface that the artists' talent will have to be first expended. The second block, turned slightly conical, and which is destined to become the "puncheon" may be put out of view *pro tem.* The engraver addresses himself to the work of etching in upon the matrix block his approved design, say of the obverse for the florin. Assured of having put in his outlines correctly, the work of engraving fairly commences, and only those who have witnessed the operation of die cutting can realize the amount of patience and skill necessary for its successful completion. After many weeks of close and constant application the design in intaglio will probably be finished, repeated impressions in clay and soft metal being taken *ad interim* by the artist as tests of the accuracy of his work. Innumerable touchings and re-touchings, with the graver, are indispensable to the minute realization of the design, but it at last satisfactorily appears on the surface of the softened steel. The letters to form the legend and the date are stamped in by aid of punches, and the matrix or first die is engraven. A very important and, to the engraver, an anxious operation follows. It is that of hardening the matrix. In its present annealed condition it is practically useless, and therefore the risk must be run of exposing a very beautiful work of art in quick succession to the tender mercies of the antagonistic elements fire and water. There is no escaping this, however; and the artist, if a nervous man, may tremble for the result. His only hope lies in the excessive care with which the work is done, and the excellence of the cast-steel of which the die is composed. The preservation unmarred of the delicate lines and tracery which have cost him so many hours and so much exertion is naturally a great consideration. To insure this, as far as possible, the engraved face of the die is covered by a mask composed of some fixed oil, thickened to the consistency of a paste by the addition of animal charcoal finely powdered. This Ethiopian-like compound is spread over the surface of the engraving to which it closely adheres, filling all interstices.

As an extra precaution an iron ring is usually made to encompass tightly the matrix before hardening, so as to lessen the risk of fracture. In this condition it is deposited with its face downwards in a pot or crucible and buried once more in animal charcoal, that is to say burnt leather, horn, etc. The crucible and its precious contents are placed now in a furnace, the whole being heated to redness. After submission to this saturation of fire, if the term be admissible, for about an hour the pot is withdrawn and the matrix, taken out of it by means of a pair of tongs, is instantly and *sans ceremonie* plunged into a cold-water bath. The bath is sufficiently capacious to contain as much water as will prevent the latter becoming sensibly warm by the immersion of the red-hot die. Held firmly by the workman's tongs, the matrix is swayed too and fro rapidly in the water until it ceases to splutter and hiss at its rough treatment. Should no unusual or singing sound proceed from it while in the bath, the probability is that the expansion induced by the fire and the sudden contraction caused by the cold water have not injured the die, and the engraver may take heart again, for his work is safe and sound. If, on the contrary, it sings the die will be found to have cracked in the process of hardening and his work will have to be done over again. For the reasons previously given such a disastrous result seldom happens at the Royal Mint.

Allowing that all has proved favorable, the coating which protects the engraved surface is removed, and the matrix is forwarded to the polisher, who, by pressing its "table" or face carefully against a flat disk of iron running rapidly in a lathe, and upon which a film of flower emery and oil has been spread, soon produces a mirror-like polish. Tempering is the next operation, for at present the steel is much too hard for its purpose, and this is effected by putting the matrix into water to be gradually heated to the boiling point or by placing it on a red-hot plate of iron. In either case the work is done when the die, after a series of chameleon-like changes of color, assumes that of pale straw. At this juncture, therefore, it is again plunged into cold water, and the obverse matrix is ready for use. Arrangements of a precisely similar character throughout are observed in the production of the reverse matrix, and thus the first and more important stage in the manufacture of coining dies is passed.

It is time that we turned to the second block of steel, namely, that intended for the "puncheon." This has been annealed and turned, not flat, but flatly conical, on the surface to be decorated. Both it and the matrix are thus made ready for a massive and powerful stamping press, with a coarse triple-threaded screw of some 6 inches in diameter passed vertically through its center attached to the upper part of the screw, and above the press are two heavily weighted fly-arms which constantly tend to force down the screw. To the lower end of the screw, and with its face downwards, the matrix is firmly fixed by a workman, who stands in the recess sunk in the floor to the depth convenient for bringing his eyes and his hands to a level with the bed of the press. The puncheon block is deposited next it with its face turned upwards on the solid cast-iron bed of the press, and immediately and fairly below the matrix. All being ready, several strong-armed workmen seize the fly-arms and walking round with them raise the screw and matrix until the latter is several inches above the puncheonblock. On a sudden they release their hold, and the weighted arms revolving with a speed and force which would be fatal to any person standing in their way, drive down the matrix until it impinges with a dull, heavy thud upon the puncheon block. Again the workmen stand to their fly-arms and raise the screw of the press. The effect of the blow is then seen in the depressed apex of the cone-topped die which received its impact, and in the transference to itself thereby of a partial copy in relief of the intaglio-engraved matrix. The compression of the particles of steel composing the puncheon by the stress of the blow, mechanically hardens the puncheon, and before its impression can be completed by a repetition of the act, it must be again annealed. This is effected in the same way as before, the puncheon is returned to the press, and the matrix, now detached from the screw, is placed loosely on the top of it, though, for an obvious reason, in such a way as that the engraving on the matrix and the partly finished impression on the puncheon shall exactly match or fit each other. A blank block of steel is then affixed firmly by aid of set screws to the place before tenanted by the matrix, and may be said to represent a hammer, for it will presently descend with great force upon the matrix. The fly-arms are turned backward by the workmen, the press screw is raised, the arms released, and, gathering momentum as they revolve, the hammer block is made to fall heavily on the matrix. The effect of the second blow will, perhaps, be to make the transfer of the engravings as complete on the puncheon as is that of a seal pressed by the hand upon molten sealing-wax, or it may be, if the steel is very obstinate, that another annealing and another blow may be required to effect that object eventually, at least the puncheon will be found upon examination to have imbibed an exact and faithful copy in relief of the engraver's work on the matrix to the finest line and most minute point of detail. The duty of this latter is now done, at all events for the present, and it is placed in the engraver's closet. Far otherwise is it with the puncheon, for its mission is about to commence. It is therefore hardened and tempered, polished it cannot be, on account of its raised surface, and then returned to the press. Such are the processes pursued in the making of matrices and puncheons in reference both to coining and medal-striking for obverse and reverse, although, from the bold impressions usual on medals, many more annealings and strikings of the puncheons are necessary than of those used for coin. Confining our attention for the sake of brevity to the florin, let it now be presumed that puncheons for its obverse and reverse have been successfully prepared, it remains to be shown how they are put into useful requisition, and how they are made the parents of rapidly-multiplying families of coining dies. Florin bars of cast-steel are about 10 feet long, $1\frac{3}{4}$ inches broad and $1\frac{1}{4}$ inches thick; upon these the mint blacksmith is the first operator. One at a time they are conveyed to the forge, and cut, while hot, into short pieces of $1\frac{3}{4}$ inches in length, and in this form, therefore, resemble Fig. 1. These square or rectangular blocks he next proceeds to hammer into a cylindrical form, as shown in Fig. 2. He then cuts off in a slanting direction one end of each of the die blocks, and shapes them, by way of preparation, for the lathe, and thus they take the appearance depicted in Fig. 3. Thus he

Fig. 2 Fig. 1

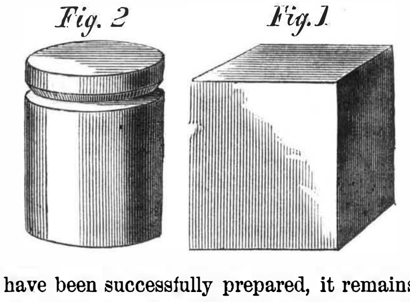
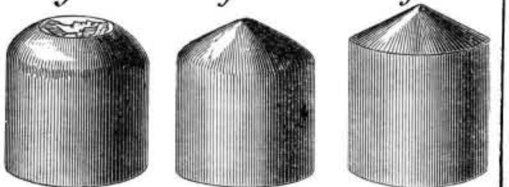


Fig. 5 Fig. 4 Fig. 3



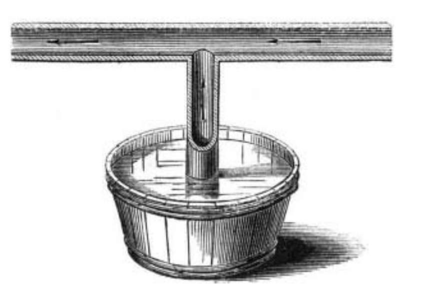
proceeds with die block after die block until he has accumulated a large quantity and diminished materially the length of the bar off which they have been cut. Owing to the severe hammering to which they have been subjected, they are at this stage very hard, and it becomes necessary to anneal them. This is effected by burying them in iron pots containing animal charcoal, and submitting the whole for many hours to the heat of coke furnaces. Subsequently, the blocks are allowed to cool gradually among the ashes and cinders of the furnaces, and are then ready for the turning-room and the lathe; here they are topped, as it is termed—that is to say the conical end of each is turned bright and prepared for its impression. After this operation they assume the appearance indicated by Fig. 4, and are removed to the die multiplying press, which is similar in form and arrangement to that already described.

[To be continued.]

OIL ENTERING A STEAM CYLINDER AGAINST PRESSURE.

In the Detroit Locomotive Works there was at one time a vertical high pressure steam engine (since altered to low pressure) which had an oil cup on the cylinder head. By opening this cup, during either the up stroke or down stroke of the piston, oil would ~~flow in, although the steam gage indicated~~ some 18 or 20 pounds pressure. This was somewhat remarkable. Oil would naturally flow in on the up stroke of the piston, because the exhaust would then be open, and the pressure less than that of the atmosphere; but how was it that steam did not blow out on the down stroke instead of the oil running into the cylinder?

By watching the operation closely we discovered



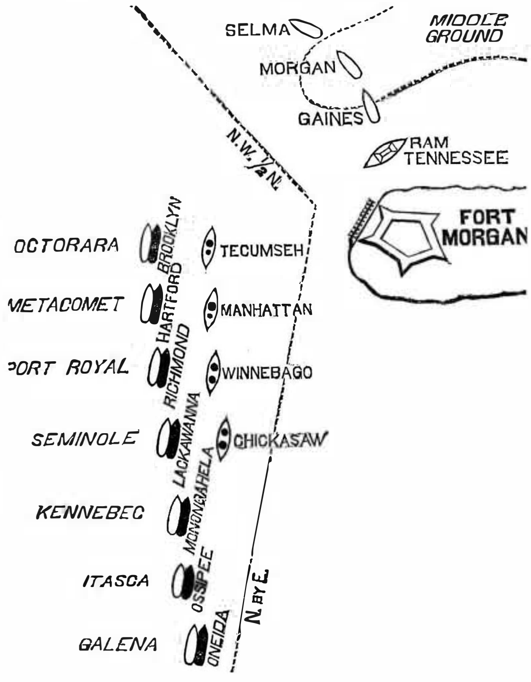
that the oil was drawn in during the first portion only of the stroke, that when the stroke was nearly completed the action was reversed and the oil was blown outward. Seeking for an explanation for this singular circumstance, we observed that the pipe from the oil cup entered the cylinder through the head, and directly over the steam port. We suppose that the oil was drawn in by the friction of the steam in its passage through the port.

A simple case of this kind of action is illustrated in the annexed cut. The two pipes communicate with each other, and the lower end of the vertical one is placed in a tub of water. Now, if a current of water, steam, or other fluid is forced rapidly through the horizontal pipe, it will carry along by friction the upper particles of any fluid filling the vertical pipe. The pressure of the air will force up other portions of the fluid in the vertical pipe to take the place of those removed, and these will in their turn be carried along. Thus an upward current will be created in the vertical tube. Steam pumps have been constructed on this principle. We suppose that this was the action in the case of the oil cup at Detroit.

An account of some experiments made in Newark by a practical engineer, were published in the *American Engineer*, a short-lived mechanical journal, printed in this city a few years ago. These experiments consisted in attaching a steam gage to the steam port, between the cylinder head and the slide valve. When the engine was at work taking steam the gage did not indicate any pressure, showing that the current passed by it entirely, the same as in the case of the oil cup. This case shows the importance of placing indicators in a position not to be influenced by the currents of steam, as they enter or leave the cylinder.

COMMODORE FARRAGUT'S REPORT OF THE ACTION IN MOBILE BAY.

From the report of the brave and skillful Commodore Farragut to the Secretary of the Navy (as published in the *Army and Navy Journal*), we extract a few paragraphs. We are also indebted to the same journal for the diagram which shows the second order of sailing of the fleet:—



"Having passed the forts and dispersed the enemy's gunboats, I had ordered most of the vessels to anchor, when I perceived the ram *Tennessee* standing up for this ship; this was at 45 minutes past 8. I was not long in comprehending his intentions to be the destruction of the flagship. The monitors and such of the wooden vessels as I thought best adapted for the purpose, were immediately ordered to attack the ram, not only with their guns but bows on at full speed. And then began one of the fiercest naval combats on record. The *Monongahela*, Commander Strong, was the first vessel that struck her, and in doing so carried away his own iron prow, together with the cut-water, without apparently doing his adversary much injury. The *Lackawanna*, Captain Marchand, was the next vessel to strike her, which she did at full speed, but though her stem was cut and crushed to the plank ends for the distance of three feet above the water's edge to five feet below, the only perceptible effect on the ram was to give her a heavy lift. The *Hartford* was the third vessel which struck her, but as the *Tennessee* quickly shifted her helm, the blow was a glancing one, and as she rasped along our side we poured our whole port broadside of 9-inch solid shot within ten feet of her casemate. The monitors worked slowly, but delivered their fire as opportunity offered. The *Chickasaw* succeeded in getting under her stern, and a 15-inch shot from the *Manhattan* broke through her iron plating and heavy wooden backing, though the missile itself did not enter the vessel.

"Immediately after the collision with the flagship, I directed Captain Drayton to bear down for the ram again. He was doing so at full speed when, unfortunately, the *Lackawanna* ran into the *Hartford* just forward of the mizzenmast, cutting her down to within two feet of the water's edge. We soon got clear again, however, and were fast approaching our adversary when she struck her colors and ran up the white flag. She was at this time sore beset: the *Chickasaw* was pounding away at her stern, the *Ossi-*