TYPOGRAPHICAL PRINTING - SURFACES

THE TECHNOLOGY AND MECHANISM OF THEIR PRODUCTION

BY

LUCIEN ALPHONSE LEGROS

MEMBER OF THE INSTITUTION OF CIVIL ENGINEERS
MEMBER OF THE INSTITUTION OF MECHANICAL ENGINEERS
MEMBER OF THE INSTITUTION OF ELECTRICAL ENGINEERS
PAST-PRESIDENT OF THE INSTITUTION OF AUTOMOBILE ENGINEERS

AND

JOHN CAMERON GRANT

AUTHOR OF "A YEAR OF LIFE"; "THE PRICE OF THE BISHOP"; "PRAIRIE PICTURES"
"BITS OF BRAZIL"; "TORRIBA: A PRINCESS OF THE AMORAYES"; ETC. ETC.

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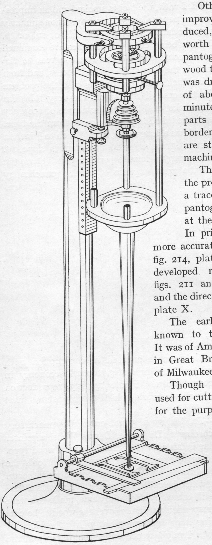

FIG. 149.—*Original Benton punch-cutting machine; from patent specification.*

Other machinery, with various improvements, was gradually introduced, and in 1834 William Leavenworth of New York adapted the pantograph to the manufacture of wood type. The router in this case was driven at the very high speed of about 14,000 revolutions per minute, and cut the superfluous parts out of the design. Letters, borders and ornaments of all kinds are still made with Leavenworth's machine, or improvements upon it.

The routing machine used for the production of wood type carries a tracer at the remote end of the pantograph and a high-speed cutter at the copying centre of the frame. In principle it is the same as the more accurately made engraving machine, fig. 214, plate XIII, the still more highly developed matrix-engraving machines, figs. 211 and 212, plates XII and XI, and the direct-cutting pantograph, fig. 164, plate X.

The earliest punch-cutting machine known to the authors is the Benton. It was of American origin and was patented in Great Britain by Linn Boyd Benton of Milwaukee in 1885.

Though this machine was originally used for cutting master-type in type-metal for the purpose of producing matrices by electro-deposition, it was subsequently improved, and, known as the Benton-Waldo, was used for the cutting of steel punches, and is still in use. To Benton, therefore, undoubtedly belongs the credit of priority in this field.

The machine is an adaptation of the pantograph, but instead of the

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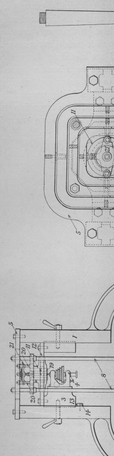

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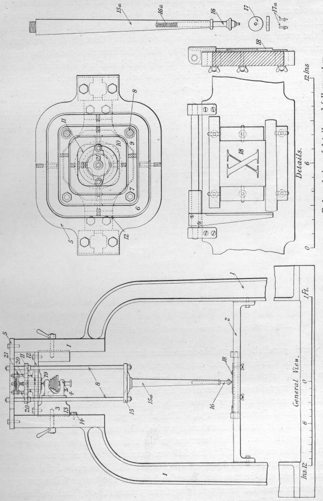
frame is also fitted with

model and its reduction being in one plane, the punch is arranged vertically over the model or former. The machine, fig. 150, consists of a vertical



Enlarged view of details and follower-stem.

FIG. 150.—*The Benton-Waldo punch-cutting machine.*

frame 1 which carries the table 2 on which the formers are secured. The frame is also fitted with a slide 3 in which the watchmaker's lathe-head 4 can be placed into position. Several of these heads are required for each machine, and they must be made interchangeable so that the axes of the milling, the roughing, and the finishing cutters all agree within the permissible error. At the top of the frame is fixed the top gimbal-plate 5 in which is pivoted the outer gimbal-ring 6. At right angles to the fixed axis of the outer gimbal-ring and in a plane passing through that axis are the centres of the inner gimbal-ring 7 to which the four slide-rods 8 are secured. These slide-rods are ground true and parallel and are a sliding fit in the lower outer gimbal-ring 9, the holes in which are fitted with bushes lapped true. The lower inner gimbal-ring 10 is pivoted to the outer gimbal-ring and also to the sliding head 11, the axes of the centres being parallel to those of the upper gimbal-ring. The sliding head is fitted with large flanges above and below the adjustable slide-frame 12, the surfaces being ground

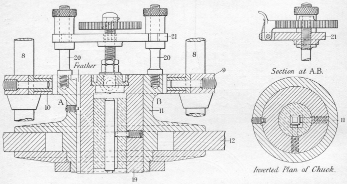


FIG. 151.—*The Benton-Waldo machine; detail of sliding head and chuck.* Half size.

true and parallel. The slide-frame has large vertical bearing-surfaces on the sides of the frame, and can be rigidly clamped at any desired height. The height is usually adjusted by bringing the frame down on a gauge 13 of the requisite size placed on the stop 14. The four slide-rods 8 are rigidly connected at their lower ends to the follower-head 15, to which is secured the follower-stem 15*a*. The upper part of the follower-head is cup-shaped; it catches the shavings which fall from the tools and so keeps the former 18 clear. The lower end of the follower-stem is bored up with an axial hole in which slides the follower-carrier 16; a spring 16*a* keeps the follower-carrier pressed down on the former 18. The end of the follower-carrier below the button fits into the holes in the larger followers 17, of which there are some twenty ranging from 3 inches to 0·13 inch in diameter; the end of the follower-carrier is 0·10 inch in diameter, and some ten followers 17*a* of smaller diameter fit inside the axial hole in the follower-carrier which then compresses the spring 16*a* to a greater extent. The sliding of the follower-carrier in the follower-stem ensures exact proportionate movement of the punch when the axis of the follower-head is inclined to the vertical.

The sliding head, fig. 151, is bored and lapped axially with the lower gimbals, and the chuck of hardened steel 19 fits in this hole; it is prevented from rotating by a ground and lapped feather fitting without shake. On each side of the chuck are distance-pillars 20 shouldered at the top ends to receive the bridge piece 21 carrying the chuck setting-screw. The chuck setting-screw is fitted with a divided wheel; the divisions are figured on the top and milled in the edge as nicks by which a spring latch locks the wheel to the bridge, and each division corresponds to 0·00025 inch of depth. Thus the chuck can be instantly removed, the punch inspected and accurately replaced as the work proceeds. Owing to the high degree of accuracy required, these machines formerly cost some £800 each. The authors recently found, however, that it was possible to

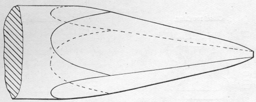


FIG. 152.—*Roughing or chisel tool for punch-cutting machine.* 20 times full size.

reduce this sum considerably, while obtaining the same degree of accuracy, in their improved punch-cutting machine recently patented.

The form of milling cutter common to all the different punch-cutting machines described, is shown in fig. 153. It is parallel and about 0·06 inch in diameter. The other cutters used are the roughing and finishing cutters. These are of peculiar shape, the four faces being cylindrical; the cutting edges, which are formed by the intersection of each pair of cylindrical surfaces, are therefore elliptical. In the roughing cutter, which has a small, chisel edge, fig. 152, two opposite cylindrical faces have their axes in a plane different from that of the other pair. In the finishing cutter the axes are all in one plane and a pointed symmetrical cutter results, fig. 156. To obtain the cutting edges accurately true to position, a hardened steel rocker-plate is used in conjunction with an oilstone slip. The rocker-plate is secured against its upper surface in the rocker frame, fig. 154, so as to admit of repeated regrinding to flatness. The oilstone slip is moved to and fro on the hardened steel surface which is cut away to clear the cutter. Both the rocker and the lathe-heads fit interchangeably on a watchmaker's lathe-bed. The heads are divided into four divisions, so that each face of the tool can be brought uppermost, and while the oilstone is applied the elevating screw is worked up and down by one finger of the operator, so that the plane of the oilstone is successively tangential to each portion of the cylindrical surface which forms the face of the cutter. To obtain the chisel face of the roughing cutter, the position of the lathe-head relatively

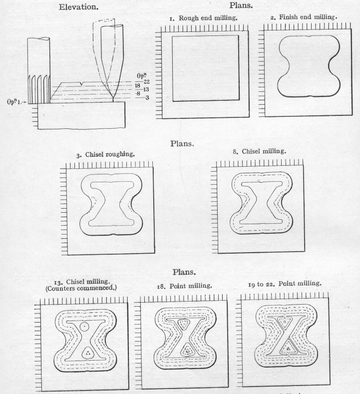


FIG. 153.—*Operations of punch-cutting.* About 4 times full size.

The figures preceding the titles give the number of the operation performed.

to the rocker is varied slightly for two of the opposite faces by inserting a thin distance-piece between the head and the stop on the rocker.

The punch is cut in the following manner. Pieces of steel are cut off to a given length, annealed and ground true and square on two adjacent sides and on the end. To save work on the punch-cutting machine the ends of the blanks are rough-milled to certain simple forms, according to the

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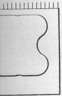

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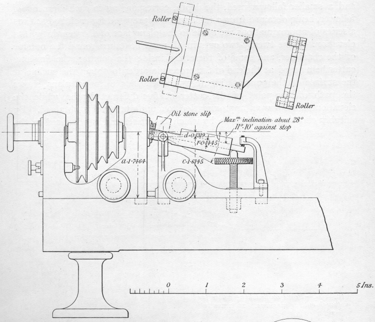

FIG. 154.—*Rocker sharpening appliance for the cutters used on the punch-cutting machine.*

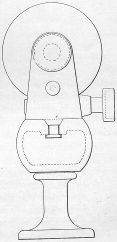

FIG. 154.—*End elevation.*

body of the fount required. The punch is held in the chuck against these true faces of the stem by the pressure of two grub-screws, and then is rubbed down truly flat on an oil-stone, the chuck acting as the stone-facer described above. The first operation in the punch-cutting machine, after setting it to the proper reduction ratio for the fount, is to mill round the outline to the depth of strike desired; a follower is used of the proper diameter to prevent the mill cutting away any of the beard. For this operation the parallel end-mill is used.

The roughing cutter is next used, and two or three cuts are taken round the periphery of the punch; this finishes the beard next to the shoulder. The depth of cut is then reduced and a smaller follower used, the depth, corresponding to each diameter of follower, being obtained from a table which is prepared for each body; thus a series of approximations are made to the plane face of the beard, fig. 153 elevation. Some twenty-two cuts in all must be taken round the outside of the character, and some of these also inside the counter, the finishing cutter being used at the end of the process in order to obtain the outline at the surface of the punch. Figure 153, operations 8 to 22, plans, shows the path of the point of the cutter at five different depths, while the elevation shows how an approximation to a uniform bevel is obtained. By suitably choosing the distance by which the chisel end is advanced in the

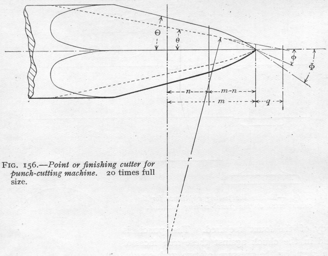

FIG. 156.—*Point or finishing cutter for punch-cutting machine.* 20 times full size.

sharpening, it is possible to obtain a cutting edge which closely approximates to a straight line for a length of about 0·011 inch.

The steel punch in three states: roughed out with the mill, cut out in the counters, and dressed to give a non-rubbing strike, is shown in fig. 155, plate V.

The dimensions of the height of the centre of the lathe and of the rocker being known, the various dimensions of the point cutter shown in fig. 156 can be obtained as follows:—

Let the height of the centre of the lathe $a = 1{\cdot}7464$ inches,

the height of the centre of the rocker plate $c = 1{\cdot}6145$ inches,

the height of the rocker-plate top when horizontal $b = 1{\cdot}7590$ inches,

and let the minimum inclination from the horizontal, θ, given to the plate when sharpening be the angle $11°\ 10'$. This dimension, however, is not really important.

Then the details of the point cutter and the position of its vertex in relation to that of a square pyramid having the vertical angle between two opposite faces equal to θ can be determined as follows :—

r the radius of the cylindrical face of the cutter $= b - c = 0{\cdot}1445$ inch,

d the height of the lathe centre above the rocker centre $= a - c = 0{\cdot}1319$ inch,

$m = \sqrt{(r^2 - d^2)} = 0{\cdot}0590$ inch,

$n = r \sin 11^\circ\ 10' = 0{\cdot}0280$ inch ;

hence $m - n = 0{\cdot}0310$ inch and

$m - n + q = (r \cos 11^\circ\ 10' - d) \cot 11^\circ\ 10' = 0{\cdot}0501$ inch ;

whence $q = 0{\cdot}0191$ inch.

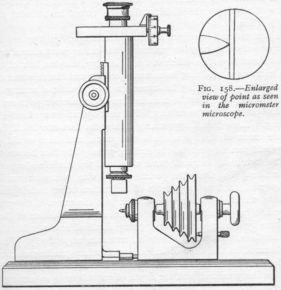

FIG. 158.—*Enlarged view of point as seen in the micrometer microscope.*

FIG. 157.—*Micrometer microscope measurer for position of point of tool.*

NOTE.—The amount of error introduced by the wear of the sharpening appliance is measured and added to the constants on the table of settings worked to on the machine.

The angle ϕ between the tangent plane at the vertex and the horizontal can be found, since $\tan \phi = 0{\cdot}445$; hence $\phi = 24^\circ\ 0'$ and over the cutting edges $\tan \Theta = \sqrt{2} \tan \theta$; hence $\Theta = 15^\circ\ 30'$ and $\tan \Phi = \sqrt{2} \tan \phi$; hence $\Phi = 32^\circ\ 20'$.

From these particulars it is possible to draw the point of the cutter to a large scale, such as 1000 times full size, using the dimension q to obtain the distance between the vertex of the pyramid formed by the tangent planes and the point of the cutter, and the dimension $m - n$ to obtain the position of the normal section at contact of the tangent planes. The curve can then be treated as an approximation to a parabola and drawn through points obtained by offsets from the tangent; then by taking sections a series of points on the cutting edge of the chisel tool can be obtained.

By completing the work it is possible to obtain the conditions giving a form of cutting edge for the chisel tool approximating to a straight line much more closely than could ever be obtained in practice; and further, the inclination Φ of the finishing portion of the cutting edge to the axis can be made such that $\tan \Phi = 0{\cdot}500$, or $\Phi = 26^\circ\ 24'$.

This angle enables all subsequent calculations to be greatly simplified, since the alteration in diameter of the cutter at a given distance from the lathe-stop is equal to the distance that the vertex has receded from its normal position.

The authors have designed a bifilar microscope, figs. 157 and 158, for the purpose of comparing the position of the cutter point after sharpening, with the normal position which it should occupy, the one hair of the field of the microscope retaining its normal position and the movement of the micrometer cross-hair giving the correction for the table of settings.

The finished punch must be examined under the microscope to see that no error has been made in the cutting. The next operations are hardening and tempering. These do not appreciably distort the character itself, but they introduce errors of three kinds into the punch, and these would prevent it being held perfectly true in the striking-press. The face becomes out of square to each of the originally true sides, and the line is no longer square to these sides. To justify the punch, a small vice, swung on gimbals, has been designed, the two movements of inclination being each operated by a separate micrometer screw. To use the vice the errors of the punch are measured on two adjustable squares, in each of which the face of the punch is set true by a micrometer screw giving identical readings for the same angles as those operating the vice adjustments respectively. The swing vice is secured to the table of an ordinary surface-grinding machine, and one side of the stem of the punch is ground true to the face. The next side is similarly treated, and the depth of cut taken is so arranged as to justify the character relatively to these two sides. The trueing up of the remaining two sides to size then requires no special skill, a batch of punches being ground up together on a magnetic chuck.

Other improvements in punch-cutting machinery were brought out by Mark Barr for the English Linotype Company about the year 1900. His machine shows some useful and important improvements upon the earlier form of punch-cutter. Ball-bearings and ball-slides were used for ensuring optical contact without friction; this was the method introduced by this able inventor after extensive tests made for the Linotype Company in which it was proved that the failures of many instruments of precision were due to the presence of an oil-film between the surfaces.

A device which is specially noteworthy in connexion with the tool-