This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

Bind

TYPECASTING AND COMPOSING MACHINERY.

BY

L. A. LEGROS, M.I.MECH.E.

EXCERPT MINUTES OF PROCEEDINGS
OF THE MEETING
OF
THE INSTITUTION OF MECHANICAL ENGINEERS.
IN LONDON, 18TH DECEMBER 1908.

T. HURRY RICHES, ESQ., PRESIDENT,
IN THE CHAIR.

BY AUTHORITY OF THE COUNCIL.

PUBLISHED BY THE INSTITUTION,
STOREY'S GATE, ST. JAMES'S PARK, WESTMINSTER, S.W.

1908

TYPECASTING AND COMPOSING MACHINERY.

BY MR. L. A. LEGROS, *Member*, OF WATFORD.

CONTENTS.

DESCRIPTION OF TYPE AND TYPEFOUNDING :—

UNITS, LIMITS OF ACCURACY, AND SPACING :—

TYPE FACES, SERIES, PROPORTIONS, AND WEIGHT :—

MACHINES AND PROCESSES EMPLOYED FOR PRODUCING PUNCHES, MATRICES, AND MOULDS :—

(I) MACHINES DEALING WITH ONE OPERATION ONLY:—

(A) TYPECASTERS:—

(B) TYPE-SETTING OR COMPOSING MACHINES:—

(C) LINE-JUSTIFYING MACHINES:—

(D) DISTRIBUTING MACHINES:—

(II) TWO OPERATION MACHINES:—

(A) COMPOSING AND LINE-JUSTIFYING MACHINES:—

(B) COMPOSING AND CASTING MACHINES:—

(III) THREE OPERATION MACHINES:—

(A) MACHINES IN WHICH TYPE IS DISTRIBUTED, COMPOSED, AND LINE-JUSTIFIED:—

Introductory Note.—Printing surfaces may in general be divided into three classes :—

(1) Etched and engraved surfaces in which a drawing or manuscript is produced by lines which are cut below the general surface of the plate. These lines are filled with ink and a damped sheet of paper laid on the face of the plate. The plate and paper are then passed through a roller press in which a blanket is interposed between the roller and the paper and forces the latter into the depressions in the plate;

(2) Lithographed surfaces, in which there is no appreciable difference of plane, but the parts to receive the ink are greasy and the parts to refuse it wet; and

(3) Typographic surfaces, in which the printing surface is in relief and may be inked by means of an inking roller. In the present Paper the author deals with those typographic surfaces which are produced directly by movable type or indirectly by means of movable matrices. The woodcut and the process block, by which the former is now almost entirely superseded, do not present features of great mechanical interest, and do not fall within the scope of the present Paper.

History of Typography.—The consideration of the evolution of typecasting and composing machines from the earliest printed works to the present day presents the peculiar difficulty, that whereas the records of all other arts and trades are effected by means of typography, yet the records of its own progress are singularly deficient, and, for a trade of such antiquity, the data available are most meagre.

In the earliest printing, in the early part of the 15th century (apart from that of the Chinese which we need not consider), wood blocks were used for the whole of a page, and at a later stage these were replaced by separate wood characters. These proved

---

NOTE.—By request of the author, in the illustrations where two or more views are shown they are placed in the position usually adopted in Continental publications.

weak, and the substitution of metal (lead and tin) was a natural sequence. The type so made were not very accurate, and could not be secured by locking up as at the present day. To enable them to be handled when set up, the shank was pierced with a hole and the types threaded together with a thread or wire. As the individual type required much hand work in their making the printer could not carry a large stock, and books were at first printed page by page, the type being distributed after the requisite number of impressions had been taken from each page.

The paper used in the early days of printing was hand made, much tougher and better capable of adapting itself to the inequalities of the printing surface than the highly-glazed, machine-made papers of today. This old paper, owing to its power of adaptation to the inequalities of the printing surface, is now much sought after by artists for printing etchings. The hand-made paper of long fibre, used damp and with an elastic back, gave an impression in which the breadth of the actual lines forming the face of the type was widened, and was in fact a parallel to the actual face cut by the punch cutter. This defect contributed in a rather marked degree to legibility, as it tended to thicken the hair lines and thus render more pronounced the difference between the less dissimilar letters. The highly-glazed papers of today, of short fibre, containing much sizing and mineral matter, are not adapted for printing from such irregular surfaces; their want of flexibility requires a hard and true backing, and hence increased accuracy in the printing surface to obtain a uniformly sharp impression. Modern calendered paper has however rendered possible the reproduction of the admirable process blocks with which the current high-class papers and periodicals are illustrated. The depth of the grain in the process block is so small that the old papers could not be used effectively.

From the earliest days of printing to the present day the thickness of paper used for ordinary book work, however, has kept approximately between the same limits.

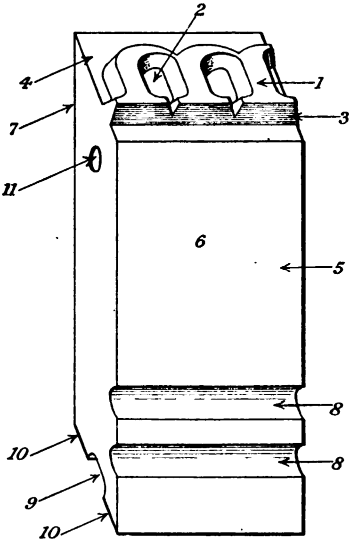
DESCRIPTION OF TYPE AND TYPEFOUNDING.

Type.—The names for the various parts of a *type* will be seen by reference to Fig. 1.

The term *face* is also generally applied to any fount of type when describing its features, *e.g.*, broad-face, narrow-face, etc.

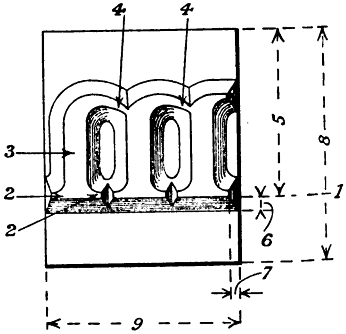
The names of the various parts of the face and of the dimensions may be seen by reference to Fig. 2.

FIG. 1.—*Perspective View of Type.*
(2½ times full size.)



1. The face.
2. The counter.
3. The neck or beard.
4. The shoulder.
5. The stem or shank.
6. The front.
7. The back.
8. The nicks.
9. The heel-nick or groove.
10. The feet.
11. The pin-mark.

FIG. 2.—*Plan of Type.*
(2½ times full size.)



1. The line.
2. Serifs.
3. Main-stroke.
4. Hair-line.
5. Line-to-back.
6. Beard.
7. Side wall.*
8. Body.
9. Set.

---

* This dimension does not appear to have had a name till recently, when it was called thus in the matrices of the Wicks machine.

The dimension 5 (*line-to-back*) is the datum for all measurements of a *fount* * of type and the lower-case m or cap. H are usually taken as the standard, but the difference between the body size and this dimension is also frequently referred to as a dimension and called the beard. In actually measuring type the dimension 5 is that which is measured.

The nick is in the front of the type in England, America and Germany, but in France and Belgium it is at the back.

A supplementary nick is cut, usually just below the shoulder, in the small capitals O S V W X Z to enable these characters to be distinguished from the lower case. In old style the small capital I is also so marked to enable it to be distinguished from the figure 1.

The pin-mark only occurs in certain machine-made type.

The dimension from the foot to the face is called the *height-to-paper ;* the standard for this is now in England 0·918 inch.

Type Founding.—Type is generally cast from an alloy of tin, antimony, and lead; the proportions in which the various metals are used vary between rather wide limits, of which the following may be taken as examples :—

	Per cent.	Per cent.
Lead	62·7	63·7
Antimony	20·8	26·4
Tin	16·5	9·9
Total	100·0	100·0

In the early days of type founding the metal was poured by hand into the mould which was jerked upwards by the founder, so as to cause the liquid to reach the matrix at the end of the mould, and so obtain a cast of the impression previously made by the punch.

Early in the 19th century a pump, partially immersed in the metal pot, was substituted, so that the metal was injected into the mould under considerable pressure and the cast effected with greater certainty and speed.†

---

* Pronounced *font,* and so spelt in America.

† The U.S. Patent of M. D. Mann and S. Sturdevant of 7 Jan. 1831 shows a pump with a spring-propelled plunger. This appears to the author to forestall both the Patent of Sir H. Bessemer, No. 7585, of 8 March 1838, and the U.S. Patent of D. Bruce, jun., No. 632, of 17 March 1838, which cover a pump with spring-propelled piston and an opening and closing mould.

The gate through which the metal passes into the mould becomes also filled with type-metal and forms a projecting *tang* which must be broken from the type; the breakage leaves a ragged surface, parts of which project beyond the feet and must be removed. In the case of type cast in the simplest machines it is necessary to set up the type on a stick and to plane the heel-nick by hand, the removal of the *tang* thus requiring three operations.

The *face* of the type is obtained from an impression, usually made by a punch, in a piece of soft copper or bronze called a *matrix*. The sides of the mould are formed of steel, ground and lapped. As the mould is opened and closed at each cast the surfaces must be so true that the liquid type-metal will not flow between them under the pressure at which it is injected into the mould, as otherwise a fin would be formed on the type at the join of the mould. The position of the matrix relatively to the sides of the mould must be very accurately determined, so that the face may be cast in the proper position on the shoulder. This work requires skill of a high order and is known as *justifying*. It is performed by casting a type from the mould, and comparing it with a standard lower-case m and correcting the matrix till the face of the trial type agrees with the standard for alinement, and occupies its correct position on the shoulder, so that the proper amount of side wall is given on each side.

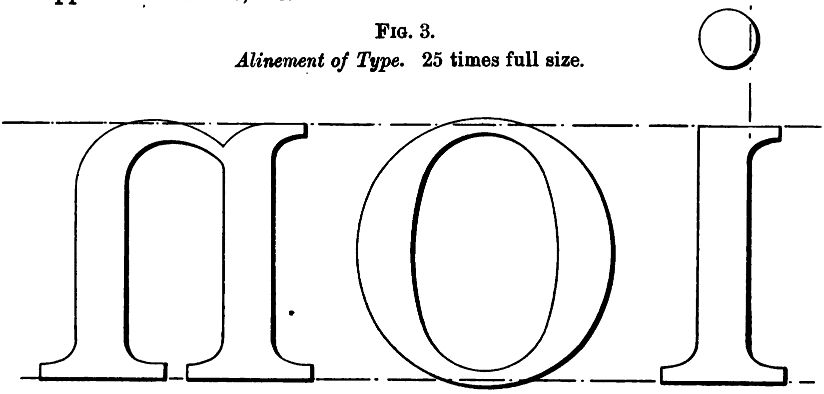
In justifying and in punch-cutting it is necessary to remember that type must not be made so as actually to be in alinement, or so that the characters shall be of equal size, but they must be made *to appear so*.

Probably not one reader in a thousand appreciates the degree to which he is critical on size and alinement of type; the ease with which the eye detects want of alinement in two contiguous lines, used by the engineer in the vernier for obtaining accuracy, here acts conversely in requiring it. A difference of one or two thousandths of an inch in alinement is readily apparent, and a difference of two or three thousandths of an inch in the size of a character is easily noticeable; not only must the characters be of the correct size and truly placed, but the proper proportions of thickness of stroke, length of serif, etc., must be maintained throughout the fount.

If the characters were made equal in their dimensions and true they would appear unequal. Fig. 3 shows the relative magnitude of the errors which must be introduced in order to make the characters of uniform appearance. Almost all the characters in a fount have some peculiarity which must be retained if they are to appear true; e.g. the round sorts must be larger than the square sorts and come below the line; the lower case t must not be vertical in the main stroke, or it will appear to lean back; the dot must not be placed centrally over the main stroke of the lower case i or it will appear on one side, etc.

FIG. 3.

Alinement of Type. 25 times full size.



Founts of Type.—A fount of type comprises all the characters which occur commonly in books and papers. A fairly complete fount adapted to casting machines for ordinary purposes is given in Table 1 (page 1036).

In addition to these characters, *spaces* and *quadrats* (or *quads*) must be provided for separating the words and spacing out the lines. These usually have the following *set* widths: hair space = $\frac{1}{8}$ body, thin space = $\frac{1}{5}$ body, middle space = $\frac{1}{4}$ body, thick space = $\frac{1}{3}$ body, en quad $\frac{1}{2}$ body,* em quad = the body, two-em quad = 2 × body,

---

* It might be inferred that these quads are of the same set as the n or m, but this only occurs under exceptional circumstances. Owing to modern conditions of noise in the printing works, and to make orders clear on the telephone, these are better called "nut" and "mutton" quads respectively.

TABLE 1.

Kind.	Characters.	Number.
Roman lower case .	a to z and æ œ ﬀ ﬁ ﬂ ﬃ ﬄ	33
Roman small capitals .	ᴀ to ᴢ and ᴁ ɶ &	29
Roman capitals . .	A to Z and Æ Œ &	29
Roman figures . .	1 2 3 4 5 6 7 8 9 0	10
Fractions . . .	½ ¼ ¾ ⅓ ⅔ ⅛ ⅜ ⅝ ⅞	9
Roman points . .	. , ; : - ’ ! ? ([	10
Roman accents . .	á à â ä ã é è ê ë í ì î ï ó ò ô ö ú ù û ü ẃ ŵ ç ñ Ç	26
Peculiars . . .	* † ‡ § ‖ ¶ ╭ ⌃ ╮ – — …	12
Commercial signs . .	@ ꝑ ℔ / £ $ % + − × ÷ =	12
Italic lower case . .	*a* to *z* and *æ œ ﬀ ﬁ ﬂ ﬃ ﬄ*	33
Italic capitals . .	*A* to *Z* and *Æ Œ & £*	30
Italic figures . .	*1 2 3 4 5 6 7 8 9 0*	10
Italic points . .	*; : ! ? ([*	6
Italic accents . .	*á à â ä ã é è ê ë í ì î ï* *ó ò ô ö ú ù û ü ẃ ŵ ç ñ Ç*	26
Total		275

three-em quad = 3 × body and four-em quad = 4 × body. In most cases where typecasting machines are concerned it is not necessary to consider the quads larger than the em, which are usually of softer and cheaper metal and cast separately.

The "*height-to-paper*" of quads varies according to the purpose for which they are intended. Where the type is to be printed from direct the height-to-paper of quads is 0·75 inch, but where stereotypes are to be taken the height-to-paper is 0·83 inch.

UNITS, LIMITS OF ACCURACY, AND SPACING.

Units.—In order to appreciate fully the difficulties to be contended with in typecasting and composing machines, the degree of accuracy required must be first considered.

The unit for measurement in this country and in America is the pica which is approximately one-sixth of an inch; until quite recently the size of the pica varied from 0·1678 inch to 0·1664 inch, but now most founders are in agreement and the size 0·16604 inch adopted in America has become standard.

The size of pica as made by the leading English type-founders recently varied as follows [*]:—

Maker.	Pica ems per foot.	Size of pica : in.
Standard size . . .	72·272	0·16604
Stephenson and Blake .	72·125	0·16638
Caslon	71·875	0·16696
Figgins	71·708	0·16735
Sir Chas. Reed and Sons	71·667	0·16744
Miller and Richard .	71·500	0·16783

The pica is divided into twelve points (= 0·013837 in.). The sizes of the various bodies are measured by points and are as follows:—

---

[*] *See* Southward. "Modern Printing," Vol. I, p. 110 *et seq.*

TABLE 2.—*Body Sizes of Type.*

Name.	Example.	Used in	Points.	Body. Inch.
2-line Pica[1] .	Typecas	These larger sizes are mainly used for display purposes.	24	0·33209
2-line Small Pica[1]	Typecasti		22	0·30441
Paragon . . .	Typecasting		20	0·27674
Great Primer[2] .	Typecasting		18	0·24907
2-line Brevier[4] .	Typecasting an		16	0·22139
English . . .	Typecasting an	Scotland for Legal Reports.	14	0·19372
Pica[1] . . .	Typecasting and c	Parliamentary Reports.	12	0·16604
Small Pica[1] . .	Typecasting and co	Text books and novels.	11	0·15221
	Typecasting and com	Patent specifications.	10½	0·14529
Long Primer[2] .	Typecasting and comp	Text books and novels.	10	0·13837
	Typecasting and comp	Proc. Inst. Mech. Eng.	9½	0·13145
Bourgeois[3] . .	Typecasting and compo		9	0·12453
	Typecasting and composi	"Times" leaders.	8½	0·11761
Brevier[4] . . .	Typecasting and composi	"Punch."	8	0·11070
Minion . . .	Typecasting and composing	"Times."	7	0·09686
Nonpareil[5] . .	Typecasting and composing m	"Engineering" ads.	6	0·08302
Agate . . .	Typecasting and composing mac	Used in America.	5½	0·07610
Ruby . . .	Typecasting and composing mach	"Times" ads.	5¼	0·07264
Five Point . .			5	0·06919
Pearl	Typecasting and composing machin	"Bradshaw."	4¾	0·06573

[1] Pronounced *Pie'ca.* [2] Pronounced *Prim'er.* [3] Pronounced *Bur-joice'.* [4] Pronounced *Bre-veer'.* [5] Pronounced *Non'parel.*

The relative importance of the various body-sizes may to some extent be gauged by the following Table which shows how many different faces of each body the American type-founders supply according to their specimen book:—

Body.	Faces.	Body.	Faces.	Body.	Faces.	Body.	Faces.
3-pt.	1	6-pt.	27	9-pt.	22	12-pt.	19
4-pt.	2	7-pt.	19	10-pt.	28	14-pt.	5
5-pt.	5	8-pt.	28	11-pt.	17	15-pt.	1
5½-pt.	9						

From this Table it will appear that the even-point bodies are most in demand. Of these 183 faces 99 are modern and 84 old style.

Much confusion and trouble has been caused in the past through want of adherence to a definite unit, and some evidences of this remain in the half-point sizes, e.g. small pica (10½), long primer (9½) and bourgeois (8½) still in use in England. In America the point system is now universally adopted. The French point system which is of much earlier origin is described in Appendix I (page 1142). (The cicero or "corps 11" measures 0·1628 inch, and is therefore nearly equal to the English pica. The French point is 0·01480 inch, whereas the English point is 0·013837 inch.)

Limits of Accuracy.—The greater portion of printed matter is set in type of the sizes comprised between english and ruby, and it is generally with these and the intermediate sizes that typecasting and composing machines deal. A column of newspaper commonly measures about 22 to 25 inches in height and is very usually set in brevier or minion; it will therefore contain from 200 to 250 lines. The type must be sufficiently parallel in body to lock up in the forme. A uniform error of one ten-thousandth of an inch in parallelism would result in the end lines being inclined each over 0·01 inch from the vertical. Greater inclination would interfere with the truth of impression and with safety in handling, therefore every

TABLE 3.

Set Widths of a Pica Fount (MODERN) *without Spaces and Quads.*

Set.	Characters.	Matrices.	Type.
0·16604	W Æ Œ + − × ÷ = — … @ ⅌ ⌐ ^ ¬ *W Æ Œ*	18	10,770
0·13145	K M ﬃ ﬄ m ℔ *ﬃ ﬄ H K M N X*	13	26,650
0·12453	H G N U X $ *m A D U V Y*	12	14,750
0·11761	A D E O Q R V Y w œ *ﬀ E F R* ẃ ŵ	16	38,270
0·11070	B C F L T æ W Æ Œ % £ ¶ & *w æ œ & B G L P T Z £* Ç *ẃ ŵ*	27	25,900
0·10378	P Z *ﬁ ﬂ C J O Q Ç*	9	4,965
0·08994	S J b d g h k n p q u ﬀ ﬁ ﬂ K M *a d n u x S* ñ ú ù û ü *á à â ä ã ñ ú ù û ü*	37	206,655
0·08302	v x y G H N U X 1 2 3 4 5 6 7 8 9 0 * † ‡ § ‖ *– h k p y I* ½ ¼ ¾ ⅓ ⅔ ⅛ ⅜ ⅝ ⅞ *1 2 3 4 5 6 7 8 9 0*	48	82,190
0·07610	a O Z A D E O Q R V Y *b f g q* á à â ä ã ó ò ô ö	24	118,270
0·07264	e c B C F L P T Z & *o r v ?* ç é è ê ë *ó ò ô ö*	23	125,700
0·06573	I r s ? J S *c e s z ç é è ê ë*	15	108,680
0·05535	f j t *i j í ì î ï*	9	80,920
0·04843	i l - / [ ) *l t !])* I í ì î ï	16	100,120
0·04151	. , : ; ’ ! : ;	8	56,160
		275	1,000,000

Length a to z = 12·50 ems.
Length 1,000,000 type = 77,630 inches = 467,600 ems.

TABLE 4.

Set Widths of a Pica Fount (OLD STYLE) *without Spaces and Quads.*

Set.	Characters.	Matrices.	Type.
0·17296	W Æ Œ *M W Æ Œ*	7	4,970
0·16604	… — + − × ÷ = ⌒ ^ ⌒ ℥	11	5,880
0·13837	H M m œ @ ℔ ¶ ﬃ ﬄ *X D ﬃ ﬄ*	13	27,910
0·13145	D G K N O Q R X W & W Æ Œ *H K N R & m* ẃ ŵ	21	39,530
0·12107	A C T U V Y æ *A B G L P U V Y* Ç *w ẃ ŵ*	19	21,830
0·11416	B E F L P Z £ $ M *C E F O Q T Z £ ﬀ æ œ Ç*	21	21,685
0·09340	S b d g h k n p q u x ﬀ ﬁ ﬂ D G H K N R U & *S J g y ﬁ ﬂ* ñ ú ù û ü	33	205,180
0·08648	a o v y A B C E L O P Q T V X Y Z *a d h k n p u x* á à â ä ã ó ò ô ö *á à â ä ã ñ ú ù û ü*	44	161,855
0·08302	1 2 3 4 5 6 7 8 9 0 * † ‡ § ‖ % – ½ ¼ ¾ ⅓ ⅔ ⅛ ⅜ ⅝ ⅞ *1 2 3 4 5 6 7 8 9 0*	36	43,380
0·07264	J c e z F S *I b q r v z ? [* ç é è ê ë	19	117,880
0·06054	I r s t - / ? J *c e f j o s t) ç é è ê ë ó ò ô ö*	25	180,990
0·05189	f i j l) [I *l i !* í ì î ï *í ì î ï*	18	112,750
0·04151	. , ’ ; : ! *; :*	8	56,160
		275	1,000,000

Length a to z = 12·99 ems.

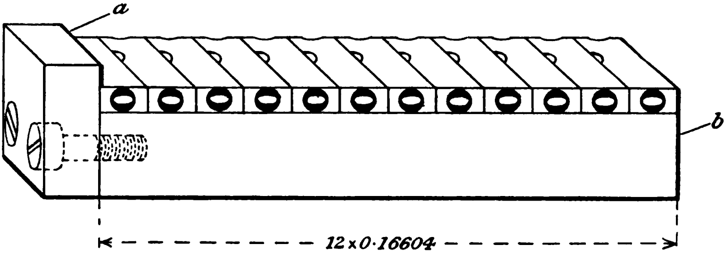
Length 1,000,000 type = 77,300 inches = 465,600 ems.

endeavour must be used to keep the body of the type uniform and the product of every machine has to be continually checked. This can readily be done in practice by means of an L gauge, Fig. 4, measuring about 2 inches but actually made to the calculated length of the type to be received.

The type are carefully cleaned from grease and small particles of metal and then pressed firmly against the stop *a* with the fingers. The finger nail is then passed over the flat surface *b* of the end of the gauge and the end of the line of type where a total difference of one-thousandth of an inch in the total body and of inequality in parallelism can easily be felt. Such a gauge would measure 1·9924 inches for 12 pica, for 18 brevier or for 24 nonpareil; a gauge 2·0340 inches would serve for 14 small pica or 28 ruby and also for 21 minion. In this connection it should be noted that the multiples of the decimal sizes given in Table 2 (page 1038) do not agree exactly, but this gauge should be 147 points in length. The variations in approximate decimal sizes have proved a great stumbling block to some founders who have first worked out the decimal approximation for the body and then multiplied it thereby obtaining varying results, which would be avoided entirely by working from the point as the unit.

FIG. 4.

Body Gauge for Type. 1½ times full size.



In setting up tabular work it is necessary that the points, figures, and fractions should all agree, so that the figures may fall vertically under each other and the columns be of equal width. For this reason the figures and two-figure fractions ($\frac{1}{2}$, $\frac{1}{3}$) are almost invariably made on the *en-set*; the diagonal and other fractions

($1/2$, $\frac{3}{16}$, $\frac{21}{32}$) on the *em-set*; and those points used in tabular work, e.g. the full point (which inverted becomes the decimal point), the comma, the colon and the semi-colon are usually placed on the same *set* as the *middle* space, namely one-fourth of the body.* The same gauge that is used for the body will serve for checking the *set* of these particular characters, but as a column of matter is seldom more than four inches wide, a larger error is here admissible than in the body size.

Spacing.—The width of a column of newspaper or a printed page of a book generally lies between 14 and 40 ems. Where this is ordinary reading matter each line will contain on the average from 7 to 10 words. As the letters are not only unequal in *set*, and since the widths of *set* generally bear no particular relation to the em (or body), it follows that the spacing has to be done after the line has been composed. If the line (made up with thick spaces in hand composition) comes short or long the spaces must be some or all removed and replaced with others.† The spacing must therefore be obtained by the use of the thin, middle and thick spaces forming $\frac{1}{5}$, $\frac{1}{4}$ and $\frac{1}{3}$ of the body respectively. Obviously the minimum error obtainable with such a system is the fraction given by the least common multiple of these used in combination, i.e. $\frac{1}{60}$ em. The line cannot be made longer than the allowed width, therefore the amount of admissible error based on practical experience may be taken at $\frac{1}{60}$ em, and it is probable that it frequently amounts to $\frac{1}{30}$ em. This in pica becomes about $\frac{1}{180}$ inch and in nonpareil about $\frac{1}{360}$ inch.

The problem of spacing is one of the most serious difficulties met

---

* Some founders place these points on the *thick* space *set* (or $\frac{1}{3}$ body), but with this arrangement spacing is more difficult, as the column can only be made a multiple of the en or em by adding two *thick* spaces, whereas with the points on the *middle* space the addition of a single *middle* space will bring the column to a multiple of the en.

† The hair space is not used for this purpose, but only for spacing out between the characters of words where a very narrow column of matter runs alongside a block or table, and occasionally its use is allowed to obviate over-running where author's corrections occur.

TABLE 5.

Self-Spacing Type.

Set.	Characters.	Number.
2 body	2 em quad	1
⅞ body	W Æ Œ *ﬃ ﬄ W Æ Œ*	8
body	em-quad m ﬃ ﬄ H K M X ℔ ⅌ @ … — × + − ÷ = ½ ¼ ¾ ⅓ ⅔ ⅛ ⅜ ⅝ ⅞ *m H K M X*	32
⅚ body	w æ œ A B D E F G N O P Q R T U V Y & H K M W Æ Œ *w æ œ ﬀ ﬁ ﬂ A B D E F G N* *O P Q R T U V Y &* ẃ ŵ *ẃ ŵ* . .	51
⅔ body	3-to-2-em quad a b d g h k n o p q u v x y ﬀ ﬁ ﬂ £ $ C J L S Z A B C D E F G L N O P Q R T U V X Y & ⎫ ⎬ ⎭ .. (leader) — (rule) 1 2 3 4 5 6 7 8 9 0 *C J L S Z a b d g h k n o p q* *u v x y I 1 2 3 4 5 6 7 8 9 0* ä á à â ã ñ ö ó ò ô ü ú ù û Ç ç *ä á à â ã ñ ö ó ò ô ü ú ù û Ç*	120
½ body	en-quad c e r s t z J S Z I ? ( ] * † ‡ § ‖ ¶ *c e f r s t z ? ( ]* ç ë é è ê *ç ë é è ê* . .	40
⅓ body	3-to-em space f i j l I . , ; : ' ! - / *i j l ; : !* ï í ì î *ï í ì î*	28
⅙ body	Hair space	1
Total .	Spaces and quads, 6. Characters, 275 . .	281

with in composing machinery; it is here called *line-justification* throughout, but is known to printers by the unfortunate term "justification" which is used elsewhere throughout this Paper for those manufacturing operations which are also so called. Various attempts have been made to effect the spacing more readily than by the crude trial and error method just mentioned. It is, however, by no means a simple problem. If all letters were equal in *set* (as in the case of most typewriter faces), there would be a variable number from 0 to 8 spaces * to be added and inserted with those already in he line. These spaces would generally make large, irregular, and unsightly white gaps over the page. The nearest approach to accurate spacing of type is afforded by the American so-called *self-spacing* type invented by Benton. In this all characters are made on *set* widths each multiples of one sixth of the body, so that any combination can be made up to a multiple of the em by the addition of some of the *self-spacing* spaces which are also equal multiples of the sixth of the body.

The provision of so small a number of *set* sizes results in the production of characters which do not conform to those ordinarily in use sufficiently closely to secure the general adoption of the system, and the difficulty, which will be apparent in comparing Table 5 with Tables 3 and 4 (pages 1040–1041) becomes even more marked with the italic sorts.

Kerned Type and Italics.—Some of the italic sorts (and, in the early type cast in the hand-mould, sometimes the roman lower-case f and j) project beyond the sides of the body, Fig. 5 (page 1046); these are known as kerned characters. The projecting kern requires to be dressed by hand so as to clear the shoulder of the adjacent sort; in early printing some of the characters kerned above or below the body, and this was liable to cause fouling where an ascending or a

---

* Taking a line ending in the longest indivisible word known to the author in English, "strength," there are 8 letters, and if this comes at the end of the line and proves one letter too long there are still 8 spaces to deal with since one space precedes the last word.

descending kern in one line came immediately under a descending or over an ascending letter in the next line. In modern type, kerning above and below the body is rare; the only notable exceptions are accented capitals,—the use of which is now being abandoned by the French *—and the very ingenious two-line letter for commencing advertisements introduced by the Linotype Co., which is further described below.

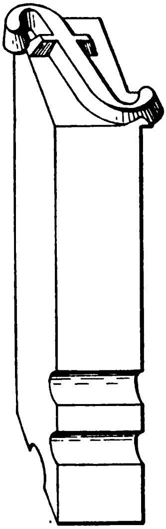


Fig. 5.

Kerned Type: Perspective View.

About 2½ times full size.

Characters kerned in *set* are however still common in the case of many of the best book founts; they present a serious difficulty to

---

* The French have for many years abandoned the grave accent on A while retaining it in the lower case. "A Paris il faisait beau, à Londres un brouillard."

In the headlines of the French newspapers, while the accent is now almost universally omitted on A, one finds accents sometimes on other characters; but the influence of the composing machine is to be seen in the gradual abandonment of accented capitals, which is now in progress.

For example: L'ANGLETERRE REFUSE LE SYSTEME METRIQUE ......car la plus grande partie du commerce extérieur britannique intéresse des pays qui n'ont pas le système métrique....*Le Matin* 23 *Mar* 1907.

most typecasting and composing machines. Where the type is ejected through the length of the mould, as in the Wicks machine, they cannot be produced.

In any case the weakness of the kern renders such italic type easily damaged in distributing and composing, and it is probably only a matter of time for the kern to be abandoned, except in the case of the highest classes of printing and in artistic work where appearance is the most important factor.

Example of kerning italic :—

The ejection of kerned italic type offers difficulty.

Example of non-kerning italic :—

The ejection of non-kerned italic type offers no difficulty.

The principal difficulty in designing a non-kerning italic lies in the ascending and descending sorts and particularly in the letters *f* and *j* ; these have to be somewhat modified from the more familiar shape. Whereas the slope of the italic main strokes in the kerning type will be found frequently to be as much as 1 in 3, it is necessary to reduce it to about 1 in 5 in designing a non-kerning fount, and 1 in 4 is about the maximum slope permissible. With this the *f* requires to be considerably distorted and shows excess of side wall and consequent space between it and the adjacent characters.

TYPE FACES, SERIES, PROPORTIONS, AND WEIGHT.

Variety of Faces.—Type faces may be divided into three main groups so far as they concern the maker of typecasting and composing machines.

(a) Old style faces. Example :—

Notice the short serifs and the ample fillet connecting each to the main stroke. These features tend to durability as well as to legibility. 1 2 3 4 5 6 7 8 9 0.

Old Style Pica (Miller & Richard).

(b) Modern faces. Example:—

> Note how thin are the hair lines, how long are the serifs, and how small the fillet connecting each to the main stroke. Wear takes place more rapidly, and legibility is sacrificed. 1 2 3 4 5 6 7 8 9 0.

Modern Pica (Miller & Richard).

(c) Fancy faces. Example:—

> Our eyesight is one of our most precious assets, and the designer of type should therefore consider legibility as of greater importance than artistic effect.

Blackfriars Pica (Wicks Type Foundry).

The faces may be extended or condensed, and the strokes may be fat or lean. The faces used for the greater part of the printed matter of the day are either old style, or modern, or follow the leading features of one or the other very closely.

(a) *The old style face* has thick hair lines and a large radius connecting the serif with the main stroke. These features render it more legible and durable. On the other hand the old style figures are irregular, and owing to the smallness of some sorts their legibility is no greater than that of the modern figures. Moreover, the fact that they comprise ascenders, descenders and small sorts makes them unsuitable for most scientific works. Old style founts are therefore frequently ordered with modern figures.

(b) *The modern face* is very largely used; the defect from which it suffers has arisen from the endeavour to obtain a more highly finished outline without regard to the ultimate object in view. Thicker hair lines and a larger radius connecting the serif and main stroke increase both the clearness and the durability of the type, and a face produced with these features is very suitable for most newspapers, periodicals, magazines, text books and novels.*

---

* *See* T. L. De Vinne. "Plain Printing Types"; De Vinne not only draws attention to the requisites for legibility but has himself produced some of the best examples of easily-readable type faces.

(c) *Fancy faces.*—There are so many varieties of fancy faces and they differ so widely that they rarely come into question under conditions which permit of their production in large quantity. These faces are used chiefly for advertisements, circulars, bill-heads and titling, where any particular fount occurs usually in such small quantity that hand composition is the only effective method of setting. Probably less than 10 per cent. of all printed matter is set in fancy faces.

The large amount of time spent by nearly all persons in reading makes the question of clearness of type one of enormous importance, though it has hitherto passed almost unnoticed. It is quite as necessary that the characters should be plainly dissimilar in form and appearance as that a body should be used of the maximum size which the nature of the work will permit.

At present there is no uniformity in the *set* widths of the various faces, but it should be possible to cover all requirements by the adoption of the strengthened modern face in three widths, viz.: extended, standard, and condensed, each bearing a definite ratio to the other. The only convenient unit for gauging whether type is extended, standard, or condensed, is by the measure of the alphabet (a–z) in ems.* In making such comparison, however, it must be noted that it is only possible to compare founts of the same body and style by this measure.

Series.—Founts of different bodies but of faces made to appear similar are said to form a series. A fount of smaller body generally has a greater number of ems to the alphabet than a larger body of the same series.

It has been the custom of type-founders to have the punches cut so that the size of the small sorts is proportionately larger as the body diminishes, the length of the ascending and descending characters being correspondingly altered.† This may be explained by

---

* By em is meant the em quad. The total aggregate set of the alphabet is consequently expressed as a multiple of the body.

† *See* measurements of series of type (page 1038).

reference to Tables 6 and 7 (pp. 1052 to 1055). It will be seen that nearly all the vowels and most of the more frequently occurring consonants are small sorts, and this is not only the case in English but also in the languages of the other countries in which typefounding has been longest established (France, America, Germany). In the English language in 10,000 lower-case characters there are on the average 5830 small sorts and 40 ascending and descending characters, but only 3510 ascenders, and 620 descenders. It is the influence of the greater number of the small sorts and the adoption of as large a size as possible for the small sorts, in order to obtain legibility, which is responsible for this change of shape as the size of the face is reduced and for the descenders being more shortened in proportion than the ascenders.

Series of Type Faces.—Owing to the enlargement of the small sorts and to the fact that the hair line is the minimum width of line which will give a good impression,* it is not possible to use the same *formers*† for a large range of reduction, but, in order that the type may appear similar, other formers must be provided of the proper proportions. It will be found in practice that the same formers can be used for pica, small pica, and long primer; a second set is required for bourgeois, brevier, and minion; and a third set for nonpareil and ruby.

The *set* widths of the second set of formers will be from 8 to 10 per cent. greater than those of the first, and the *set* widths of the third set from 16 to 20 per cent. greater than those of the first.

The relative appearance of the characters of the three sets of formers is shown in Fig. 6.

The a–z length for a standard face in pica is about 12·5 to 13 ems,‡ in brevier about 13¾ to 14¼ ems, and in nonpareil about 15 to 15⅔ ems.

---

* The minimum width usually permissible for the hair-line in modern faces is 0·002 inch.

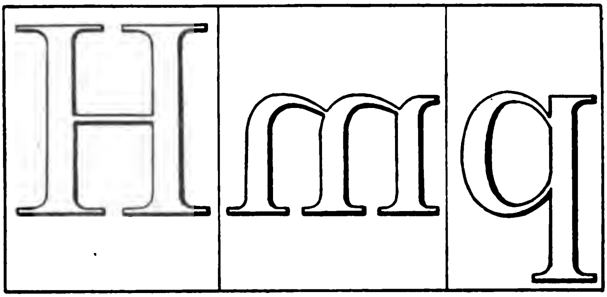
† *See* description of punch cutting machine (page 1059).

‡ Owing to different characters being affected by differences in set, 13 ems old style will average nearly the same length as 12·5 ems modern. (*See* foot of Tables 3 and 4, pages 1040–1041.)

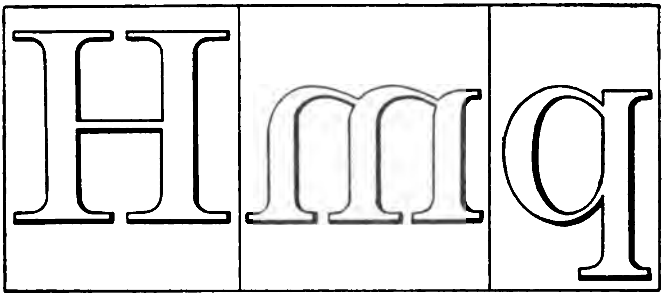
FIG. 6.

Type Series.

12 point (Pica) *9 times full size.*



9 point (Bourgeois) *12 times full size.*



6 point (Nonpareil) *18 times full size.*

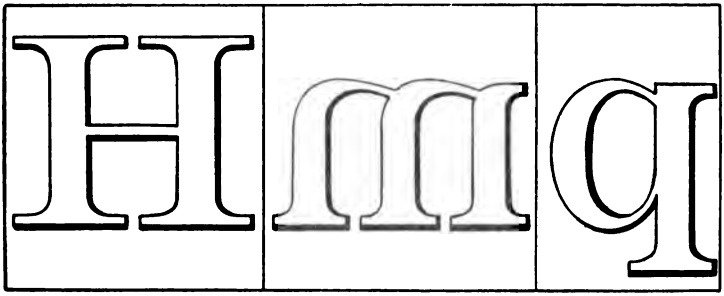


TABLE 6 (*continued on next page*).

Bill of 1,000,000 *type, exclusive of spaces and quads.* (*England.*)

Roman lower case.		Roman small capitals.		Roman capitals.		Roman figures. Fractions and points.		Roman accents.	
m	16,780	A	2,510	A	3,900	1	3,900	á	250
a	50,330	B	1,510	B	2,510	2	3,350	à	1,200
b	11,180	C	1,960	C	2,800	3	3,350	â	600
c	22,370	D	1,960	D	3,070	4	2,800	ä	250
d	27,960	E	2,510	E	4,200	5	2,800	ã	200
e	78,300	F	1,680	F	2,510	6	2,800	ç	250
f	16,780	G	1,510	G	2,510	7	2,800	é	1,200
g	11,180	H	1,680	H	2,510	8	2,800	è	600
h	33,550	I	2,510	I	5,020	9	2,800	ê	400
i	50,300	J	1,120	J	1,680	0	3,900	ë	600
j	2,800	K	1,120	K	1,680	½	840	í	250
k	4,470	L	1,680	L	3,070	¼	840	ì	250
l	27,960	M	1,680	M	3,630	¾	840	î	250
n	44,740	N	1,960	N	3,070	⅓	280	ï	250
o	44,700	O	1,960	O	3,070	⅔	280	ñ	200
p	13,420	P	1,510	P	2,800	⅛	280	ó	250
q	3,360	Q	670	Q	1,120	⅜	280	ò	250
r	39,150	R	1,850	R	2,800	⅝	280	ô	300
s	44,740	S	1,960	S	3,320	⅞	280	ö	300
t	55,930	T	2,350	T	4,440	.	16,780	ú	250
u	25,170	U	1,340	U	2,000	,	25,170	ù	250
v	8,390	V	1,120	V	2,000	;	4,470	û	300
w	13,980	W	1,510	W	3,070	:	3,350	ü	300
x	2,800	X	670	X	1,120	-	5,600	ẃ	200
y	13,980	Y	1,120	Y	2,000	’	4,470	ŵ	200
z	1,680	Z	670	Z	840	!	1,120	Ç	50
æ	1,120	Æ	330	Æ	560	?	1,680		
œ	560	Œ	330	Œ	560	(	2,240		
ff	2,240	&	1,120	&	1,680	[	1,120		
fi	2,800								
fl	1,680								
ffi	1,680								
ffl	1,120								
Total	677,200	Total	43,900	Total	73,540	Total	101,500	Total	9,400

TABLE 6 (*concluded from opposite page*).

Bill of 1,000,000 *type, exclusive of spaces and quads.* (*England.*)

Peculiars and commercial signs.		Italic lower case.		Italic capitals.		Italic accents.		Italic figures and points.	
*	1,400	*a*	5,030	*A*	390	*á*	25	*1*	390
†	560	*b*	1,120	*B*	250	*à*	120	*2*	330
‡	560	*c*	2,240	*C*	280	*â*	65	*3*	330
‖	560	*d*	2,800	*D*	310	*ä*	25	*4*	280
§	560	*e*	7,830	*E*	420	*ã*	20	*5*	280
¶	370	*f*	1,680	*F*	250	*ç*	25	*6*	280
╭	280	*g*	1,120	*G*	250	*é*	120	*7*	280
⁀	280	*h*	3,350	*H*	250	*è*	50	*8*	280
╮	280	*i*	5,030	*I*	500	*ê*	40	*9*	280
-	560	*j*	280	*J*	170	*ë*	65	*0*	390
—	2,800	*k*	450	*K*	170	*í*	25	*;*	450
...	560	*l*	2,800	*L*	310	*ì*	25	*:*	350
@	280	*m*	1,680	*M*	360	*î*	25	*!*	110
⅌	280	*n*	4,470	*N*	310	*ï*	25	*?*	170
℔	280	*o*	4,470	*O*	310	*ñ*	20	*)*	220
£	1,120	*p*	1,340	*P*	280	*ó*	25	*]*	110
$	560	*q*	340	*Q*	110	*ò*	25		
%	560	*r*	3,910	*R*	280	*ô*	30		
/	560	*s*	4,470	*S*	330	*ö*	30		
+	280	*t*	5,590	*T*	440	*ú*	25		
−	280	*u*	2,510	*U*	200	*ù*	25		
×	280	*v*	840	*V*	200	*û*	30		
÷	280	*w*	1,400	*W*	310	*ü*	30		
=	280	*x*	280	*X*	110	*ẃ*	20		
		y	1,400	*Y*	200	*ŵ*	20		
		z	170	*Z*	80	*C*	5		
		æ	110	*Æ*	55				
		œ	60	*Œ*	55				
		ff	220	*&*	170				
		fi	280	*£*	110				
		fl	170						
		ffi	170						
		ffl	110						
Total 13,810		Total 67,720		Total 7,460		Total 940		Total 4,530	

Totals.

R. l. c.	677.200
R. s. c.	43,900
R. c.	73,540
R. figs. & pts	101,500
R. accs.	9.400
Pec. & coml.	13.810
Ital. l. c.	67,720
Ital. c.	7,460
Ital. accs.	940
It. figs. & pts.	4,530
Grand Total	1,000,000

TABLE 7 (*continued on next page*).

Bill of 1,000,000 *Type, inclusive of Spaces and Quads.* (*England.*)

Roman lower case.		Roman small capitals.		Roman capitals.		Roman figures. Fractions and Points.		Roman accents.	
m	13,230	A	1,990	A	3,000	1	3,110	á	200
a	39,700	B	1,190	B	1,980	2	2,640	à	950
b	8,820	C	1,540	C	2,420	3	2,640	â	470
c	17,630	D	1,540	D	2,420	4	2,200	ä	200
d	22,040	E	1,990	E	3,300	5	2,200	ã	160
e	61,710	F	1,320	F	1,980	6	2,200	ç	200
f	13,230	G	1,190	G	1,980	7	2,200	é	950
g	8,820	H	1,320	H	1,980	8	2,200	è	470
h	26,450	I	1,990	I	3,960	9	2,200	ê	300
i	39,680	J	880	J	1,320	0	3,110	ë	470
j	2,200	K	880	K	1,320	½	660	í	200
k	3,530	L	1,320	L	2,420	¼	660	ì	200
l	22,040	M	1,320	M	2,840	¾	660	î	200
n	35,300	N	1,540	N	2,420	⅓	220	ï	200
o	35,270	O	1,540	O	2,420	⅔	220	ñ	160
p	10,580	P	1,190	P	2,200	⅛	220	ó	200
q	2,640	Q	530	Q	880	⅜	220	ò	200
r	30,860	R	1,460	R	2,200	⅝	220	ô	230
s	35,270	S	1,540	S	2,640	⅞	220	ö	230
t	44,090	T	1,860	T	3,520	.	13,230	ú	200
u	19,840	U	1,670	U	1,540	,	19,840	ù	200
v	6,610	V	880	V	1,540	;	3,530	û	230
w	11,020	W	1,190	W	2,420	:	2,650	ü	230
x	2,200	X	530	X	880	-	4,410	ẃ	160
y	11,020	Y	880	Y	1,540	’	3,530	ŵ	160
z	1,320	Z	530	Z	660	!	880	Ç	40
æ	880	Æ	260	Æ	440	?	1,320		
œ	440	Œ	260	Œ	440	(	1,760		
ff	1,760	&	880	&	1,320	[	880		
fi	2,200								
fl	1,320								
ffi	1,320								
ffl	880								
Total	533,900	Total	34,610	Total	57,980	Total	80,030	Total	7,410

TABLE 7 (*concluded from opposite page*).

Bill of 1,000,000 *Type, inclusive of Spaces and Quads.* (*England.*)

Peculiars and commercial signs.		Italic lower case.		Italic capitals.		Italic accents.		Italic figures and points.	
*	1,110	*a*	3,970	*A*	300	*á*	20	*1*	310
†	440	*b*	880	*B*	200	*à*	90	*2*	260
‡	440	*c*	1,760	*C*	240	*â*	50	*3*	260
‖	440	*d*	2,200	*D*	240	*ä*	20	*4*	220
§	440	*e*	6,170	*E*	330	*ã*	15	*5*	220
¶	300	*f*	1,320	*F*	200	*ç*	20	*6*	220
╭	220	*g*	880	*G*	200	*é*	90	*7*	220
⌃	220	*h*	2,650	*H*	200	*è*	40	*8*	220
╮	220	*i*	3,970	*I*	400	*ê*	35	*9*	220
-	440	*j*	220	*J*	130	*ë*	50	*0*	310
—	2,220	*k*	350	*K*	130	*í*	20	*;*	360
…	440	*l*	2,200	*L*	240	*ì*	20	*:*	260
@	220	*m*	1,320	*M*	280	*î*	20	*!*	90
⅌	220	*n*	3,530	*N*	240	*ĩ*	20	*?*	130
℔	220	*o*	3,530	*O*	240	*ñ*	15	*(*	180
£	880	*p*	1,060	*P*	220	*ó*	20	*[*	90
$	440	*q*	260	*Q*	90	*ò*	20		
%	440	*r*	3,090	*R*	220	*ô*	25		
/	440	*s*	3,530	*S*	260	*ö*	25	Total 3,570	
+	220	*t*	4,410	*T*	350	*ú*	20		
−	220	*u*	1,990	*U*	155	*ù*	20		
×	220	*v*	660	*V*	155	*û*	25		
÷	220	*w*	1,100	*W*	240	*ü*	25		
=	220	*x*	220	*X*	90	*ẃ*	15	Totals.	
		y	1,100	*Y*	155	*ŵ*	15	R. l. c.	533,900
		z	130	*Z*	65	*Ç*	5	R. s. c.	34,610
Total 10,890		*æ*	90	*Æ*	45			R. c.	57,980
		œ	50	*Œ*	45			R. figs. & pts.	80,030
Spaces.		*ff*	180	*&*	130			R. accs.	7,410
Hair	13,230	*fi*	220	*£*	90			Pec. & coml.	10,890
Thin	35,270	*fl*	130					Spaces	211,600
Middle	35,270	*ffi*	130					Ital.	53,390
Thick	88,150	*ffl*	90					Ital. c.	5,880
Enquad	26,450							Ital. accs.	740
Em quad	13,230							It. figs. & pts.	3,570
Total	211,600	Total 53,390		Total 5,880		Total 740		Grand Total	1,000,000

Proportions in which Type is Usually Supplied.

*Bill of Fount.**—Type is usually supplied according to a scheme which determines the proportion each character bears to the whole. In some cases the order is for a certain total weight of type and this is translated by the type-founder into a bill of so many ems. In this case it is the lower case m which is taken as the standard of demand and the bill is for 3,000 or 5,000, etc., m's; for this reason the lower-case m is placed first in the bill. The spaces and quads are usually reckoned separately from the characters. For many of the problems which arise, in the design of typecasting and composing machinery, it is necessary to consider the total number.

The author has calculated Tables 6 and 7 which show the number of each character in a million type in the two cases *exclusive* of and *inclusive* of spaces and quads up to the em quad. Although these proportions are followed very closely in making up an order, the trade recognise the possibility of irregularity in the demand; for example directories and voters' lists will require an abnormally large supply of capitals and small capitals, while almanacs and some scientific works require an excessive quantity of figures.†

MACHINES AND PROCESSES EMPLOYED FOR PRODUCING PUNCHES, MATRICES, AND MOULDS.

Punch-Cutting.— In the process of cutting a punch by hand the end of a piece of steel about 2 inches long and ¼ inch square (in the case of pica and smaller bodies) is filed up square to two adjacent faces which have been squared up. This face is ground true on an oil stone by means of the stone-facer of hardened steel shown in Fig. 7 (page 1058). The character is then marked out on the face of the

---

* Known in America as a *scheme*.

† It happens, however, that printers occasionally require abnormal quantities of some particular character, of capitals, of small capitals or of figures. By the custom of the trade the printer is entitled to be supplied with "sorts" at the same rate as paid for the fount, provided these are ordered within three months of the date the fount is supplied.

TABLE 8.

Approximate Weight of 1,000,000 *Type in lb. Exclusive of Spaces and Quads.*

	Points.	Lengths a–z in ems.								
Modern . .	—	8·75	10·00	11·25	12·50	13·75	15·00	16·25	17·50	18·75
Old Style . .	—	9·10	10·40	11·70	13·00	14·30	15·60	16·90	18·20	19·50
Gt. Primer . .	18	6,050	6,770	7,490	8,210	8,930	9,650	—	—	—
Two-line Brevier	16	4,780	5,350	5,920	6,490	7,060	7,630	—	—	—
English . . .	14	3,660	4,100	4,530	4,970	5,400	5,840	—	—	—
Pica	12	—	3,010	3,330	3,650	3,970	4,290	4,610	—	—
Small Pica . .	11	—	2,530	2,800	3,070	3,340	3,600	3,870	—	—
	10½	—	2,300	2,550	2,790	3,040	3.280	3,530	—	—
Long Primer .	10	—	2,090	2,310	2,530	2,760	2,980	3,200	—	—
	9½	—	1,890	2,090	2,290	2,490	2,690	2,890	—	—
Bourgeois . .	9	—	—	1,870	2,050	2,230	2,410	2,590	2,770	—
	8½	—	—	1,670	1,830	1,990	2,150	2,310	2,470	—
Brevier . . .	8	—	—	1,480	1,620	1,760	1,910	2,050	2,190	—
Minion . . .	7	—	—	1,130	1,240	1,350	1,460	1,570	1,680	—
Nonpareil . .	6	—	—	—	910	990	1,070	1,150	1,230	1,310
Agate . . .	5½	—	—	—	760	830	900	970	1,040	1,110
Ruby	5¼	—	—	—	700	760	820	880	940	1,000
Five Point . .	5	—	—	—	—	680	740	800	860	920
Pearl	4¾	—	—	—	—	620	670	720	770	820

The stepped columns between the heavy lines show type which would appear in series.

In this Table due allowance has been made for the commercial signs, figures and points remaining constant in *set* width.

punch with a scriber and the counters struck in by means of "counter punches" used by hand with a hammer. The punch is kept true on the face by occasionally rubbing on the oil stone in the stone-facer and the sides are trimmed off with gravers and engraving tools. The production of the work requires the continued use of a magnifying eyeglass combined with the artistic ability to produce the correct curves and the accuracy to obtain the result to 0·0003 inch. There are not many good punch-cutters * and it can be easily understood that a punch-cutter capable of working to this degree of accuracy earns about £4 to £6 per week. Moreover the amount of work finished by this method is not large and the punches of a fount so cut by hand will be found to have cost on the average from 12*s.* to 15*s.* each; to the engineer who has purchased a small complete alphabet of 27 punches with a set of 9 figures for 5*s.* or 6*s.*, this cost, without further explanation, will appear absurd. As the engraving of the punch is proceeded with, the face is smoked and an impression taken on a piece of fine-surface paper alongside an impression similarly taken from the corresponding standard character, the **H**, o, m, or p, according to the character which is being cut. The smokes are examined with the magnifier and the

Fig. 7.

Stone-facer for Punches, or Jointer.
Half size.

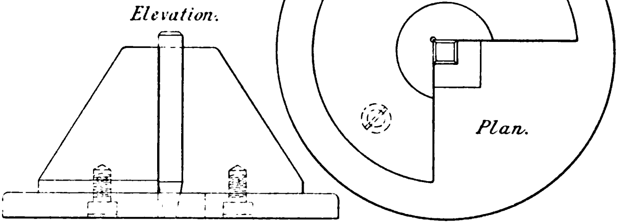
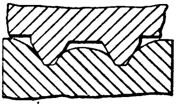


Fig. 8.

Bad Striking Metal: Section.

5 times full size.



---

* Anthony Bessemer, the father of Sir Henry Bessemer, cut a number of faces for Messrs. Caslon, and subsequently engaged in typefounding himself. *See* Life of Sir Henry Bessemer, p. 60.

work continued till the result agrees to the desired extent. Since the punch is the first stage in the process and from it a matrix must be obtained in which again the type is cast, the problem is one of cumulative error. In the case of the punch, the very thin film of deposited carbon forming the smoke enables a higher degree of accuracy to be obtained than prevails with the inked impression made from the type. The hand-cut punch when finished has a long taper ½ inch to ¾ inch in length and the bevels of the actual strike are seldom constant in slope. Moreover the face does not occupy a definite position with regard to the sides of the shank. Owing to the great expense of cutting punches by hand, the hand-cut punches for the vowels and the n are usually ground away flat on the back to enable them to be used in conjunction with separate punches for the accents. This first step towards economy in punches gives very unsatisfactory results.

Striking.—Matrices are now usually struck in a press. The punch is forced into the soft matrix metal which must be of such quality that it will readily flow. It is quite possible to obtain metal which will take the impression to the required depth without injuring the punch and yet will not flow sufficiently freely under the pressure to fill the counter as shown in Fig. 8 (page 1058).

Owing to the unsymmetrical form of the character the pressure applied in striking causes the punch to spring, and this is particularly the case with the hand-cut punch which has the long taper portion unsupported. In the case of the accented sorts this difficulty is increased and the two parts of the punch tend to separate, to give unequal depths and an irregularity which is inadmissible. This leads to increased cost in finishing the matrices, and as most typecasting machines use matrices in quantity, it is necessary to obtain cheaper, more accurate and readily interchangeable punches.

Punch-Cutting Machine.—The Benton-Waldo punch-cutting machine is of American invention and an adaptation of the pantograph. Instead of the model and its reduction being in one plane, the punch is arranged vertically over the model or *former*. The machine, Fig. 9, consists of a vertical 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 lathehead 4 can be placed in 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 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 determined 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, Fig. 10, 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.

FIG. 10. *Enlarged View of Follower Stem.*

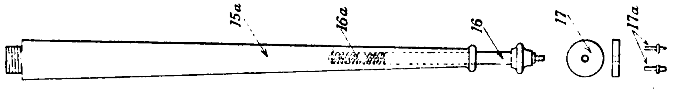
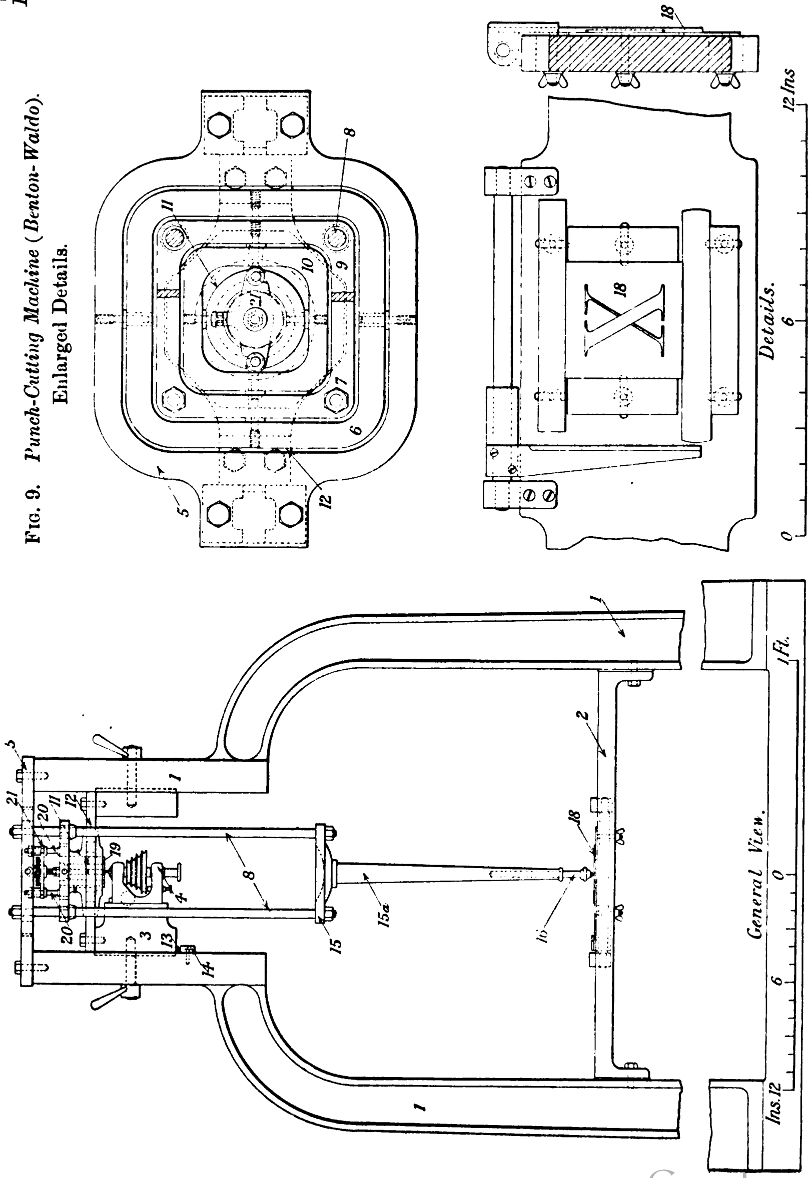


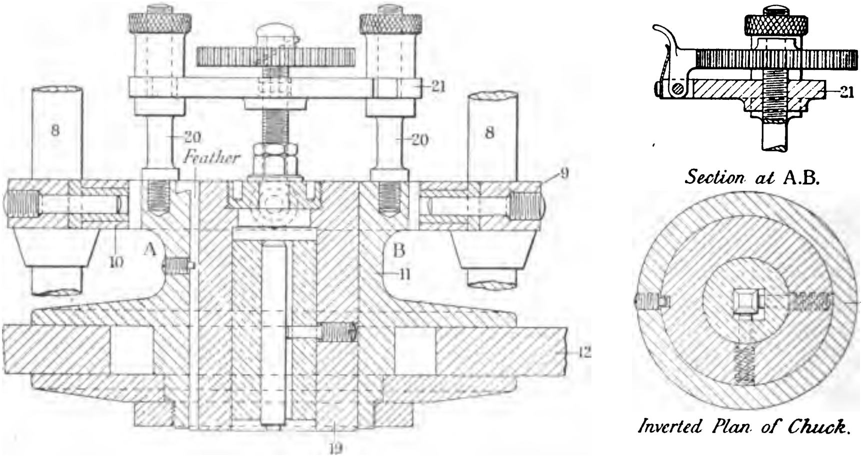
FIG. 9. *Punch-Cutting Machine (Benton-Waldo).* Enlarged Details.



The sliding head, Fig. 11, 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 graduated to correspond to ¼ thousandth of an inch of depth; 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. 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 cost some £800 each a few years ago; the author recently found however that it was possible to reduce this to about one-third of that sum while obtaining the same degree of accuracy.

Fig. 11.

Detail of Sliding Head and Chuck Fig. 9 (*Benton-Waldo Machine*). Half size.

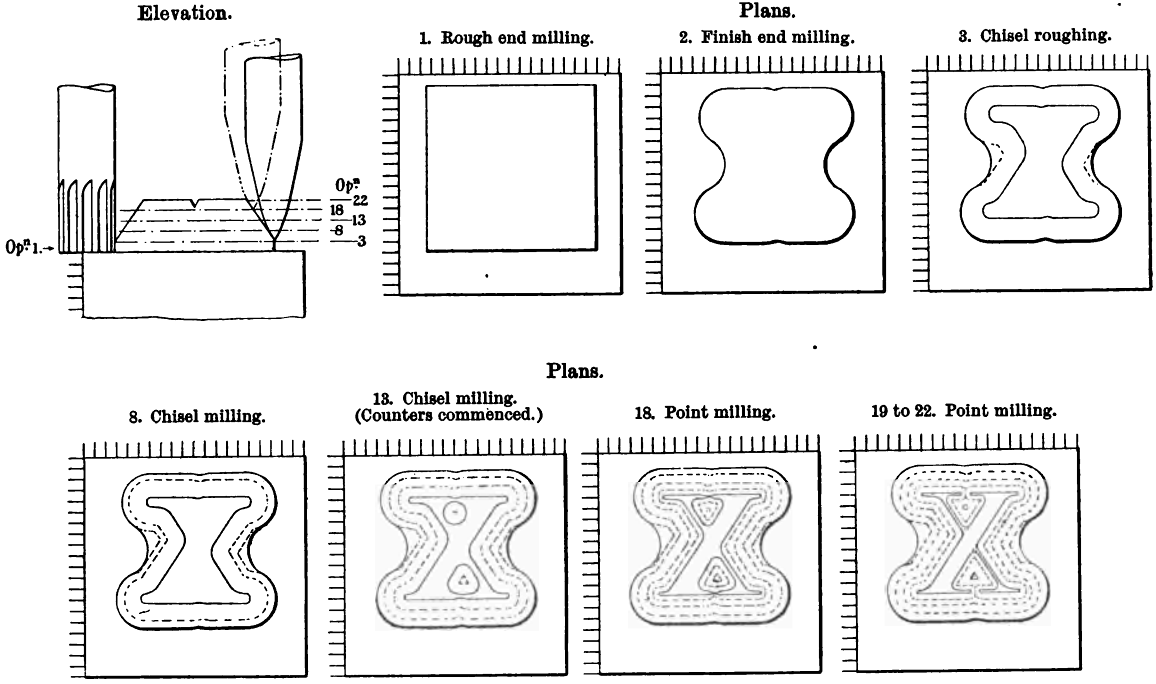


Section at A.B.

Inverted Plan of Chuck.

The milling cutter used in punch-cutting is shown in Fig. 12; 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

FIG. 12.—*Operations of Punch-Cutting* (*Benton-Waldo Machine*).
(About 4 times full size.)



Elevation.

Plans.

1. Rough end milling.

2. Finish end milling.

3. Chisel roughing.

Plans.

8. Chisel milling.

13. Chisel milling.
(Counters commenced.)

18. Point milling.

19 to 22. Point milling.

FIG. 13.

Roughing (or Chisel) Tool for Punch-Cutting Machine (Benton-Waldo).
20 times full size.

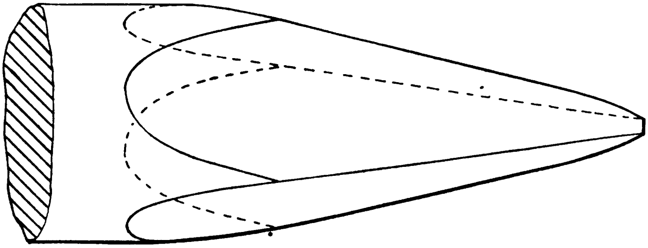
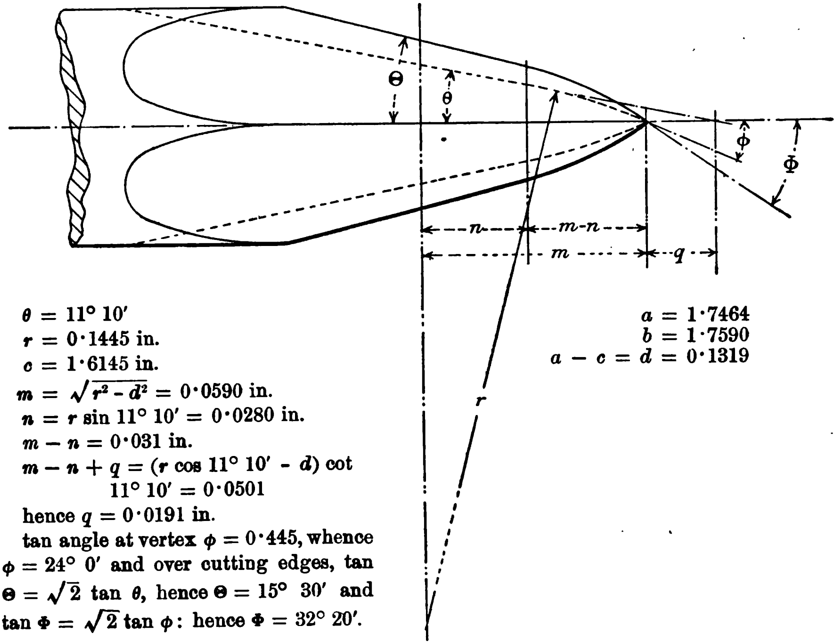


FIG. 14.

Cutter for Punch-Cutting Machine (Benton-Waldo). 20 times full size.



$\theta = 11^\circ\ 10'$
$r = 0\cdot 1445$ in.
$c = 1\cdot 6145$ in.
$m = \sqrt{r^2 - d^2} = 0\cdot 0590$ in.
$n = r \sin 11^\circ\ 10' = 0\cdot 0280$ in.
$m - n = 0\cdot 031$ in.
$m - n + q = (r \cos 11^\circ\ 10' - d) \cot 11^\circ\ 10' = 0\cdot 0501$
hence $q = 0\cdot 0191$ in.

tan angle at vertex $\phi = 0\cdot 445$, whence $\phi = 24^\circ\ 0'$ and over cutting edges, $\tan \Theta = \sqrt{2} \tan \theta$, hence $\Theta = 15^\circ\ 30'$ and $\tan \Phi = \sqrt{2} \tan \phi$: hence $\Phi = 32^\circ\ 20'$.

$a = 1\cdot 7464$
$b = 1\cdot 7590$
$a - c = d = 0\cdot 1319$

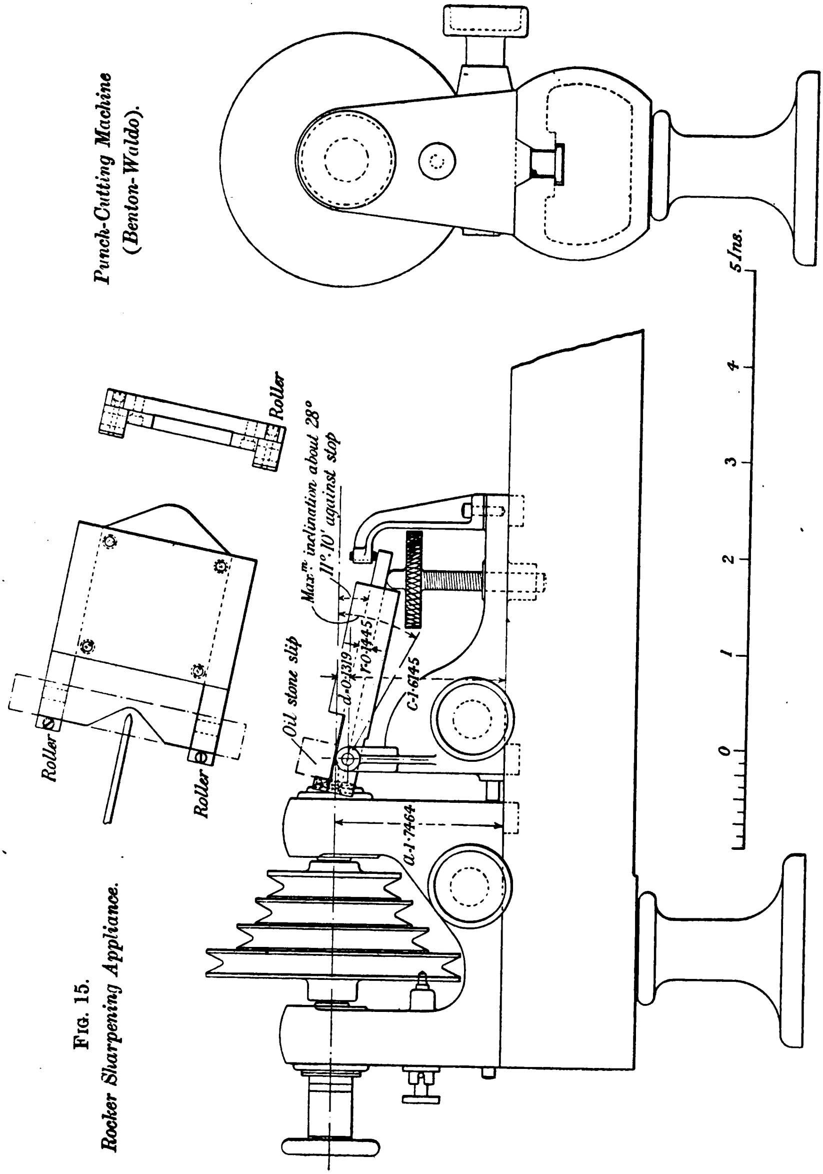


FIG. 15.
Rocker Sharpening Appliance.

Punch-Cutting Machine
(Benton-Waldo).

formed by the intersection of each pair of cylindrical surfaces are therefore elliptical. In the roughing cutter which has a small chisel edge, Fig. 13 (page 1064), two of the opposite cylindrical faces have their axes in a different plane to the other pair. In the finishing cutter the axes are all in one plane and a pointed symmetrical cutter results, Fig. 14. 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. 15 (page 1065), 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 in 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 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 body of the fount worked on. The punch is held in the chuck against these true faces of the stem by the pressure of two grubscrews, and then is rubbed down true on an oilstone, 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 taken round the periphery of the punch, thereby finishing 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. 12 (page 1063). 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 is used at the end of the process in order to obtain the outline at the surface of the punch. Fig. 12 shows the path of the point of the cutter at five different depths. The punch must be examined under the microscope to see that no error has been made in the cutting. The net labour up to this stage costs about 2*s.* per punch. 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 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 faces. To justify the punch the author, with the assistance of Mr. C. Colebrook, of the Wicks Co., designed a small vice swung on gimbals, the two movements of inclination being each operated by a separate micrometer screw. To use this 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 so arranged as to justify the character in respect 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.

The *formers* are secured in place on the table of the machine by a pair of folding wedges. They are justified on the two sides which correspond to the trued sides of the punch blank, so that the character which rises about $\frac{1}{16}$ inch above the base of the *former* occupies the desired position in respect to these edges. The base of the *former* is about $\frac{3}{32}$ inch thick. In the case of accented sorts the upper part of the *former* is cut away to receive the accent *former*, so that the number of *formers* required can be kept a minimum. Special accents are required for the i owing to its small *set*, and a blank piece of equal size for the production of the non-accented sorts. With the exception of the i the accents can be made interchangeable.

A few of the *formers*, such as the mathematical signs, can be conveniently made on ordinary machines out of two thicknesses of metal riveted together, but for the majority a different method is usually employed.

A *drawing* of the character is made about five times the size of the *former* required. The edges of the *former* are shown on this drawing to scale and in their proper position. The drawing is then fastened on the table of a pantograph under the tracing pin. The marking head of the pantograph is fitted with a plain cylindrical tool. The ratio of the pin diameter to the tool diameter is the same as the ratio of the pantograph. It is essential that there should be no backlash in the pantograph, and that it should be extremely rigid. The author with Mr. Colebrook designed a pantograph which has given very satisfactory results. The frame was made of bicycle tubing with steel single and double joints brazed in, the centres being all made adjustable double cones like lathe centres.

The *formers* are produced by electrotyping in the following manner. Type-metal plates of equal and uniform thickness are coated with a wax composition which is shaved off on a machine to the thickness of the raised portion of the letter. The pantograph tool is lowered so as to pierce the wax and pushes its way through it, the first tracks being kept a small distance away from the finished line. After the character has been roughed out the wax surface is rubbed true by going round with the outside of the tracer pin touching the line on the drawing. The burr on the wax is dressed off on the shaving machine; the wax is examined and any holes stopped. The whole is then blackleaded and electrolytically coated with copper to a thickness of about 0·03 inch. The shell is removed by warming the wax, the rough edges are trimmed, it is then tinned inside and filled with lead. The filled *formers* are milled off on the back to thickness, and squared up on the justified edges so that the character is truly in place in respect to these edges.

The "hand" and size of the character as compared to pica body varies through these and the following operations thus :—

(1) Drawing . . .	inverted	90 times full size.
(2) Wax mould for *former* .	inverted, but reduced to .	18 ,, ,, ,, *
(3) Electrotyped *former* .	erect	18 ,, ,, ,,
(4) Punch	inverted	natural size.
(5) Matrix	erect	,, ,,
(6) Type	inverted	,, ,,
(7) Printing . . .	erect	,, ,,

In the case of newspapers and many books two more reversals occur, a mould in flong (which somewhat resembles papier mâché) being taken from the type and a stereotype cast from this.

Matrices (Figs. 16 to 21, page 1070).—In consequence of the care expended on the punch, the actual impression made in the matrix when the punch is struck is practically as accurate as the punch when the mass of the matrix metal is large, but in some cases the metal in the centre of the strike rises under the action of the internal stresses caused by striking, with the result that the character cast in it is hollow in the face. Such difficulty may be dealt with successfully by drilling a hole transversely in the matrix blank below the centre of the strike as shown in Fig. 18. The form of the matrices varies greatly with the machine in which they are used; the simplest form (generally of copper) is that shown in Fig. 16, and is used in the simple typecasting machine for casting one character at a time. The matrix for the Wicks machine is struck in the end of a long stem of brass which

---

* In the case of pearl the reduction in the punch-cutting machine is about one forty-fifth.

Matrices. **Full size.**

FIG. 16.

Titchener.

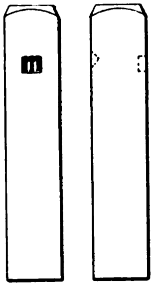


FIG. 17.

Wicks Rotary.

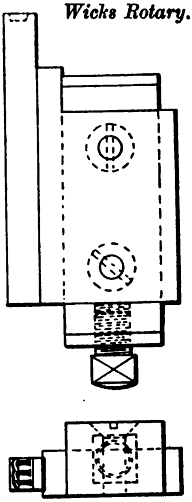


FIG. 18.

Lanston Monotype.

FIG. 19.

Monoline.

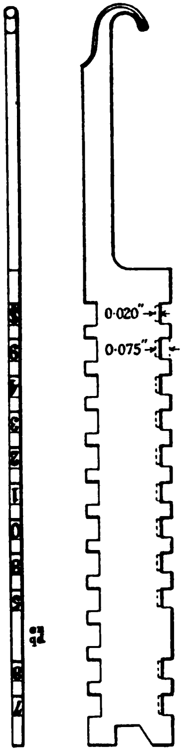


FIG. 20.—*Linotype*

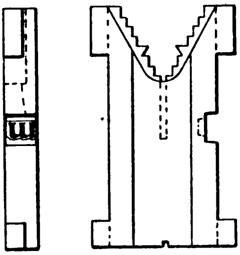


FIG. 21.—*Stringertype.*

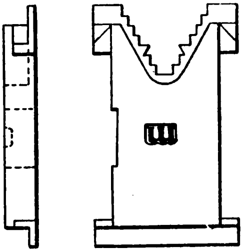
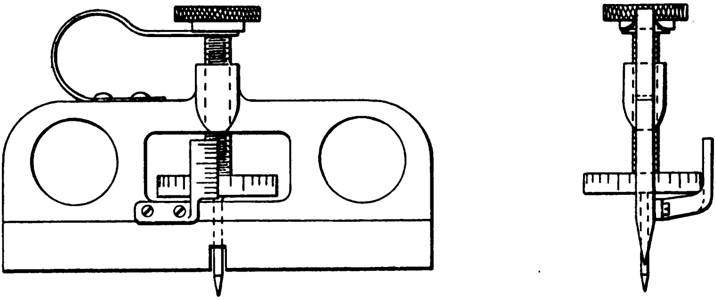


FIG. 22.—*Needle-Point Micrometer Depth Gauge.* **Full size.**

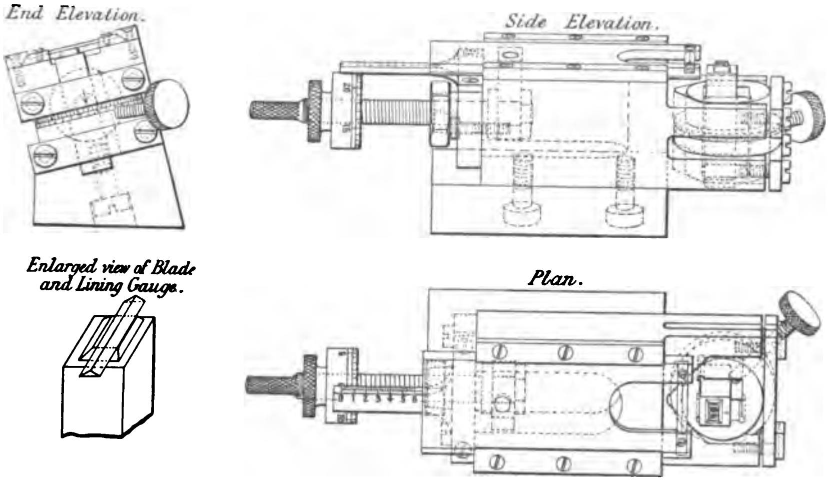


is machined on its sides, Fig. 17. The Lanston Monotype matrix, Fig. 18, is struck in the end of a small square block of bronze. The Linotype matrix is struck in the edge of a sheet brass stamping, Fig. 20. The Monoline machine uses a compound matrix having several strikes on one bronze bar, Fig. 19, and the Stringertype matrix is struck on the flat side of a brass stamping, Fig. 21.

Fig. 23.

Micrometer Measurer for Punches and Type.

Half size.



Justifying.—The operation of fitting or machining the surrounding metal so that the face of the strike, which is at the bottom of the depression in the matrix, is accurately placed in respect to the exterior is known as justifying. The matrix is tested by taking a trial cast, comparing this with a standard letter, usually the lower case m, and measuring it with various appliances. A needle point micrometer, Fig. 22 (page 1070), is used for the depth and a bevelled edge micrometer, Fig. 23, is used for measuring the face. Squares are used for testing the face, the type being sighted against the light in two directions at right angles to each other. In the case of the simple matrix shown in Fig. 16 the trial and error method suffices, but in the

Wicks matrix a number of milling operations are necessary. The trial type must be measured, and the matrix stem bent and twisted to bring the strike true for squareness of face and line. Cuts are then taken off the sides of the matrix and off the base; trial type are again taken, and the matrix further corrected if found necessary; finishing cuts are taken, and last the matrices are gang-milled to length and end-milled to body. With hand-cut punches some twenty-three operations were necessary; with machine-cut punches the number was reduced to about seventeen; the various operations are shown in Fig. 24. The work of justifying is very highly skilled, a good justifier earning £3 10*s.* to £4 per week; it is therefore of great importance to reduce this work to a minimum. The reduction in number of operations was largely effected by rigidly holding the punch close to the face, by rigidly holding the matrix close up to the strike, by supporting the metal on all sides, and by accurately setting the punch in position before striking. The saving in justification was effected by elimination of some of the earlier roughing operations.

In the case of matrices which are required in large quantities for matrix composing machines, the adjustment of the striking press must be made by the justifier, and when set the product controlled from time to time. The larger the number of matrices to be struck and justified, the more important it is that the punches be themselves accurately justified and accurately set in the press. In the earlier matrices made for the Wicks machine the author used a light, overhung striking press weighing only some 100 lb.; for the later matrices made in quantity, a press with symmetrical slides and a central plunger was used weighing some 30 cwt., the extra rigidity contributing greatly to saving in justifying.

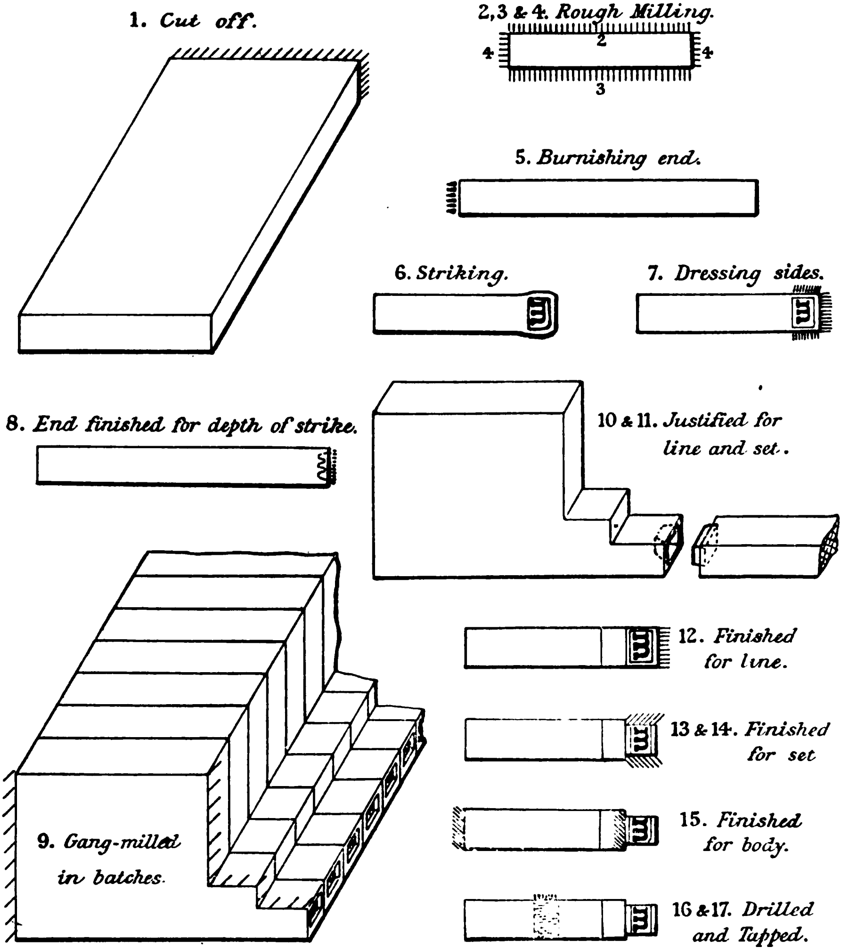
Depth of Strike.—The depth of strike in ordinary matrices is usually 0·045 to 0·050 inch. It is, however, less in the matrices of several of the casting and composing machines; it attains its minimum 0·02 inch in the Linotype and Monoline.

Engraving Matrices.—A method of manufacturing matrices has been introduced in the last few years, in which the operation is

Fig. 24.

Operations in Machining Matrices.
(*Wicks Typecaster.*)

Full size.



performed by a small high-speed cutter carried on a pantograph; a *former* is used and the process is the converse of that employed on the punch-cutting machine.

The Ballou Engraving Machine for Matrices.—The problem of engraving the matrix is much simpler than that of cutting punches. The character can be cut out of metal plate like a stencil and then secured by riveting or tinning to the backing. The follower may be of constant diameter, but must be sufficiently small to allow it to follow the outline in the hair lines. The shape of the cutter can be that obtained by grinding a small amount off two of the opposite faces of a square pyramid, so that these faces meet in a line, the length of which is in the same ratio to the follower as the reduction ratio on which the machine is to work. The depth of cut is constant, the flat surface of the main stroke being obtained by traversing ten or more times to and fro over the length. The complex settings of the Benton-Waldo machine are here unnecessary, and since the material to be cut is soft the cutter lasts a long time without sharpening, and the sharpening itself is a comparatively simple matter. The machines when set and adjusted by skilled mechanics can be operated by girls.

A similar machine known as the Dietrich was introduced about 1899. It was arranged to operate successively on four matrices.

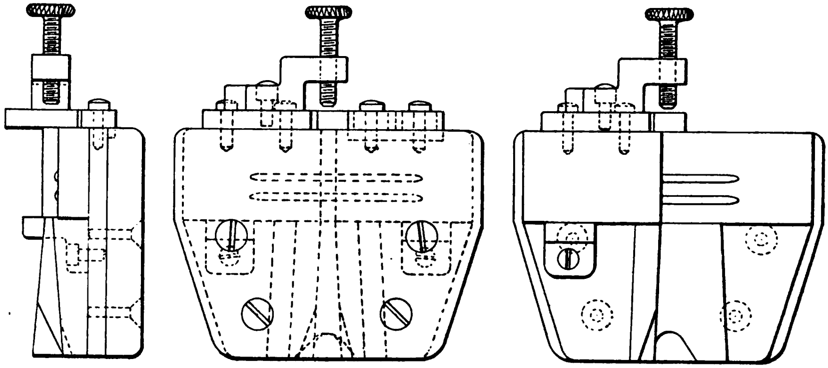
Electrotyping Matrices.—The easiest method of making matrices for the simple typecasting machines is by electrolytic deposition of copper. A type of the desired character can be surrounded by two pieces of type-metal of similar form to the mould, and the *face* of the matrix is thus obtained true in the first place; the rough deposited sides of the matrix are filed or machined true subsequently. There can be no objection to the use of this method in cases of urgency or repetition, for example when a punch has been damaged or broken, but it has been resorted to by less-principled founders in copying the founts of the leading founders. For the matrices used in the later forms of typecasting machinery electrolytic copper is not generally hard enough to stand the wear, and the rough deposited surfaces require too much and too troublesome machining. A new process has recently been introduced in Germany by which the matrices are deposited in nickel much harder than the bronzes hitherto in use, and it appears to the author that this may be of considerable importance in the manufacture of machine matrices.

Moulds.—The simplest form of mould consists of two halves which are nearly alike. Both are built up of pieces of hardened steel ground and lapped true, and screwed together. The mould thus made is of definite size for *body* but variable for the width of *set*, the parts being fitted with stops which close on the matrix and obtain from it the correct *set* width, the width of each matrix being therefore the *set* + a constant. In the direction of the height of the type the mould is wider than the length of stem, so as to provide for the gate for the injection of the molten metal. In one part of the mould are inserted the raised beads for producing the nicks in the type, and in the counterpart grooves are ground and lapped to fit the raised beads which are exposed in the mould for a greater length as the *set* of the type to be cast is increased. The author has found that type-metal under the conditions of typecasting machines will flow into an opening between surfaces varying from 0·0005 inch where the surfaces are water-cooled internally, to 0·0002 inch (and even less) where the mould is allowed to become warm. This inflow of metal will cause difficulty in ejecting the type, and will give it a fringe or ragged edge. In moulds of the kind just described, where no provision is made for continuously cooling the mould, the type cast from the mould before it has attained the working temperature are not accurate for size; the speed is limited to that at which the mould does not overheat unduly, and in practice it is kept from overheating by stopping the machine from time to time and cooling with a wet rag. Some idea of the difficulty and expense of mould making may be gathered from Fig. 25, which shows a mould for type with two nicks (the average number). The one half consists of at least five pieces while the counterpart carries in addition the beads and the stop. The beads for forming the nicks contribute greatly to the difficulty, since the hole is partly in each of two pieces of hardened steel which must be finished before the hole is lapped out, and the wire, which is made a gauge fit, must have its axis parallel to the surface within the degree of accuracy required for tightness in respect to the melted metal. As the mould undergoes some distortion when heated, and some due to wear, the fit when new requires to be within 0·0001 inch. Mould making as a trade is over

Fig. 25.

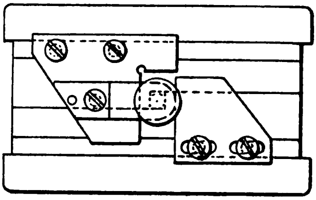
Justifier's Type Mould.

Half size.



Side Elevation, one half removed. *Front Elevation.* *Front Elevation, front half removed.*

Plan.



200 years old, and as in the case of lapidaries' work the finishing is usually done by means of lead laps; the skill attained by the workmen in this trade is remarkable.

The Wicks Mould (Fig. 48, page 1096).—Difficulties, however, beset on all sides the inventor and the engineer who have to design and make moulds of forms different from those to which these workmen are accustomed. The mould of the Wicks machine will serve as a particular example. The moulds of the Wicks machine are of the form of 100 radial grooves in a disk 20 inches in diameter. The groove, three inches in length, forms three sides of the mould (the back and sides of the type). The matrix, Fig. 17 (page 1070), slides in the mould; the top cover, *c*, Fig. 48 (page 1096), which is fixed and under which the mould passes, forms the remaining side of the body (the front of the type) and the shield, *q*, through which the molten metal is injected forms the foot.*

The first attempts to build a mould not proving successful, the next step taken was an attempt to mill and lap out the grooves in the disk. This also failed to give satisfactory results, and recourse was again taken to building up the mould. The mould-wheel in this form was as shown in Fig. 29 (page 1079). The mould-wheel was built up of a cast-iron wheel in which an annular groove formed the water space, which was covered by a cast-steel foundation ring turned all over, the latter being secured by studs to the upper surface of the cast-iron wheel.

The upper surface of the foundation ring was turned flat and scraped true; the wheel was then mounted on a division plate and dowel holes drilled through a jig carried on the central column of the division plate. Dowel pins were driven into the holes in the foundation ring and the segments (also drilled in the jig) pressed down into place; tapped holes were also necessary in the segment to enable it to be drawn off the dowels for grinding and for lapping the

---

* The error introduced through the foot having a 10-inch radius is very small. A pica em quad has for sagitta of the arc forming its base a length of only 0·00035 inch, which is less than the permissible error in height-to-paper for type.

sides. To obtain squareness in the parts of a mould, the knife-edge square, Fig. 26, was used; for straightness of the faces the knife-edge triangular straight-edge, Fig. 27, was employed, and to measure the width of the mould at various parts of its length, folding-wedge gauges divided on the upper sides were used as shown in Fig. 28. The segments were made of cast steel and left soft. Allowance for grinding was made on the thickness of the segments and the aggregate top surface ground true in place. This wheel gave fairly satisfactory results, but the top of the segments wore rapidly under the top cover which was kept in contact by spring pressure. The next improvement was to adjust the top cover by means of folding-wedges and a screw adjustment so arranged that the cover could be brought down into contact with the segments and then backed off some 0·0002 inch to 0·0003 inch. This did not, however, stop the wear of the segments owing to the difficulty of lubricating sufficiently and yet obtaining perfect type. The next step consisted in milling dove-tailed grooves in the foundation ring, and in fitting the hardened steel base pieces which were secured by dowel pins, Fig. 30. The whole surface of the foundation ring was then ground true in place on its column, transferred to the division plate and hardened steel segments fitted. These segments were

Fig. 26.—*Diamond Square.*
Half size.

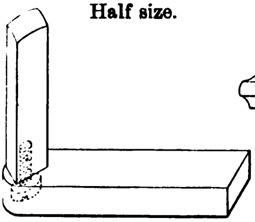


Fig. 27.—*Knife-edge Straight-edge.*
Half size.

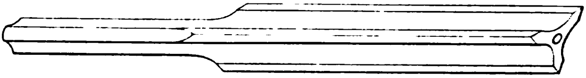


Fig. 28.—*Folding-wedge Gauges for Measuring Type-moulds (taper* 1 *in* 100).
Full size.

Details of Rotary Typecasting Machine (Wicks). Full size.

Fig. 29.—*Soft Moulds.*

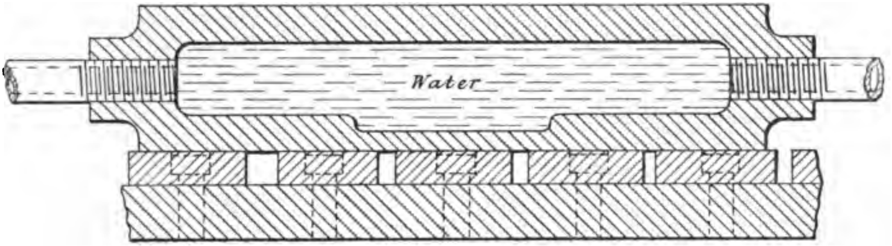


Fig. 30.—*Hard Moulds.*

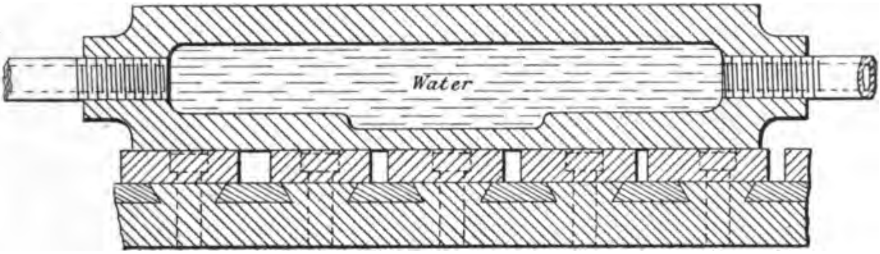
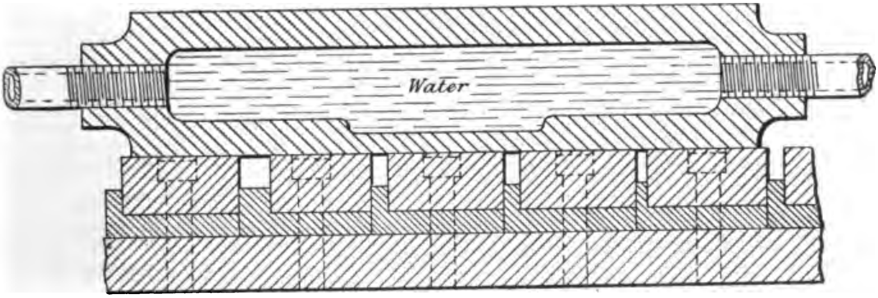


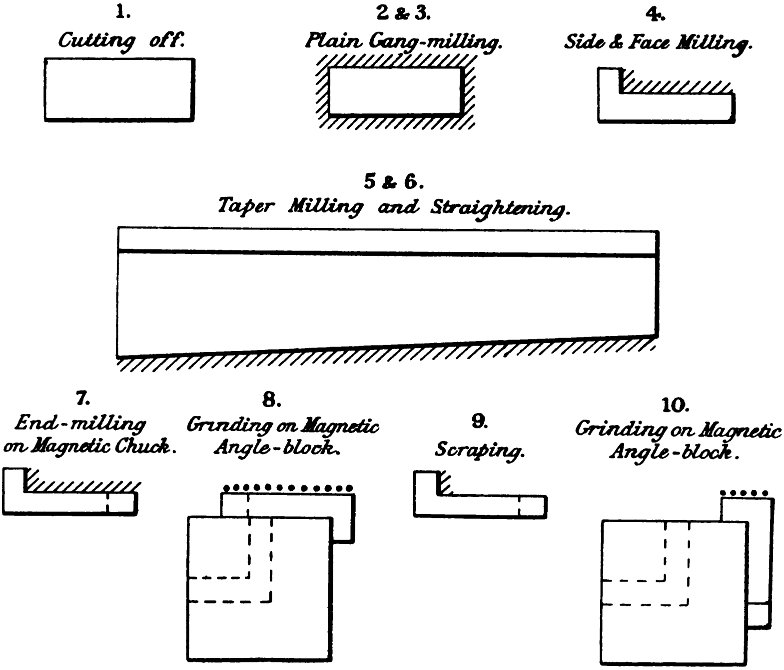
Fig. 31.—*Angle-base Moulds.*



secured by dowels and screws as in the case of the soft segments just described. This wheel was extremely costly to make, and when put to work showed appreciable wear in so short a period of time that the amount of type produced before the wheel required new segments would not have been sufficiently large to ensure commercial success.

Fig. 32.

Angle-Base Operations. Rotary Typecasting Machine (Wicks). Full size.



A number of machines had now to be constructed in a limited time, and the problem was dealt with by the author in the following manner. The surface of the foundation ring was turned and ground true in place on its column, and the mould was built up of two segments as shown in Fig. 31 (page 1079). The angle-base segments were of annealed cast steel and produced by the following operations, Fig. 32. (1) cut roughly to length; (2) and (3) rough gang-milled all over; (4) reduced over part width by milling; (5) tapered by milling in batches; (6) straightened; (7) end-milled in angle on magnetic chuck; (8) ground on back on magnetic chuck; (9) scraped straight on short vertical face; and (10) ground to *set*-width on magnetic angle-block.* The top segment operations consisted in (1) cutting to length; (2) and (3) rough gang-milling; (4) tapering; (5) straightening; (6) and (7) grinding on flats; (8) and (9) grinding on edges. Both top and bottom segments were at this stage about ½ inch longer than necessary for the reason that the bottom segment, if made to the standard dimension from the centre of the mould to the edge at the periphery of the wheel, would fail to make up the width should the next preceding segment be narrower in *set* of the mould of which it forms the base.

Assembling.—The first operation consisted in drilling and tapping the foundation ring; the drilling was performed by aid of a jig carried on the division plate and the tapping was done by an automatic tapping-head. The drilling jig was then removed and a segment put in place which had been already drilled by the setting jig while clamped on the plate; each segment was numbered as put in place; this setting jig had gauge surfaces a constant distance, C, from the centre of the mould; gauges were used for the setting of a width equal to C − ½ (*set*). The setting ring was then put on the outside

---

* The surface of the ordinary magnetic chuck, Fig. 33, will probably be familiar to many Members of this Institution, but for the class of work now in question it was frequently necessary to grind segments on the edge; also, owing to the high degree of accuracy required, the surfaces of the vice on which the segments were placed required re-grinding whenever the magnetic vice was replaced after being removed from the machine. The author designed the two kinds of magnetic angle-blocks shown in Fig. 34, which have proved useful for a number of purposes. The blocks each consist of two soft mild steel bars of good permeability milled out to ∟ or ⊔ shape and cross-milled with cuts which leave space for the complete separation of the two pieces of mild steel. The ends are secured by brass plates and screws, and the whole of the interspace is run up with white metal. The block is placed on the magnetic chuck, so that its poles respectively come over the poles on the chuck. The exterior can then be ground true, in place, on the surface grinder.

of the wheel and secured roughly true by means of four set-screws; this ring carried 100 screws, each of which served to adjust a segment in place by sliding it along the preceding segment; and as each was brought to position, it was then clamped by a temporary clamping plate and screw at the inner end. The setting having been completed, a sensitive drill, used in conjunction with the drilling jig, drilled the necessary holes in each segment, viz. three clearing holes for the holding-down screws, one hole for dowelling the angle base to the foundation ring and one hole dowelling the top segment to the angle

FIG. 33.—*Magnetic Chuck, Plan.*

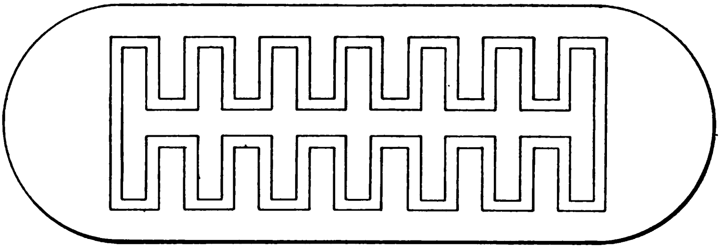
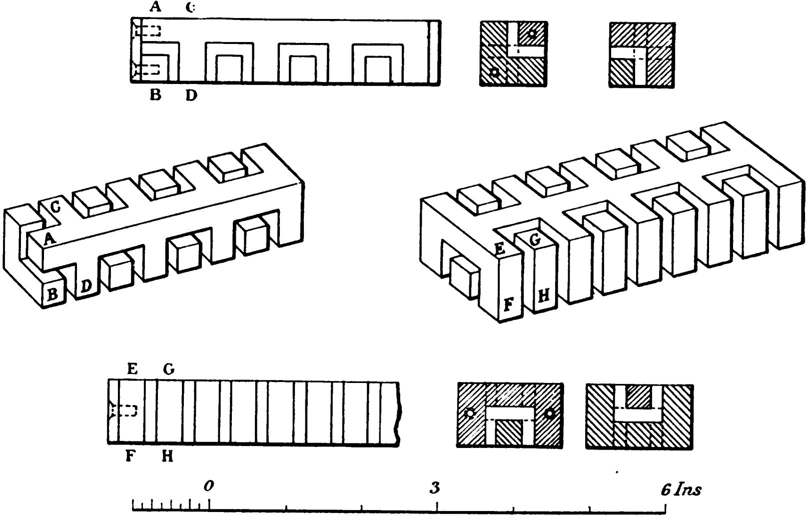


FIG. 34.—*Magnetic Angle-Blocks.*



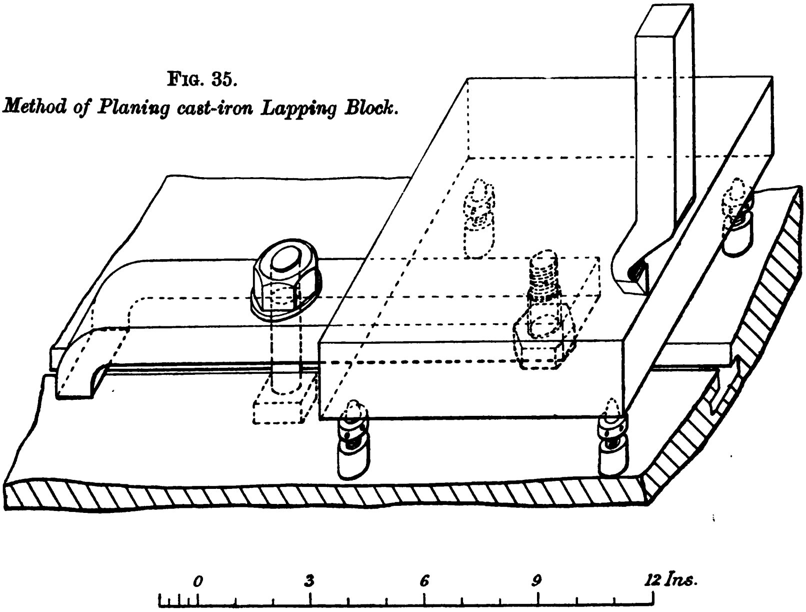
base, one forcing screw-tapping hole for removing the angle base from its dowel; and, in every tenth segment, a seventh hole for clearing the supporting stud of the matrix guide-ring. The angle bases could now be removed from the wheel, cut to length, and the burrs removed; the tapping could be performed and the straightness checked; if found necessary the short vertical face was again scraped. The setting ring was then raised and clamped roughly true so that the centres of the screws came opposite the *top* segments. The bottom segments were replaced on the wheel and secured by temporary screws through the clearing holes. One angle base being dowelled to the wheel, a top segment was placed on this and another top segment on the next consecutive angle base, each top segment having been lapped true on its vertical faces. The top segments were pressed towards the centre of the wheel by the setting screws, and the width of the mould formed by them was measured by means of the folding-wedge gauges, Fig. 28 (page 1078). The angle base was then forced off its dowel and lapped on the vertical face, until the mould obtained was a gauge fit through its length. Each mould was thus finished in turn and the top segments as finished were dowelled to the bottom segments, each being numbered as put in place. The top segments were then all removed, and the angle bases secured by temporary screws with thin flat heads; the wheel was transferred to its own central column on which the foundation ring had been ground true. The tops of the angle bases were now ground true in place, the top segments replaced and also ground true, the depth of the mould or size of body being thus obtained. The wheel was then ground true on the periphery and the shield scraped to fit. The underside of the wheel was also ground true, to give a bearing for the lower bearing surface carried by the shield. These adjustable folding-wedges are shown at o_3, o_4, Fig. 48 (page 1096).

The soft wheel, however, did not meet all requirements. The body-size could be restored a large number of times by grinding the tops of the angle bases and the tops of the segments; but the top segments wore after a considerable period, so that the less important dimension, the *set*, became large; but the greatest difficulty to be met was the provision for the nicks in the stem. Experiments made on a wheel with soft segments demonstrated the possibility of casting the nicks instead of milling them, and thus obtaining type more free from burr, with a nick more acceptable to the compositor, and with less risk of breakage of the thin sorts.

The necessity for hard top segments now became apparent. In making these the first five operations were the same as in the case of the soft segments. The sixth operation consisted in drilling in a jig, in which the segment was set in place with allowance for grinding, according to the sizes of the preceding and succeeding moulds of both of which it formed part. The seventh operation was cutting to length, and the eighth hardening. The tempering was performed by heating in an oil bath at a temperature of about 320° F. for some four hours. By this method the hardness could be adjusted with great nicety and equality, for the whole of the wheel. The inner ends of the segments, in which the hole for the dowel pin had not yet been drilled, were softened. The segment was then rough

FIG. 35.

Method of Planing cast-iron Lapping Block.



ground on both flats, rough ground on the edges, re-ground on the faces after an interval of time for recovery, re-ground on the vertical faces, and finally lapped on these faces.

The wheel being assembled, the nick grooves were ground in with a fine emery wheel turned to shape on the edge to give the required section and depth. The beads in the top cover were produced in the following manner. The top cover was mounted on the circular rotary table of a vertical milling machine; a small cutter spindle, driven by an electric motor, was used to mill out a groove of the required width for the bead and to the correct radius from the axis of the wheel. The bead was made of hardened steel wire ground and lapped cylindrical and subsequently ground flat on two faces to fit the milled groove tightly. At the one end the milled groove was tapered by hand to permit of removal of the bead for fitting. The final fitting was done by lapping the face of the wire opposite the bead. The curvature of the groove in the top cover was so slight that the bead wire could be sprung into place without difficulty. The nick bead is shown at *e*, Fig. 48 (page 1096).

The Linotype Mould is shown in Fig. 36 (page 1086). As in the case of the moulds already described, it is built up of several pieces of hardened steel. The special features of its construction, will, however, be seen best by reference to the drawing of the type slug cast from it, shown untrimmed in Fig. 38 (page 1087). The cross projections at the foot of the slug prevent the slug from being sucked forward through the mould when the matrices are withdrawn from the face. These projections are removed by the end trimming knife, during the partial revolution of the mould wheel; to prevent the nozzle drawing the slug back, each end of the mould is formed with a small projection at the foot. The grooves in one long face of the mould form raised ribs on the back of the slug; in ejection from the mould these pass through between the trimming knives which shave them down, and ensure correct body size when the slugs are placed in column.

In the limited space of this Paper the author cannot describe in detail the moulds of all other typecasting machines, but single type

Fig. 36.

Mould and Mould-Wheel (Linotype Machine).

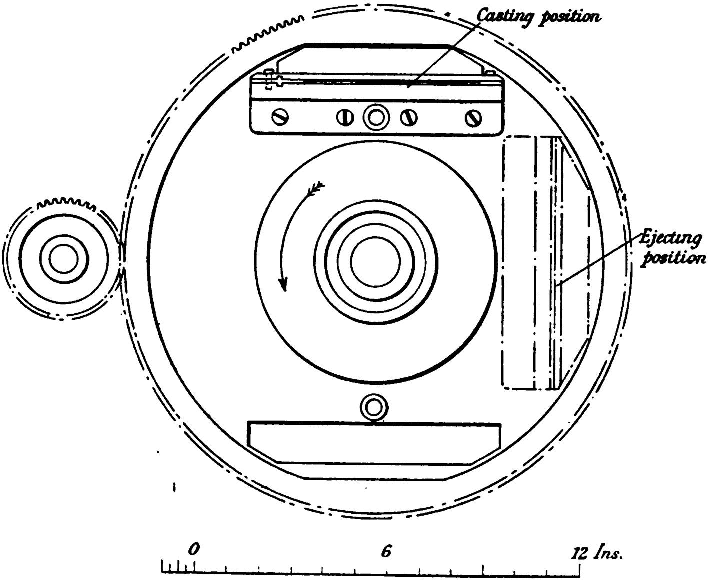


Fig. 37.

Interrupted-revolution Driving Gear of Mould-Wheel (Linotype).

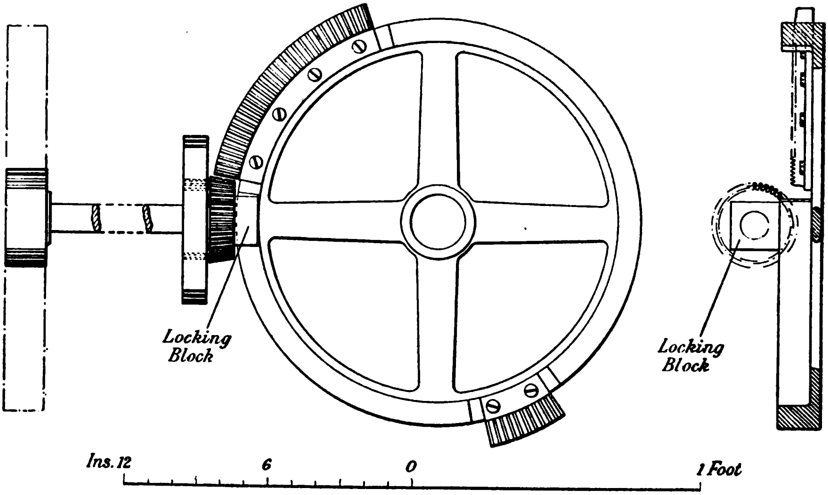


FIG. 38.—*Type Slug as cast in Machine before trimming (Linotype).*

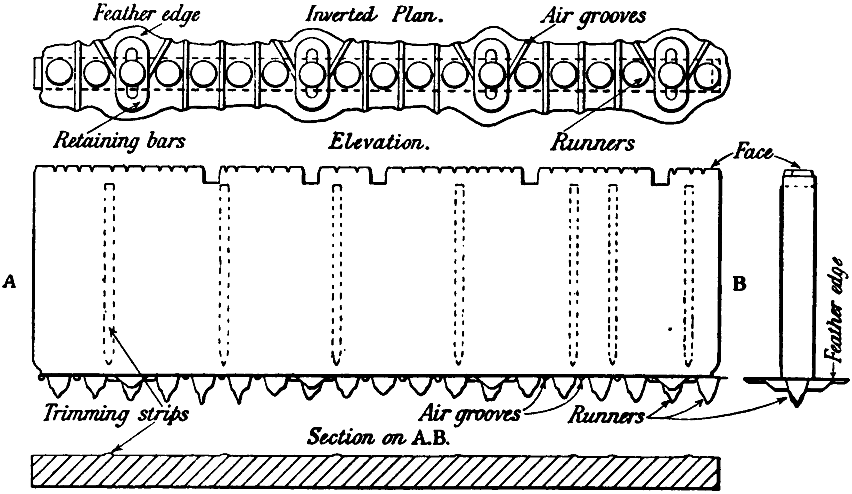


FIG. 39.—*Type Slug finished (Linotype).*

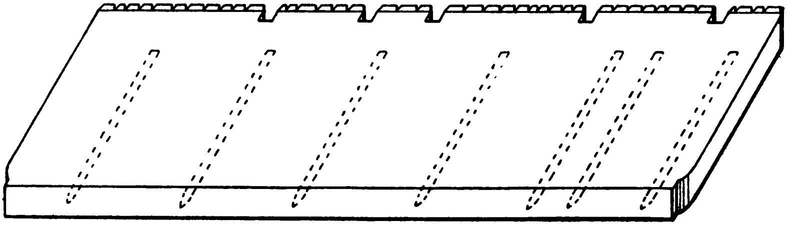


FIG. 40.—*Type Slug finished (Monoline).*

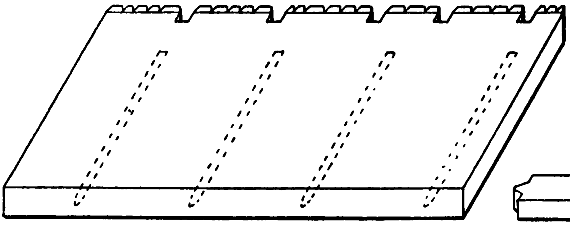


FIG. 42.
Type (Stringertype). As cast.

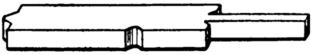


FIG. 41.—*Type as Cast in Machine (Lanston Monotype). Tang and jet shown dotted.*

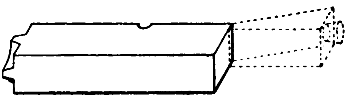
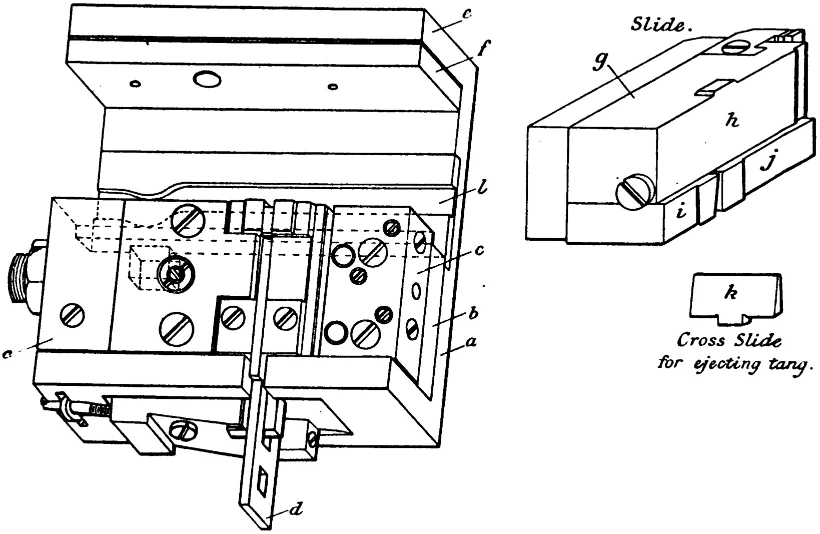


FIG. 43.
Type (Stringertype). Tang broken off.

as cast in two of the machines mentioned in the Paper are shown in Figs. 41 to 43.

The Mould of the Lanston Monotype Machine, Fig. 44, is built up of several pieces. In the foundation plate of the fixed part is the hole for the injection of metal from the pump; this hole is coned to fit the end of the pump nozzle which is elevated into place before starting the machine. To the foundation plate is secured an intermediate plate, and on the top of this are fixed two body-blocks which form respectively the back and front of the type; between these blocks, through which water is circulated, slides a rectangular plate of the same section as the type measured from foot to shoulder. The position of this slide is regulated by means of wedges, as

FIG. 44.—*Casting Machine* (*Lanston Monotype*).
Perspective View of Mould.



Cross Slide for ejecting tang.

a.	Foundation plate.	*g.*	Slide.
b.	Intermediate plate.	*h.*	Main portion of slide.
c, c.	Body blocks.	*i, j.*	Tang pieces secured to main portion of slide.
d.	Rectangular sliding plate.	*k.*	Tang cross-slide.
e.	Vertical plate.	*l.*	Cam groove.
f.	Hardened steel bearing plate.		

described below, so as to give the required *set* width to the type to be cast. A vertical plate is secured to the end of the foundation plate opposite to the mould, and a hardened-steel bearing plate is secured to this by dowels. In the space between this bearing plate and the face of the body-blocks the slide travels to and fro for each character cast. The slide itself is built up of a number of pieces, two of which, fixed to the main portion, form the front and back of the tang of the type; a tang-slide working between these forms the side of the tang. The fourth side of the tang is formed by the vertical face of the intermediate plate between the foundation plate and the body-blocks. The slide is guided by the projection of the tang pieces below the body-blocks; the tang cross-slide is moved by a projection fitting in the cam groove milled out of the foundation plate.

The operation of casting is performed as follows: the slide comes to rest with the tang opening opposite the mould; the cross slide moves to the *set* width required, which is generally determined by the position of the matrix grid; the matrix grid descends on to the top of the mould and is brought to true position by means of the conical hole in the back of the matrix, Fig. 18 (page 1070). The pump plunger makes its stroke and fills the mould and tang. The matrix grid is lifted and the slide moves to the right, shearing off the tang from the type and the jet; as the slide continues its movement the tang cross-slide moves towards the body-blocks, ejecting the tang through the hole in the intermediate plate. When the slide has travelled clear of the type, the cross-slide ejects the type from the mould into the type carrier which delivers it to the galley; the slide then returns to the casting position. The whole cycle is repeated for each type cast.

Pumps.—Some of the greatest difficulties in the design of typecasting and matrix composing machines are to be found in the pump. They are generally of three kinds: (*a*) freezing of the jet, (*b*) stoppage of the jet by accumulated oxide (which occurs in pumps of intermittent action), and (*c*) difficulty in getting rid of the air which fills the pump delivery-pipe and mould and causes blowholes in the type.* These difficulties are met by various expedients; the jet is separately heated by gas burners, and is so arranged that metal does not remain adhering to the orifice and there become oxidised; the plunger throughout the working length is immersed below the oxidised surface in the metal pot and the surplus metal which is pumped is returned to the pot without exposure to the external air; the metal is delivered in large quantity and continuously, so that but little heat need be supplied by extra burners under the jet; and last, in some cases (e.g. the Linotype machine), special provision is made for clearing the air by fine grooves cut on the face of the nozzle.

The pump employed on the simplest typecasters consists of a single plunger mechanically fitted and spring operated. The pressure on the plunger at the commencement of the stroke is about 60 lb. per square inch, and falls during the stroke.

The Wicks Rotary Typecasting Machine Pump has four plungers about 1 inch diameter by 2 inches stroke, each driven by an eccentric and rod from a belt-driven shaft. The plungers are a mechanical fit in holes in a steel block forming the cylinders; the inlet and delivery valves are flat-seated disks enclosed in cover-plates bolted to the pump body. The delivery pipe is fitted with a vertical branch which forms a cylinder in which a mechanically-fitting plunger operates; this plunger is loaded by a lever and dead weight through the intervention of a long coiled tension-spring; at the top of the travel of the plunger in the cylindrical bore is a cross hole; the plunger thus serves the double purpose of accumulator and relief valve. The pump runs normally at 100 revolutions per minute, and the relief valve works at a pressure of 150 to 250 lb. per square inch. The diameter of the jet is about 0·1 inch. The pump delivers a large surplus of metal through the jet, which is returned through a shoot to the metal pot of pressed steel in which

---

* In his typecaster Sir H. Bessemer created a vacuum in the mould immediately before casting; although this method appears to have been successful in his case, it has no practical application at the present time so far as the author is aware. *See* "Life of Sir Henry Bessemer," p. 38 *et seq.*

the pump body is immersed. The metal is kept at a temperature of 700° to 800° F. by gas burners beneath the pot.

Linotype Pump.—This pump plunger is shown in Fig. 45, and the jet in Fig. 46. The plunger is made an easier mechanical fit than in the pumps previously described, and depends largely on the effect of the grooves. This method will be familiar to many Members of the Institution from its adoption some 25 years ago for the piston-rod in some tandem steam-engines. The pump is spring operated, the pressure being about 27 lb. per square inch at the commencement of the stroke and about 16 lb. per square inch at the end. The metal used is softer and has a lower melting point than that used in the other pumps described above.

FIG. 45.—*Pump Plunger* (*Linotype*).
Half size.

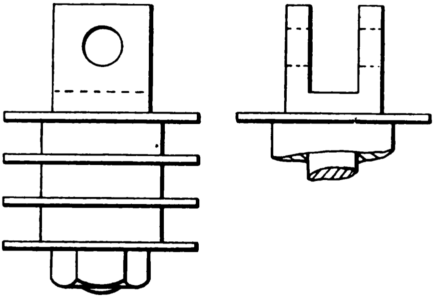
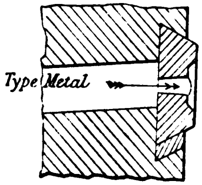


FIG. 46.—*Metal-Pot Mouth: Section* (*Linotype*). Nearly full size.



The Pump of the Lanston Monotype Casting Machine delivers the metal vertically upwards into the mould, see Fig. 44 (page 1088).

CLASSIFICATION OF TYPECASTING AND COMPOSING MACHINERY.

There are four operations usually required in the composition of printed matter: (*a*) typecasting; (*b*) composing; (*c*) line-justifying; * and (*d*) distributing.

The machines may be divided into four classes according to the number of these operations performed by each.

---

* To avoid confusion with the *justification* of type previously referred to, this term, when used in this Paper in reference to justification of line, is called *line-justification*.

Class I.—These are the simplest machines; they deal with one operation only.

Examples:—

I a. Simple typecasting machine (Titchener) (single mould).
Foucher typecasting machine (double mould).
Wicks Rotary typecasting machine } (multiple mould).
Bhisotype* (Prof. S. A. Bhisey) }
I b. Kastenbein, Wicks and Pulsometer composing machines.
I c. Stringer automatic line-justifying machine.
I d. Empire and Pulsometer distributing machines.

Class II.—Two-operation machines.

II a. Machines in which composing and line-justifying only are effected.

Examples:—

The Empire and the Dow composing and line-justifying machines.

II b. This comprises those machines in which the cycle is divided into two parts; generally the composition is effected on one machine and the record (in which the line-justification is provided for) is transferred to the second machine, on which the casting and line-justifying are performed automatically, the type being delivered in lines into a galley. In such machines the type is not usually intended to be distributed, but to be remelted. It follows that in general such machines are interdependent and designed to work together.

Examples:—

The Lanston Monotype composing and casting machines, the Tachytype (F. A. Johnson), the Graphotype† (G. A. Goodson), and the Dyotype* (J. Pinel).

Class III.—Three-operation machines.

III a. Machines in which type is distributed, composed and line-justified.

---

* See Appendix V (page 1163).

† See Discussion (page 1203).

Examples:—

The Thorne and the Paige distributing, composing and line-justifying machines.

III b. Machines in which matrices are composed into line and line-justified, a slug being then cast from the complete line. There can obviously be no distribution, and the slugs are remelted. Distribution of the matrices is effected after each line is cast.

Examples:—

The Linotype (O. Mergenthaler), the Monoline (W. S. Scudder), and the Typograph* (J. R. Rogers).

Class IV.—Four-operation machines.

IV a. Machines in which the matrices are composed into line and line-justified; single type are cast from the matrices (the spaces being of the width determined by the line-justification of the matrices) and delivered into a galley. The single machine performs the whole of the work which, in Class II b, is divided between two machines. The type is not generally intended to be distributed, but to be remelted. Distribution of the matrices is effected after each line is cast.

Example:—

The Stringertype typecasting and composing machine.

IV b. No machine performing the four different operations of casting, composing, line-justifying and distributing is known to the author.

Class Ia. Typecasting Machines.

The Simple Typecasting Machine is usually known in England as the Titchener machine; this is substantially the same as the Bruce machine, invented and used in America prior to 1845. In this machine the mould is very similar to the justifier's mould shown in Fig. 25 (page 1076). The two halves of the mould are mechanically operated, so that they are brought together and held in contact by the pressure of a spring with the gate of the mould pressed against the nozzle of the pump. The pump plunger, which is at the top of its stroke, is now allowed to descend under the action of its spring; after the completion of the stroke the mould is drawn away, and

---

* See Appendix V (page 1169).

the two halves separated, the type with the tang attached falling into a tray. A different mould is required for each body, but the mould is adjustable for those variations in *set* which occur in a fount of type; a different mould is also required for quads, on account of the difference in height-to-paper. As the nicks differ for different faces of the same body, a suitable mould is required for each different arrangement of nick. The nicks on the body are produced in casting, but the removal of the tang and the cutting of the heel-nick must be performed subsequently. The type, after the tang has been broken off, are arranged by hand on a stick for the operation of planing the heel-nick, which is also performed by hand. The machine is belt driven, and the movements of the pump plunger and mould are effected by ordinary cam mechanism presenting no remarkable features of interest. The output of the single mould typecasting machine varies from about 3,000 per hour in pica, to 4,000 per hour in smaller bodies.

The Wicks Rotary Typecasting Machine represents the highest development at the present time of machines for producing finished type, Fig. 47, Plate 32. The machine has 100 moulds mounted in a wheel which is revolved continuously by worm gear, the number of moulds of each particular *set* being determined by the demand for type of that *set* size. The last columns of Tables 3 and 4 (pages 1040–1041) show the normal demand based on the bill of fount,* and the number of moulds of each *set* must be determined from this so as to give the minimum of waste due to overproduction of certain sorts. It is moreover necessary that some of the matrices should be changed at suitable intervals, so that the proper proportional number of each

---

* Although type is produced by the Wicks Rotary Typecasting Machine at a much lower cost than by the single-mould machine, it is obvious that the machine cannot cope with a heavy demand for extra sorts if these are of a *set* width of which there may happen to be but few moulds in the mould wheel. Hence it is a commercial necessity that a foundry equipped with Wicks Rotary casting machines should have, in addition, some single-mould machines; these may, however, be adapted to use the Wicks matrices by providing suitable moulds.

character may be cast. From these considerations it follows that, if more than one face is to be cast in the wheel, these faces must be so designed that they agree closely in total demand for each *set* width. Type of different faces may be distinguished by supplementing the cast nicks with a cut nick, produced by a milling cutter in a similar manner to that used for producing the heel-nick.

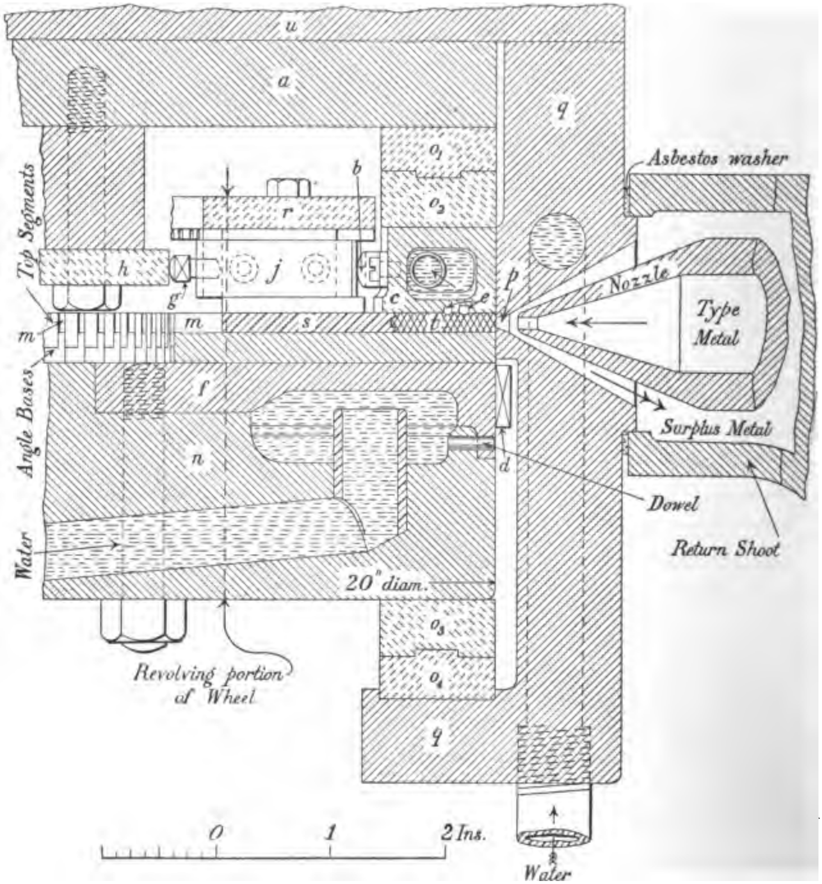
The sequence of operations in the Wicks machine is as follows:—After the type has left the mould *m*, Figs. 48 and 49 (pages 1096–1097), the matrix *s* is gradually withdrawn by a cam carried on the head *a* of the machine and bearing against the hard steel surface of the matrix jacket *j*. The matrix is guided on the stem by the mould, and at the upper part by a groove in the matrix guide ring *r*. After passing the withdrawing cam *w*, Fig. 49, the matrix is slightly advanced towards the periphery of the wheel by the height-to-paper cam *h*, Fig. 48, which acts on the screw *g* in the matrix jacket; a light plate spring *b* carried on the top cover *c* presses against the outer surface of the matrix jacket *j* ensuring contact with the screw, and so secures uniformity in height-to-paper. Before reaching this point the end of the matrix stem *s* has been covered by the top cover, and the end of the mould has also been covered by the shield *q* which is mounted under an adjustable sliding-head *u*. On nearing the centre of the shield the port *p*, in which the stream of metal delivered by the pump is playing, becomes uncovered and the metal enters the mould. The type sets in a very short interval of time after the mould has closed the port in the shield,* since the mould-wheel *fn* and top cover *c* are both cooled by water circulation. As the revolution proceeds the type is carried round in the mould, and, when it is clear of the shield, the ejecting cam (not shown in the drawings) begins to operate on the matrix jacket, causing the matrix and the type *t* with it to move outwards. When ejected about 0·05 inch, and therefore well supported in the mould, the heel-nick is cut in the foot of the type by a rapidly revolving milling cutter; when further ejected (to about

---

* So far as the author can ascertain, the type sets in less than 0·03 second in a water-cooled mould, for bodies not larger than long primer.

FIG. 48.

Section through Mould at Casting Point. Rotary Typecaster (Wicks).

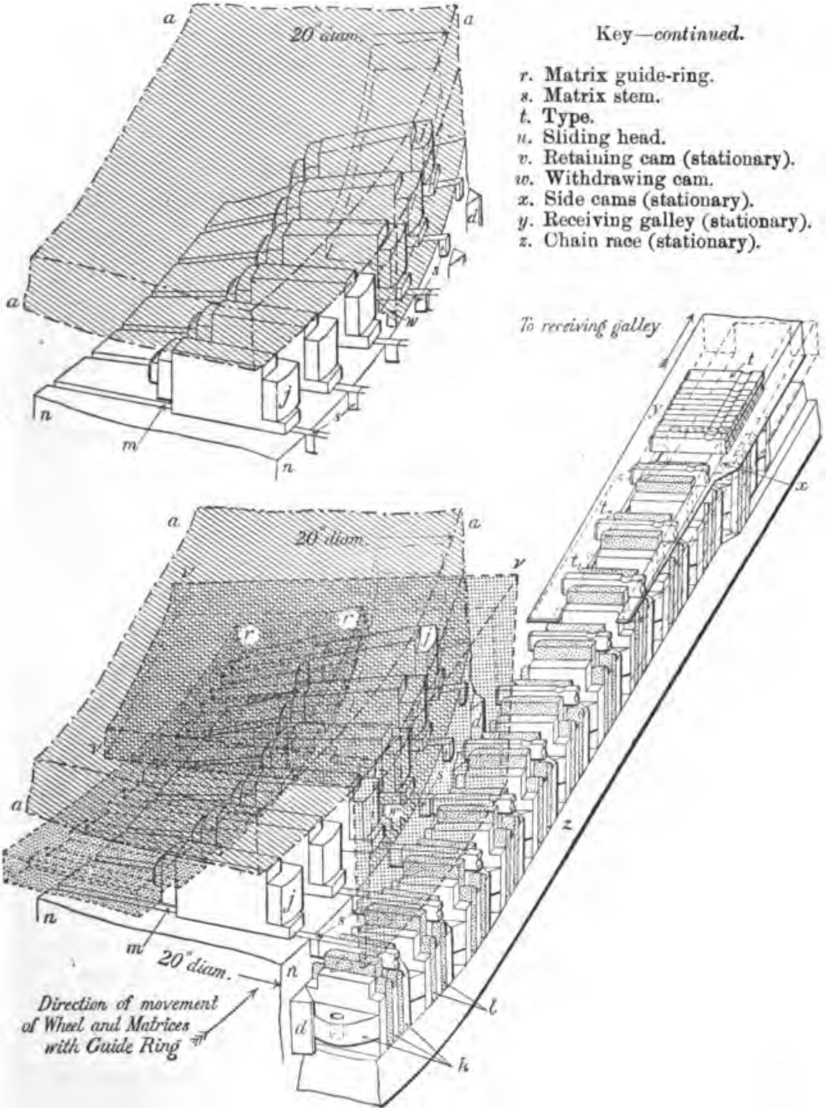


Key for Figs. 48 and 49.

a. Cam head (stationary).
b. Plate spring.
c. Top cover.
d. Chain driving teeth.
e. Nick beads.
f. Foundation ring.
g. Height-to-paper screw.
h. ,, ,, cam.
j. Matrix jacket.
k. Chain link.
l. Chain leaves.
m. Mould.
n. Mould wheel.
o_1 o_2 o_3 o_4. Folding wedges.
p. Port.
q. Shield.

FIG. 49.

Delivery of Type from Rotary Typecaster (Wicks).



Key—*continued.*

r. Matrix guide-ring.
s. Matrix stem.
t. Type.
u. Sliding head.
v. Retaining cam (stationary).
w. Withdrawing cam.
x. Side cams (stationary).
y. Receiving galley (stationary).
z. Chain race (stationary).

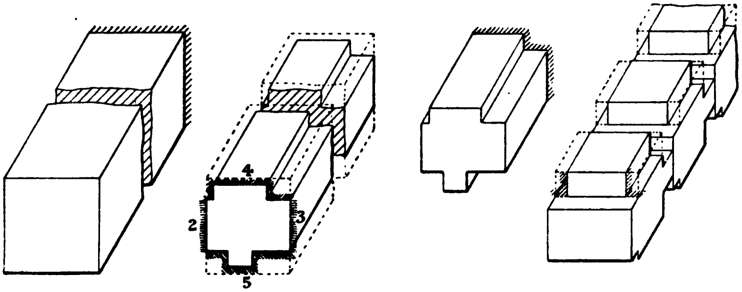
0·20 inch) an extra body-nick for distinguishing founts may be milled in if required. The ejection continues with the revolution of the wheel, and the end of the type when ejected about 0·35 inch enters the space between the leaves *l* of the chain link *k* corresponding to its mould, Fig. 49. The chain consists of 100 links and is driven by the teeth *d* cut on the periphery of the mould-wheel. The ejection continues till the type is just clear of the mould, when the retaining cam *v*, carried by the head of the machine *a*, engages with one of the body-nicks in the type and prevents the type from being drawn back with the matrix under the action of the withdrawing cam *w*. The cycle of operations with the matrix is now repeated.

The type which has left the mould is carried by the leaves *l* of the chain link *k* to the receiving galley *y*; this is slotted so that the type t_1 t_2 is supported at the ends on the galley plate, while it is propelled along the galley, and supported from tilting by the leaves *l* of the chain; near the end of the slot in the galley plate the leaves of the chain, which have up to the present been carried on the chain race *z*, drop so that the upper ends clear under the galley plate; side cam pieces *x*, which bear on the rounded shoulders of the leaves, control the dropping, Fig. 49. The type is now free in the galley along which it is impelled by the next succeeding type. The stream of type is received on a stick of ∟ section, and removed by a boy who places the type either 300 or 400 at a time in a type galley in which they occupy the same relative positions. The recurrence of the largest *set* size or of a sequence of characters of large *set* serves as a guide to the boy in sliding the type along on to the stick, and at the same time gives stability to the last line in the galley.

The type as received in the galley form a block, the appearance of which is shown by the portion printed as Fig. 51 (page 1100). The number of lines in which the blocks are made up is so chosen as to give a nearly constant width of block body-wise (about 4½ inches). The blocks are then divided by cutting them up at right angles to the direction of the lines of which they are made up. This work is performed by girls who insert thin strips of metal or celluloid between the rows of different characters, and add the lines of the same character

Fig. 50.—*Operations in Machining Chain-links for Rotary Typecaster* (Wicks).

Half size.

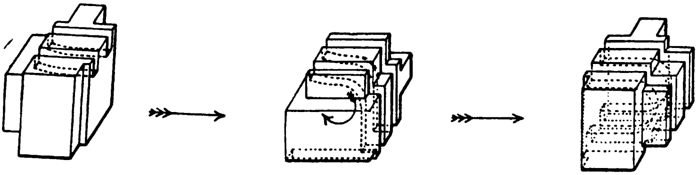

1. Cut off in lengths.

2 & 3. Slab milling.
4 & 5. Gang milling.

6. Cut up to length.

7. Stradde milled.

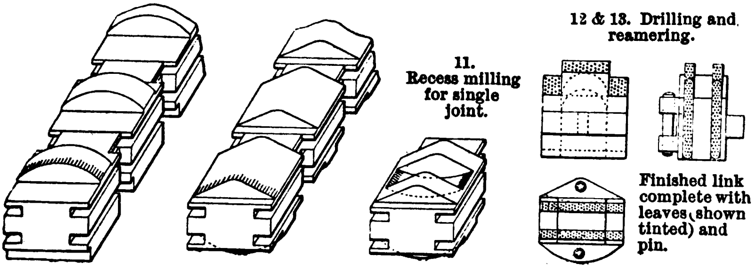
8. *Gang-milling Grooves.*


Traversed.

Rotated.

Traversed.

Former Milling in Batches.


9. Profile of single joint.

10. Profile of double joint.

11. Recess milling for single joint.

12 & 13. Drilling and reamering.

Finished link complete with leaves (shown tinted) and pin.

FIG. 51.

Block of Type as delivered by Rotary Typecasting Machine (Wicks).

WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll...,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll...,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll...,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt
WttttttjfPeeeeeeeeeccorMmffiyy0123456iiiiilll..,,,?;HGnnnnnhhhhddduuubgSnhADEwIrrrssss?eBT£aaaaaooooxz... Wtttt

together in small galleys to form *pages* of an approximately constant width. These *pages* are examined for defective type which are replaced; the *pages* are then tied round with string and packed in thick whitish paper. The handling of several lines of separate type between two flat pieces of metal requires a peculiar knack which the girls acquire easily.

The casting machine is operated by one skilled type-founder who attends to the lubrication, to the maintenance of the metal in the pot at the correct temperature and level, to the exact adjustment of the top cover so that the body-size is maintained, and to the finish of the type left by the milling cutter. One boy takes off the type, and four to five girls distribute the output of each machine.

The output of the Wicks machine is from 60,000 to 70,000 finished type per hour for bodies from ruby to long primer, and falls with larger bodies to about 35,000 for pica.

The pump runs at 100 revolutions per minute and requires about 0·7 H.P. The machine runs normally on bodies up to long primer at 10 revolutions per minute and takes about 1·1 H.P. The total power required to run both the machine and the pump is 1·8 H.P.

It was the original idea of Mr. Wicks that type could be produced so cheaply by this machine that it could be replaced by new type for less than the cost of distributing. The cost of distributing by hand is generally 25 per cent. of the cost of composing by hand, or about 2½*d.* per 1000 type. The type when so distributed is not, moreover, in lines in the form required by composing machines, and a small further expenditure would be necessary to set up the type in the composing machine tubes. The author is of opinion that, if the Wicks machine had been brought to the present state of perfection some fifteen years earlier and a foundry equipped with a large number of machines, the system adopted by *The Times* of employing fresh type every day and distributing by remelting would have found favour with a large number of the most important daily papers.

Type Slicing Machine.—For charging composing machine tubes with type an auxiliary appliance has been designed by Mr. Wicks, and is shown in Fig. 52. The lines of type are transferred from the galley in which they are received to a slotted galley *g* in which the faces are turned towards the galley. The slot is temporarily covered with a slip of metal which rests on the lower edge of the galley when placed on the slicer, and is ejected at the first stroke of the blade. The blade *b* is drawn back by means of the handle, a tube *u* is placed on the hinged carrier *c* in front of the machine, and charged by the next stroke of the handle. The end type in the tube are pressed towards each other by the fingers of the operator, and at the same

FIG. 52.
Type Slicer (Wicks).
⅓rd full size.

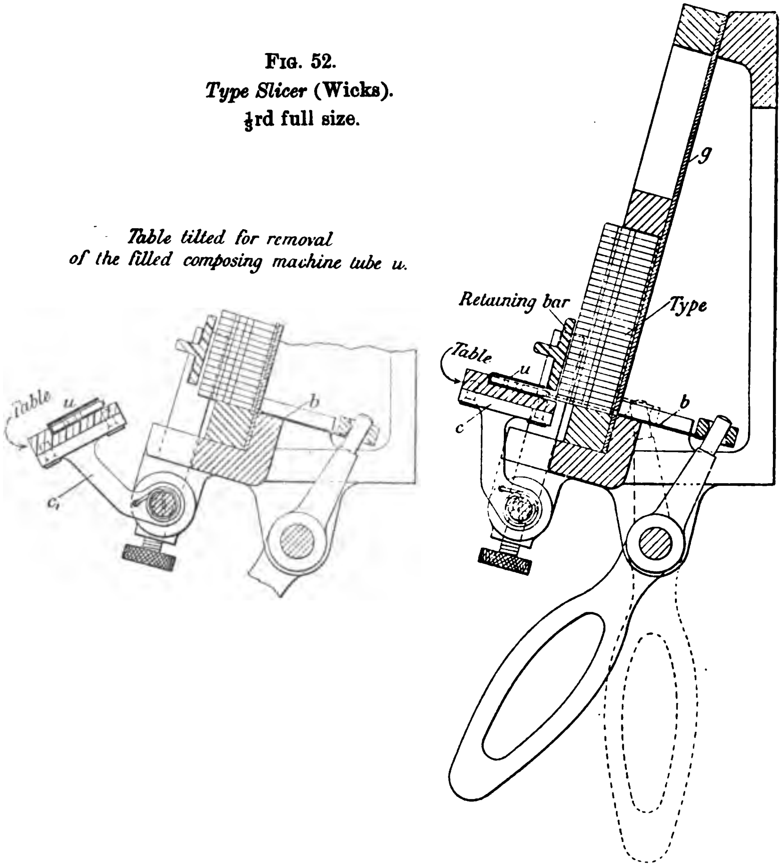
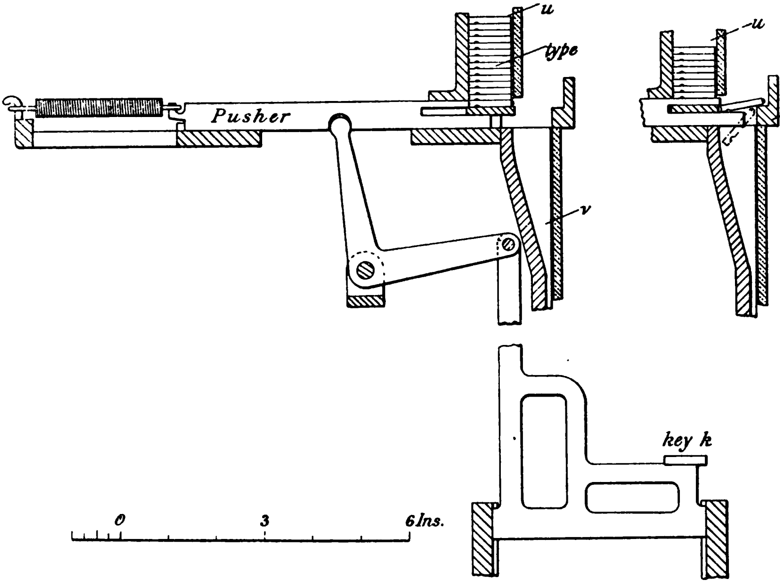


Table tilted for removal of the filled composing machine tube u.

time the hinged carrier is brought forward (as at c_1), till the type are inclined upwards, when the tube can be lifted off and transferred to the magazine of the composing machine, Fig. 52. About 200 of these machines are in use at the printing office of *The Times.*

Fig. 53.—*Type-Freeing Mechanism for Composing Machine* (Kastenbein).



Class Ib. Type-Setting or Composing Machines.

The earliest machine with the guide plate and many other features of subsequent type-setting machines is probably the Young and Delcambre setter, which was used for setting the *Family Herald* as early as 1842.*

The Kastenbein Composing Machine invented prior to 1870 was brought into practical working form at the *Times Printing Office*, and, with some modifications there introduced, is used for composing

---

* Many of the details of this machine were worked out by Sir Henry Bessemer. *See* "Life of Sir Henry Bessemer," p. 43 *et seq.*

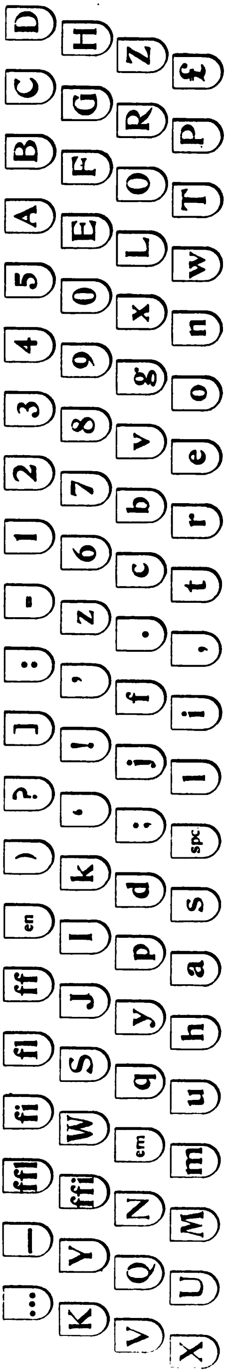


FIG. 54.—*Keyboard of Composing Machine* (Kastenbein). ⅓rd full size.

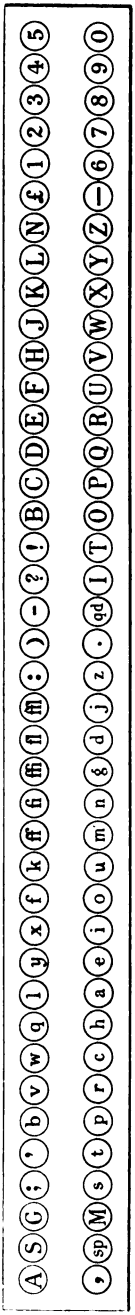


FIG. 56.—*Keyboard of Composing Machine* (Wicks). ⅙th full size.

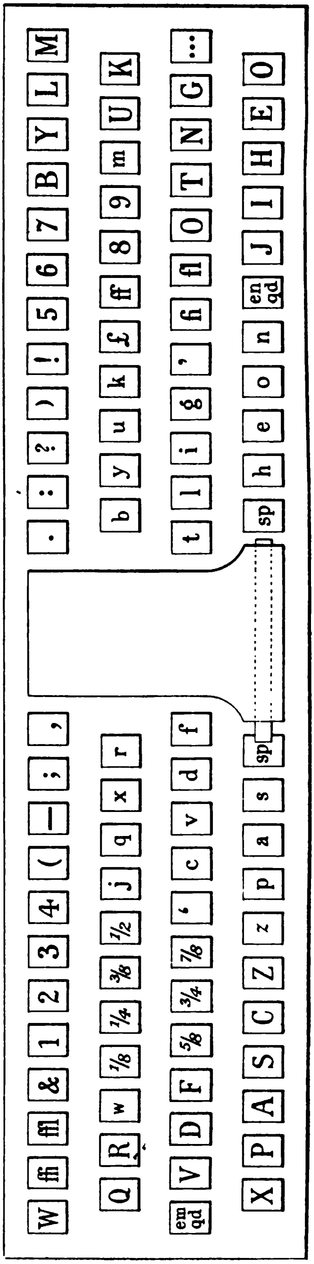


FIG. 57.—*Keyboard of Composing Machine* (Pulsometer). ⅓rd full size.

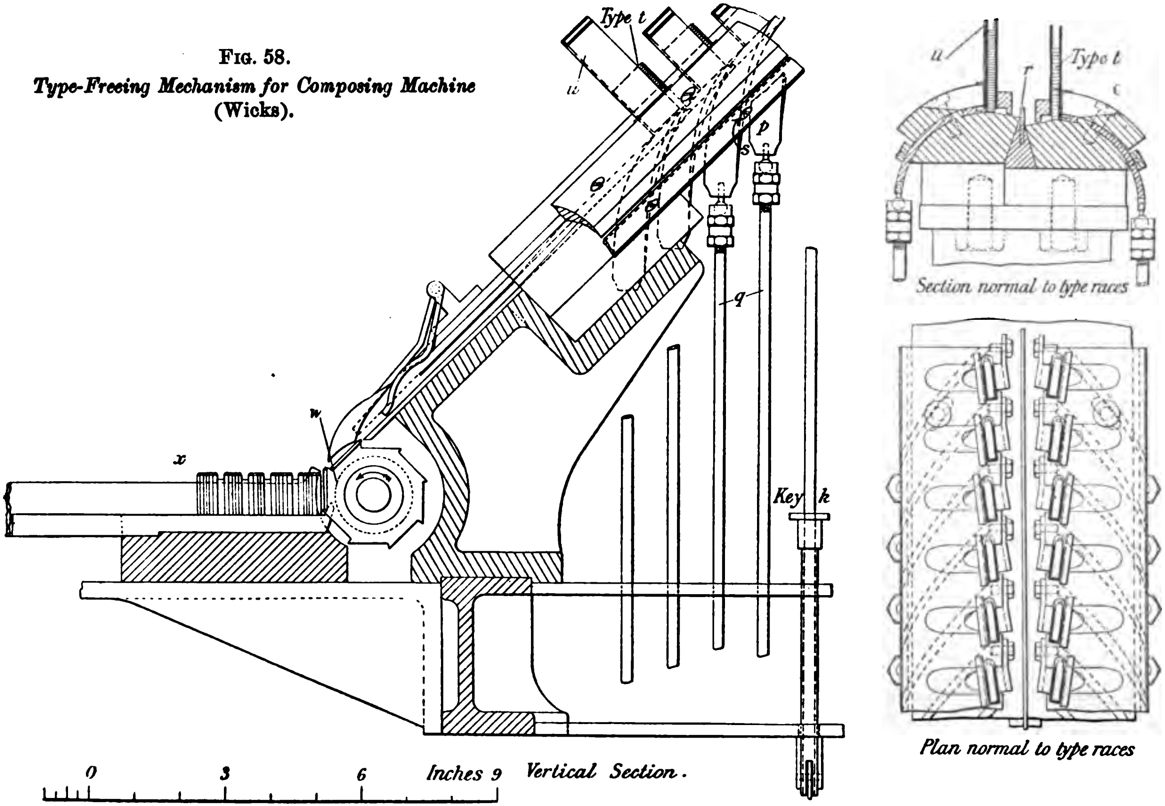
almost the whole of *The Times* and many other publications printed in the *Times Office.* The tubes *u* are U shaped, the type are arranged *set*-wise, all the nicks being downwards and the faces towards the operator, when the tube is placed in the vertical position it occupies in the machine. The depression of a key *k*, Fig. 53, pushes the lowest corresponding type forward by the foot towards the front of the machine; when more than half ejected, the front end comes over a bar *b* running along the front of the machine; when the type is fully ejected it overbalances backwards from this bar (as shown dotted) on the release of the pusher, and falls feet downwards down a guiding groove in the guide plate *v* of the machine. A lightly-balanced lower lever arm against which the type bears in falling into the race corrects any tendency to turn. The type as they arrive at the level of the race are pushed forward by a continuously-driven reciprocating plunger having a stroke a little greater than the body-size of the type. The type are thereby delivered along a type race from which they are drawn by hand by a second operator who performs the *line-justifying.* The keyboard of the Kastenbein machine is very compact, and comprises eighty-four keys arranged in four rows as shown in Fig. 54 (page 1104).

The power required is less than 0·1 H.P.

The Wicks Composing Machine.—In the Wicks composing machine, Fig. 55, Plate 32, the keyboard is of great length with only two rows of keys, Fig. 56 (page 1104), the arrangement resembling more closely that of the piano than that of the typewriter. The keys *k* operate vertical rods *q*, Fig. 58 (page 1106), which are jointed to plunger sectors of helical strip *p* working in the spaces of a coarse square-thread screw *s*. Two quarters of round bar with screws milled out are arranged, the one right hand and the other left hand facing each other, and are machined so as to form a pair of races (between which is an intervening strip *r*) inclined at 45° to the horizontal for the type to slide down. The type *t* are contained in U-shaped tubes *u* of tin or thin brass inclined at 45° to the horizontal (and at 90° to the race). The type are arranged in the tube body-wise, i.e. the nicks lie against one side of the U. The depression of a

Fig. 58.

Type-Freeing Mechanism for Composing Machine (Wicks).



Vertical Section.

Section normal to type races

Plan normal to type races

key causes the plunger, the end of which is reduced to the *set* width of the type, to remove the lowest character from the corresponding tube and push it into the race down which it slides on its side by gravity to the nose of the machine where a star wheel *w* catches it, brings it to an erect position and pushes it in place against the line accumulating in the type race *x*. The star wheel is driven continuously by a pedal or a small electric motor. Sections of the line are drawn away by a second operator who *line-justifies* each line and transfers it to a galley in exactly the same manner as in the other machines of this class.

The Wicks machine is interesting chiefly for the reason that the keyboard was designed so as to enable a number of the most-frequently-occurring combinations of characters to be obtained by the simultaneous depression of two or more keys, for example *the*, *ing* and *and*.* While this effects some saving of time, the long distance which the more remote characters must travel under the action of gravity makes the machine slow in such cases, though this is said to be compensated for by the advantage gained on the chords; also the distance through which the operator must move his hand is greater than in those machines which have a compact multiple-row keyboard.

The power required is less than 0·1 H.P.

The Pulsometer Composing Machine, Fig. 59, Plate 33.—The type *t* are contained in horizontal tubes *u*, and the contents of each tube or trough are kept pressed towards the front of the machine by a weighted follower *f*, Fig. 60 (page 1108); the type are supported by a front plate *v*, which extends about 0·50 inch in height above the bottom of the tubes and is bevelled at the top to a knife edge. The depression of a key *k* causes the front type in the corresponding tube to be raised till it clears the knife edge, when the action of the follower ensures this type being projected over the edge of the front plate. It now falls freely down a vertical groove in the front plate or apron *v* of the machine, which is shaped as an inverted triangle. At the lower end

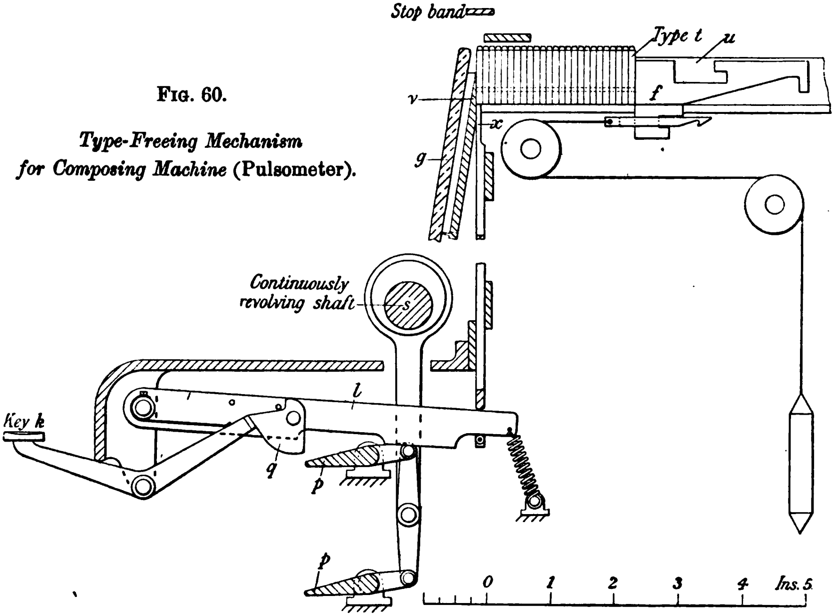
---

* *See* Appendix III, *Logotypes* (page 1148).

of the vertical groove it is guided by the inclined raceways, into which it falls, to a central channel, and thence to the entrance to the composing race, into which it is pushed by a continuously-revolving eccentric. The front plate is covered with a sheet of plate glass g to keep the type from turning, and to enable the operator to see that the apron grooves do not become blocked. A continuously-driven horizontal shaft s imparts a vertical reciprocating motion to two steel swing plates p placed longitudinally with the machine. Across the direction of these are flat steel levers l, one for each character, pivoted at the front end and each carrying a triangular pawl q which is normally raised. When a key k is depressed the corresponding pawl drops into the range of action of one of the swing plates,* which carries it and the lever upwards; the vertical pusher is driven

FIG. 60.

Type-Freeing Mechanism for Composing Machine (Pulsometer).



---

* The keys acting in conjunction with the lower swing plate are not shown in Fig. 60.

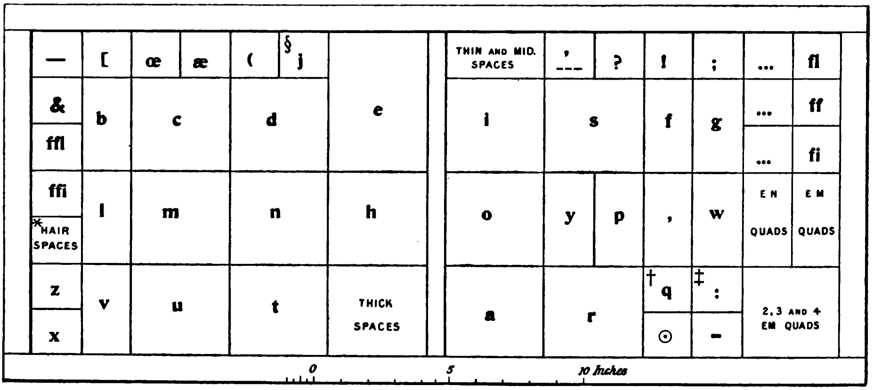
upwards by the lever, and its upper end x passing through the lower side of the U, lifts the corresponding first type up till it clears the front plate. There are four rows of keys arranged as shown in Fig. 57 (page 1104).

The power required is stated to be about 0·1 H.P.

Other machines of Class I b are the Hattersley, the Fraser, and the Hooker machines; the latter, which was patented about 30 years since, is interesting as the keyboard was not made of the form usual in other typesetting machines or in typewriters, but was arranged as a series of plates forming a copy of the ordinary lower-case, Fig. 61, from which the compositor would pick up the type in hand composition; but instead of picking up the characters, his touch freed a type through the intervention of a contact exciting an electromagnet corresponding to each plate.

Fig. 61.

Lay of Lower-Case (Hand Composition).



* In Hooker's machine the space marked "hair spaces" was occupied by "k." In the modern lay it is occupied by "q."

† " " " the space marked "q" was occupied by "k."

‡ " " " the "colon" space was occupied by "j."

§ " " " the space marked "j" was occupied by ' (apostrophe).

The warning bell which gives notice before the completion of the line to the operator of typewriting machines is usually fitted on typesetting machines.

CLASS IC. LINE-JUSTIFYING MACHINES.

Compressible Spaces.—Many inventors have endeavoured to effect line-justifying by the use of compressible spaces, but the difficulties have not been satisfactorily overcome. The compressible space should be capable of occupying the width of the em quad before compression and of being compressed to the thickness of the thick space. This should be possible without risk of throwing the sides of the adjacent type out of parallel, without lifting the type from their feet and without bending a character occurring singly, such as a or I which may come between two spaces. Moreover the space must not itself rise so as to interfere with the typographic surface. Two attempts to solve the problem of the compressible space are shown in Figs. 62 and 63.

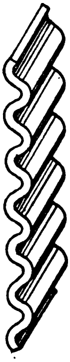


FIG. 62.
Compressible Space
(Mackie).
Twice full size.

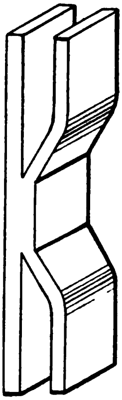


FIG. 63.
Compressible Space
(Wicks).
Two and a half times full size.

The Stringer Line-Justifying Machine.—A machine recently invented by Mr. H. Gilbert Stringer has been made in which a line of type as delivered by any typesetting machine of Class I b can be accurately line-justified.

The method adopted is to set em quads throughout the line in place of spaces, and subsequently to reduce these by milling down to the correct width for equally spacing the line. As it is essential that the justified line should contain quads under some conditions (e.g. at the end of a sentence and beginning of a new paragraph) these must not go through the reducing process for line-justification. It is therefore necessary that two kinds of quads be used. Those which are intended to remain quads are of shoulder height while those which are to be reduced may be of stereo height. The former are supplied by the depression of the *quad* key on the type setter and the latter (*space-quads*) by the depression of the *space* key.

Coupled to the *space* key, by tappet action, is a rod which advances a bar step by step below one pair of folding wedges for each *space-quad* set in the line in the automatic line-justifier. The line is composed into a measure longer than the finished line, which allows for the amount to be machined from the *space-quads*. Having composed a line in excess of the length required, the operator depresses a starting key and resumes composition. The line-justifier, while he is so occupied, acting independently first transfers the excess of length of the line to the wedge box, and when those wedges which are above the counting bar are driven home by vertically lifting the bar and with it the long part of each folding wedge, the amount that the lifter rises automatically divides the difference of length by the number of spaces and sets the milling device for reducing the *space-quads*. The machine then operates by pushing the line of characters forward along a race which has an opening at the side provided for a reciprocating feeler. Any character having the requisite height stops the feeler, and is then pushed through by the pusher into the continuation of the race. When a *space-quad* occurs, the feeler passes over it and the *space-quad* is then gripped between narrow jaws on its front and back edges in a slide, carried vertically down past a rapidly-revolving face-mill (the depth of cut being proportional to the lift of the wedges of the measuring device). It is replaced in the line by the automatic release of the jaws and the forward pressure of the next character. The gear which drives the feeler and pushing plunger is thrown out during the milling operation and recommences to operate as soon as the milling operation is completed. When the complete line has been line-justified, it is automatically transferred to a galley.

About 0·5 H.P. is required to run the line-justifying machine.

CLASS ID. DISTRIBUTING MACHINES.

In the earliest distributing machines the type was sliced off the column, the line read by the operator and the type returned to the tubes used on the composing machine, by depressing keys corresponding to each character, the operation being the converse of composing.

The Pulsometer Distributing Machine, Fig. 64, Plate 33.—The galley containing the matter to be distributed is inclined at 45°, and slopes downwards towards the keyboard. The lowest line is raised into the receiving trough, where it is read by the operator and is distributed through shutters on an apron inclined at 45° to the horizontal and at right angles to the galley. There are 24 keys, and each generally corresponds to a group of three type which are selected so as to differ by at least 0·008 inch in *set* width among themselves. The distribution of the three sorts of type is performed automatically by two bridge pieces, arranged at different heights, which divert the character to the mouth of the corresponding tube, Fig. 65 (page 1113). A brass follower is placed in each tube to keep the type upright; the type as they fall are pushed into the tubes by a series of eccentrics, one to each tube, carried on a continuously-rotating shaft. The keyboard of the Pulsometer distributing machine is shown in Fig. 68 (page 1114).

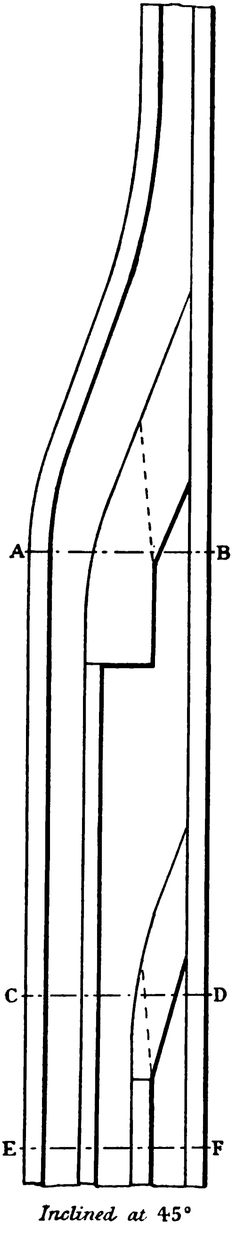
The power required is stated to be about 0·1 H.P.

Automatic Distributing Machines perform the work by means of nicks cut on the back (and occasionally on both back and front) of the type. The type are nicked so that each sort dealt with by the distributor has a different combination.

In the *Empire Automatic Distributing Machine*, which was in use for

FIG. 65.—*Detail of Separating Bridges for Distributing Machine* (Pulsometer).

Full size.



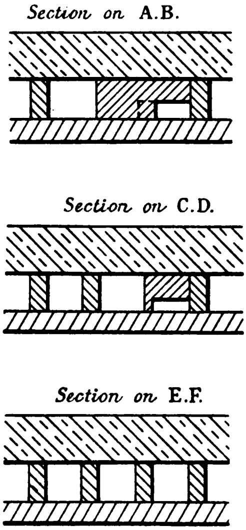


FIG. 66.

Type nicked for Distributing Machine (Empire).

Twice full size.

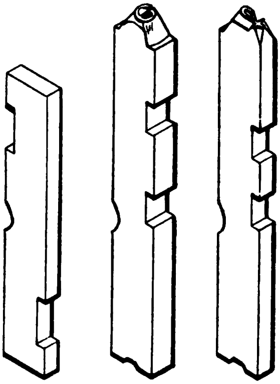
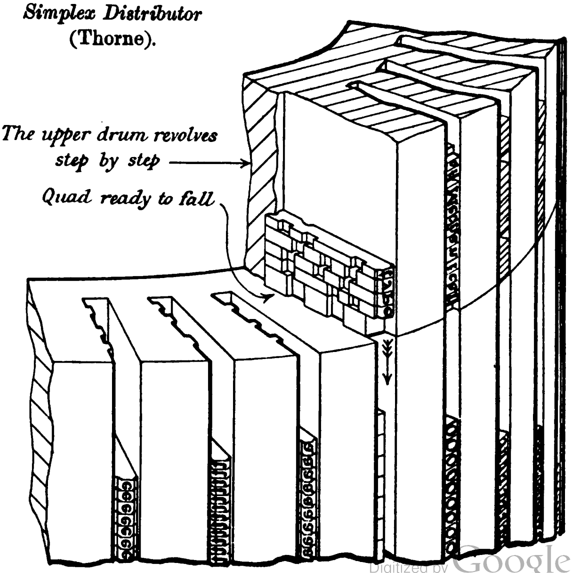


FIG. 67.

Method of Distribution.

Simplex Distributor (Thorne).



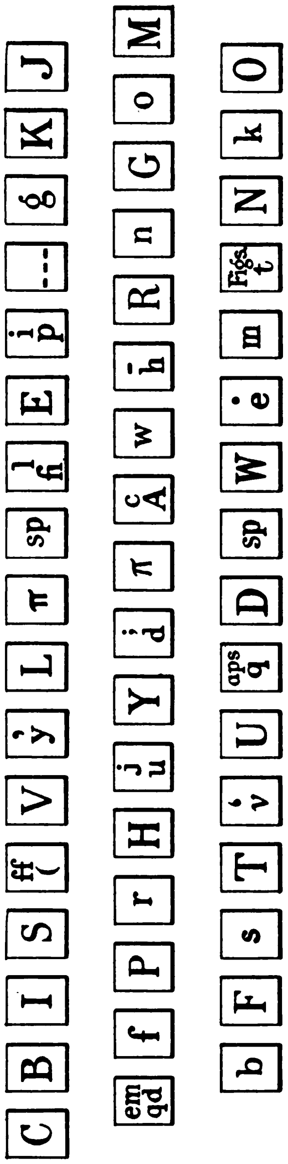


Fig. 68.—*Keyboard of Distributing Machine* (Pulsometer). Half size.

Fig. 69.

Where two characters appear on the same key, the upper is roman or italic, the lower small caps.
The 30 hatched keys are coloured blue.

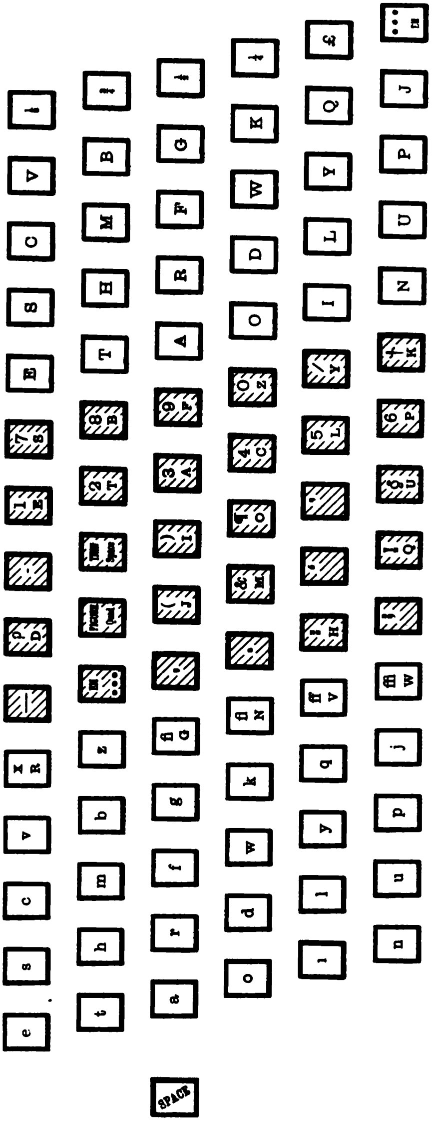


Fig. 69.—*Keyboard of Matrix Composing Machine* (Linotype). ⅓rd full size.

some years at the Office of *The Times*,* the type were nicked on the back, Fig. 66 (page 1113), by means of a planing machine with two sliding tool-holders. The setting of the tools could be rapidly effected by putting dowel pins into numbered holes in each slide. A table was provided with the machine giving the numbers of the holes to be used on each slide for each character. Actually the combinations in the nicking machine were arranged in a somewhat haphazard manner. The type in the distributing machine was automatically removed from the galley in a line and then pushed by a pusher, one character at a time, into a series of carriers. The carriers had a step-by-step motion and stopped consecutively in front of feelers which were formed to the counterpart of the nicks cut in the type. The feeler slides advanced against the type, and when a feeler fitted the nick combination in the type it could move forward releasing the type from the carrier and thereby allowing the type to fall into the magazine of tubes. The machine distributed 84 sorts.

Class IIa. Composing and Line-Justifying Machines.

The Empire Composing and Line-Justifying Machine.—The type are contained in three cases, each of about 30 channels, which are carried on cradles with glass fronts. The cradles can be placed horizontally for receiving the cases and then turned vertically with the face of the type to the front so as to be visible through the glass. The arrangement of guide plate, pendulum check and type race is very similar to that of the Kastenbein composer. Tapered space-bars are used temporarily in composing, and are put in position by the space key. When the line is nearly completed a bell warns the operator, and he either completes the word or divides it. The temporary space-bars are then driven home to expand the line to the proper measure. The bars are arranged to correspond with six different *set* widths of spaces, viz. 0·25, 0·375, 0·5, 0·625, 0·75 and 0·875 of the body. The distance that the space-bar

---

* And subsequently in the Office of *The Hereford Times*, to the Proprietors of which the author is indebted for some of these data.

projects decides the width of space supplied; the machine supplies a space not greater than the setting and at the same time withdraws the space-bar. After each operation of inserting a space, the remaining space-bars are driven home so that the final maximum possible error is 0·125 of the body. This is a considerably larger error than that usually obtained in spacing by hand, in which the limit attainable depends on the L. C. M. of the fractions of the body represented by the thin, middle and thick spaces.

$$\tfrac{1}{5} \times \tfrac{1}{4} \times \tfrac{1}{3} = \tfrac{1}{60} \times \text{body}.$$

The Dow Composing and Line-Justifying Machine is of recent American design. The type are contained in a magazine of vertical tubes and do not fall down a guide plate, but are pushed by carriers from right or left to the centre of the machine where the line is composed *vertically;* the arrangement is said to be somewhat similar to that previously adopted in the Paige machine. Temporary brass spaces are set in the line; and on depressing the *justifying* key the line is transferred to a horizontal position and measured. A space magazine, placed on the left of the machine, supplies the proper spaces from a range of ten different *set* widths. The line-justification therefore can be a much closer approximation than in the case of the other composing and line-justifying machines of this class using fewer *set* widths.

CLASS IIB. COMPOSING AND CASTING MACHINES.

The Lanston Monotype Composing and Casting Machines.—These machines consist of two separate and quite distinct parts; firstly the composing and line-justifying machine, Fig. 70, Plate 34 (frequently called the keyboard); and secondly the casting and setting machine, Fig. 71.

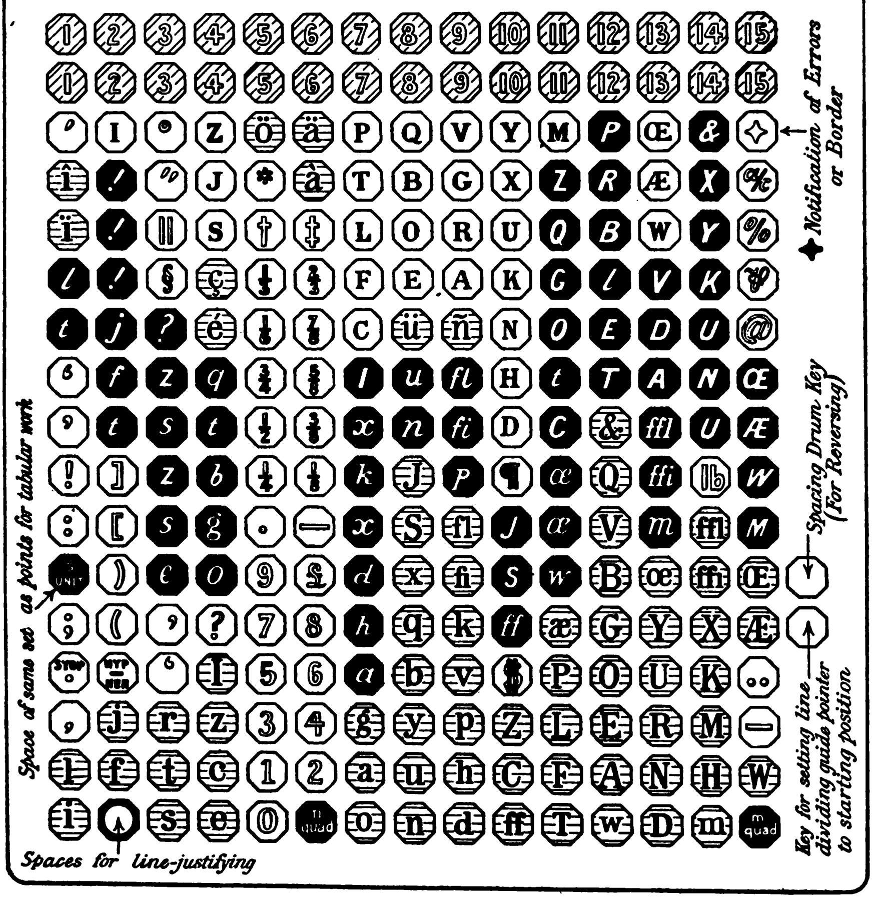
The keyboard of the composing machine is very much like that of a typewriter, but with a larger number of keys, Fig. 72.* A ribbon of paper is fed through the machine, guided, as in the Wheatstone

---

* The inverted comma and apostrophe are repeated in two *set* widths, some printers preferring more white, and accordingly they can use either.

Fig. 72.

Plan of Keyboard of Composing Machine (Lanston Monotype).
Scale: about ⅓rd full size.



▨ = *Line-justifying keys. (Red)*

● S = *Italics: lower-case, capitals, points and quads. (Black)*

○ = *Small capitals, points, peculiars, figures & fractions. (Blue)*

▤ = *Roman: lower-case, capitals and lower-case accents. (White)*

Two additional keys on extreme right of keyboard (*Green*).

perforated strip, by side perforations.* The two top rows of (*red*) keys, bearing numbers, fulfil the function of line-justifying described later. The right-hand vertical row of keys and the bottom horizontal row of keys each effect one perforation only in the ribbon. The other keys each effect two perforations. Each key when depressed about $\frac{1}{4}$ inch admits compressed air to the required combination of 31 plungers, equally spaced, which perforate the roll; 14 of these perforations produce variation of the position of the matrix grid in x and 14 in y so that a total of 225 characters, spaces and quads can be produced (the case of $x = 0$ and of $y = 0$, being provided for by the keys which give one perforation only).

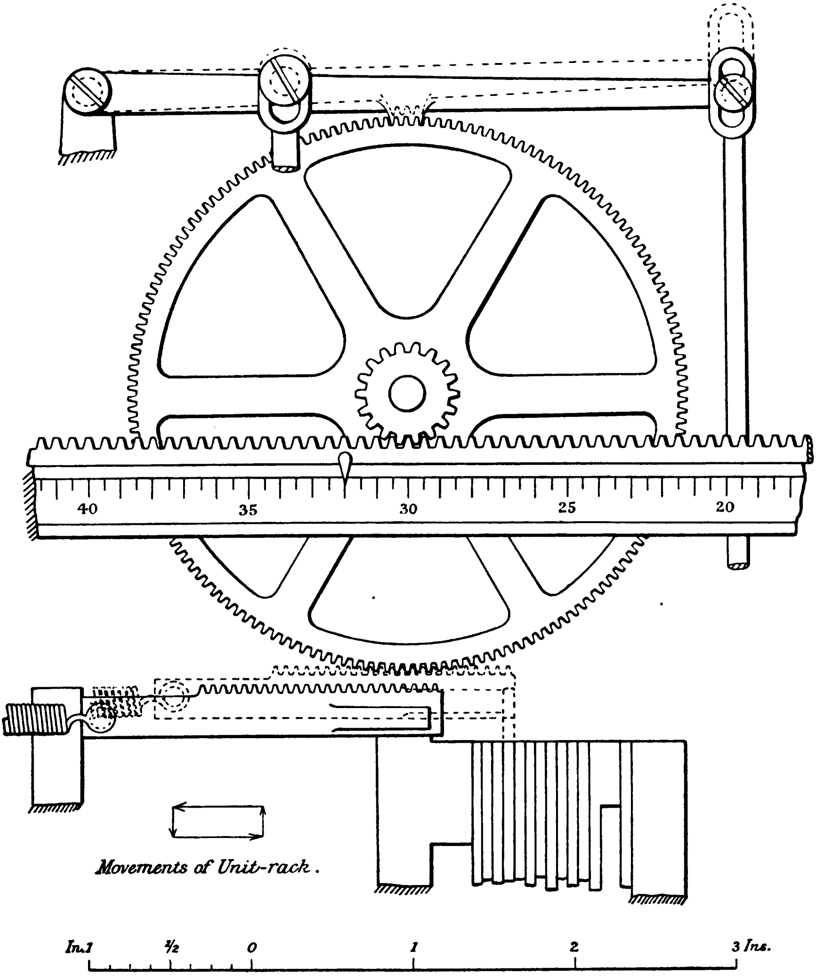
Above the keyboard proper is a pointer which rises step-by-step for each depression of the space key, and a drum (somewhat like the cylinder of a Fuller's slide-rule) on which are figures giving the resulting spacing required for the line. This drum can be rotated up to a movable stop by depressing the upper of the two (*green*) keys on the extreme right of the keyboard. This justifying scale key is depressed when ready to justify, and causes the line-justifying scale to rotate until it stops with the correct number at the end of the pointer. The bell rings 5 ems before the completion of the line; this is sufficient to ensure the acceptance or rejection of the longest indivisible word. The mechanism driving the drum stop, Fig. 73, aggregates the total *set* of the letters on a scale like that of a typewriter, and enables the operator to see whether he will proceed with the space and the next word, or will divide the word, or complete the line at the end of the word. Having completed the setting of the line, he depresses the upper (*green*) key and then refers to the reading shown on the drum which is of the form $\frac{2}{7}$. This reading gives the two (*red*) keys to be depressed in the top row and second row respectively; the reading corresponds to the settings of two differential wedges which divide the surplus space (left on completing the line) over the number of spaces in the line.

---

* The perforated ribbon was employed by Mackie, of Warrington, in 1868 in his composing machine. He used 14 rows of holes in combinations of two at a time, giving $\frac{14 \times 13}{2} = 91$ combinations available.

FIG. 73.

Counting Mechanism for Composing Machine (Lanston Monotype).



All the fifteen characters of a row arranged vertically on the keyboard (or of a row arranged body-wise on the grid) have the same *set* width; this is a most important feature in designing faces to suit the machine. The unit employed is one eighteenth of the quad and the vertical rows of keys give the following *set* widths, one row each 5, 6, 7, and 8 units, three rows 9 units (en quad), two rows 10 units, one row each 11, 12, 13, 14, 15, and 18 units, Fig. 74. The space key operates in a different manner and gives a setting of 4 units only; the keys act by elevating stops which limit the travel of a rack engaging with the counting wheel; one tooth of which equals one unit, and one revolution of which is equal to 9 ems, Fig. 73.

FIG. 74.

Standard lay-out as cast in long-primer modern.
(Lanston Monotype Machine.)

The small figures below the columns show the set-values in eighteenths of an em for the type in each column.

′	I	°	Z	Ö	ä	P	Q	V	Y	M	*P*	Œ	*&*	◆
î	*!*	″	J	*	à	T	B	G	X	*Z*	*R*	Æ	*X*	ᵃ/c
ï	*:*	‖	S	†	‡	L	O	R	U	*Q*	*B*	W	*Y*	%
l	*;*	§	ç	⅓	⅔	F	E	A	K	*G*	*F*	*V*	*K*	℔
t	*j*	*?*	é	⅙	⅞	C	ü	ñ	N	*O*	*E*	*D*	*U*	@
‘	*f*	*z*	*q*	¾	⅝	*I*	*u*	*ﬂ*	H	*L*	*T*	*A*	*N*	*Œ*
’	*i*	*s*	*v*	½	⅜	*x*	*n*	*ﬁ*	D	*C*	&	*ﬄ*	*H*	*Æ*
!	]	*r*	*b*	¼	⅛	*k*	J	*p*	¶	*æ*	Q	*ﬃ*	℔	*W*
:	[	*c*	*g*	.	–	*y*	S	ﬂ	*J*	*æ*	V	*m*	ﬄ	*M*
	)	*e*	*o*	9	£	*d*	x	ﬁ	*S*	*w*	B	œ	ﬃ	Œ
;	(	’	?	7	8	*h*	q	k	*ﬀ*	æ	G	Y	X	Æ
.	-	‘	I	5	6	*a*	b	v	$	P	O	U	K	..
,	j	r	z	3	4	g	y	p	Z	L	E	R	M	—
l	f	t	c	1	2	a	u	h	C	F	A	N	H	W
i		s	e	0		o	n	d	ﬀ	T	w	D	m	
5	6	7	8	9			10		11	12	13	14	15	18

To enable different faces and different bodies to be cast from the same ribbon two difficulties have to be met:—

(1) The difference in *set* widths which exists in certain sorts between old style and modern;

(2) The increased *set* width of the sorts as bodies decrease in series, or when an extended or condensed face is required to be cast.

The first difficulty is got over by designing the old style face of modernized form so that the lower case r, s are wider, the h, k, n, u, etc., narrower, the a and the o much narrower while the e remains unaffected. The resulting face is very legible, though many of the distinctive features of old style are almost absent.*

The second is dealt with by increasing the whole of the *set* widths proportionately; the quads are thus no longer square or half square, though the em is double the en; the spaces must also be proportionately widened, and this involves altering the space-wedges in the casting machine to give the correct measure.†

The actual perforation of the ribbon is effected by means of compressed air from the same supply used for controlling the casting machine.

The lower of the two additional (*green*) keys to the extreme right of the keyboard, Fig. 72 (page 1117), serves for returning the counting gear to zero, ready for commencing a new line.

The appearance of the perforated ribbon is shown in Fig. 75 (page 1122). The ribbon is rolled on a drum as it is perforated, and on completion is removed from the composing machine. The completed ribbon can now be fed into the typecasting machine and is in proper order for this, as it requires to go through in the *opposite* direction; the casting machine begins work at the end of the matter and works back to the beginning. The last operation in composing is the depression of the two keys in the top row; the corresponding perforations are now the first to come into operation, and provide the adjustment for the space-wedges which retain their setting till the casting of the line is completed.

The perforated ribbon passes over the air tower of the caster between a long port and a drilled surface, which communicates by pipes with the cylinders of 31 plungers which correspond to the

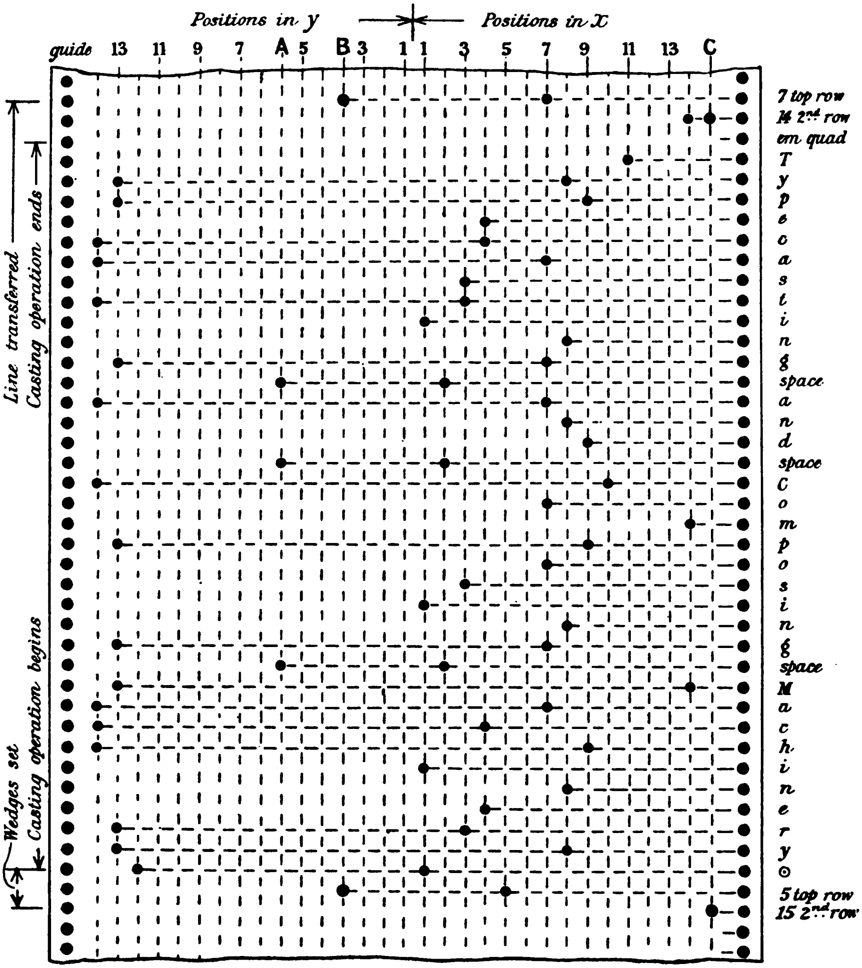
---

* It is however possible by altering the "lay-out" (or arrangement of matrices) and by marking certain keys for a different character to that originally shown on them, to cast an old-style face having the full peculiarities of old style.

† A different drum is used on the keyboard corresponding to the number of points in the *set* width of the special em quad.

Fig. 75.

Perforated Ribbon for Typecaster (Lanston Monotype). Scale: about full size.



A Space transfer. **B** Coarse wedge. **C** Fine wedge.

When **C** and **B** are operated the line is transferred to the galley. The caster can be so set that consecutive strikes of **C** and **B** do not transfer the line, enabling double or multiple justification to be performed for tabular work. The final justification is effected by striking the required key of the top row, and then striking Key No. 1 of the top row simultaneously with the required key of the second row.

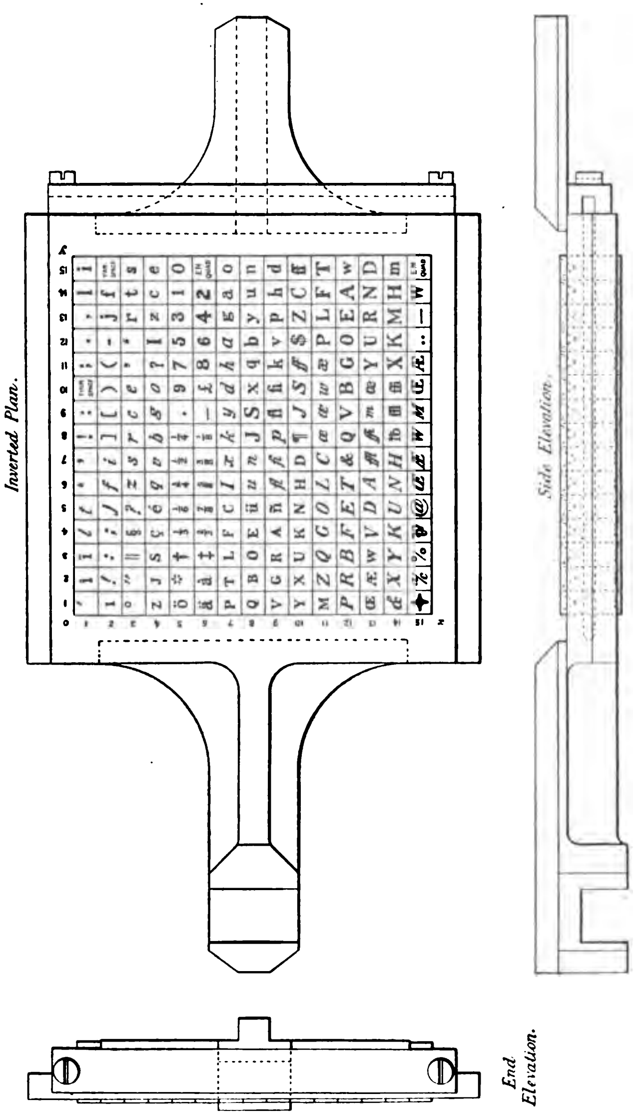


FIG. 76.

Matrix Grid for Casting Machine (Lanston Monotype).

Scale: about half size.

31 rows of holes which can be punched in the ribbon. The holes in the ribbon act like ports in a valve and admit air only to those cylinders the plungers of which are to be actuated. In the first instance the space-adjusting wedges for controlling the opening of the mould are set, and this setting remains constant till the line is completed and a new setting is given. Then for each character a third wedge comes into operation, determining the *set* width to be given to the mould for that character. The position of this wedge is dependent on the position of the matrix grid in the direction of the *set* width relatively to the mould. The matrices, Fig. 18 (page 1070), are secured in the grid, Fig. 76 (page 1123), by wires passing through the cross holes. They are arranged in 15 rows of 15 each, all the characters of a row body-wise being of the same *set* width. The matrix grid is spring-controlled so that it tends to be driven the maximum distance in both directions; i.e. it tends to travel to the origin in both x and y, and actually travels the full distance in both when there is no perforation in the ribbon (em quad). The movement is checked by 14 plungers, for each direction which rise vertically and stop the travel of the grid horizontally. The plungers are operated by compressed air at a pressure of about 15 lb. per square inch.

The plungers also perform another function; the two justifying keys of the top row on the keyboard (which are last depressed in composing the line) operate the plungers in x and y respectively, the one controls the distance moved by the coarse space-wedge and the other by the fine space-wedge one-fifteenth the taper of the coarse wedge. Once set, these wedges retain their position for the whole of the line; hence all these spaces are equal in *set* width. The whole travel of the fine wedge may correspond to only 0·0075 inch in the mould, the minimum difference of width for each space being 0·0005 inch. The maximum error of line-justification in a line containing ten spaces will then be 0·005 inch and in small pica body it will be nearly double the minimum error obtainable by hand-justification, but probably nearly equal to the error actually obtained in practice. The coarse wedge will move 0·0075 inch for each step and the total range will represent 14 × 0·0075 inch × 14 × 0·0005 inch or 0·1120 inch. In the case of small pica of 11 point the space already represents 4 units (each of about 0·0085 inch) or 0·0338 inch. The limits of width between which the space can be varied are therefore from 0·0338 inch to 0·1458 inch, or from rather less than the middle space up to nearly the em quad.

In the event of a line being cast of wrong length, the machine stops automatically.

The machine presents some very special features. The ribbon, if rolled up, can be used again an indefinite number of times; it can be used for any body size (say pica to nonpareil) provided the *set* widths are proportional to the bodies, and it can be used for either modern or modernized old style. A different drum must be used on the keyboard machine however, and a different ribbon produced if the matter is required to be printed in a style which necessitates variation in the space-wedge settings or in the lay-out. The ribbons can be stored, and represent a much smaller amount of capital locked up than in the case of type or stereotypes.

The speed of the Lanston Monotype can be as great as 180 type per minute for a medium-sized body, and in ordinary work 150 type per minute can be obtained.

The power required to run the keyboard and the casting machine is about 0·5 H.P.

The Tachytype, invented by F. A. Johnson of America, is a very similar machine. The perforated strip is narrow, being about 2 inches wide; the line-justification is effected automatically by the machine, and at the same time that the holes are perforated the character represented is typed on the strip so that the operator or any other person can read the record. The English rights in this machine have been acquired by the Linotype Co.; the machine has not been worked commercially.

CLASS IIIA. MACHINES IN WHICH TYPE IS DISTRIBUTED, COMPOSED, AND LINE-JUSTIFIED.

The Thorne Machine in its earlier forms did not line-justify the type, but in its latest form an automatic line-justifier is combined.

In the Thorne machine there are two coaxial vertical cylinders having radial grooves to receive the type. The upper cylinder is charged with matter for distributing without special preparation except that, as in the Empire machine, the type are specially nicked in the back with a different combination for each character. The grooves in the top cylinder are plain without any projections, Fig. 67 (page 1113). The grooves in the lower cylinder, on the other hand, bear the combinations of raised beads corresponding to the nicks at the back of each individual character. The lower cylinder remains stationary, and the upper revolves intermittently with a pause when the grooves are in alinement. When the beads in the lower cylinder groove agree with the nicks in a type above it the latter descends, and is available in due course for composition. The composition is effected by ejecting the lowest type (from the groove corresponding to the key depressed) on to a revolving circular disk. The type are brought round by the disk to the point of delivery, where they are received on a belt and thence travel to the receiving race. The *line-justifying* mechanism comprises a summing device which registers the total *set* of the line, and a registering device for the number of spaces. There are four *set* widths of spaces, and the justification takes account of any tendency to under- or over-space the line as in the Empire machine; but owing to the smaller number of sizes available, the result is not even so close an approximation as in the case of the Empire. The Thorne machine patents for England were acquired by the Linotype Co.; the machine has not been worked here commercially.

The Paige Distributing, Composing and Line-Justifying Machine is probably one of the most complicated machines ever devised, and contests the first place with Babbage's original calculating machine. Only two of the Paige machines have been made, and they are preserved in America in the Cornell and Columbia Universities as curiosities.*

---

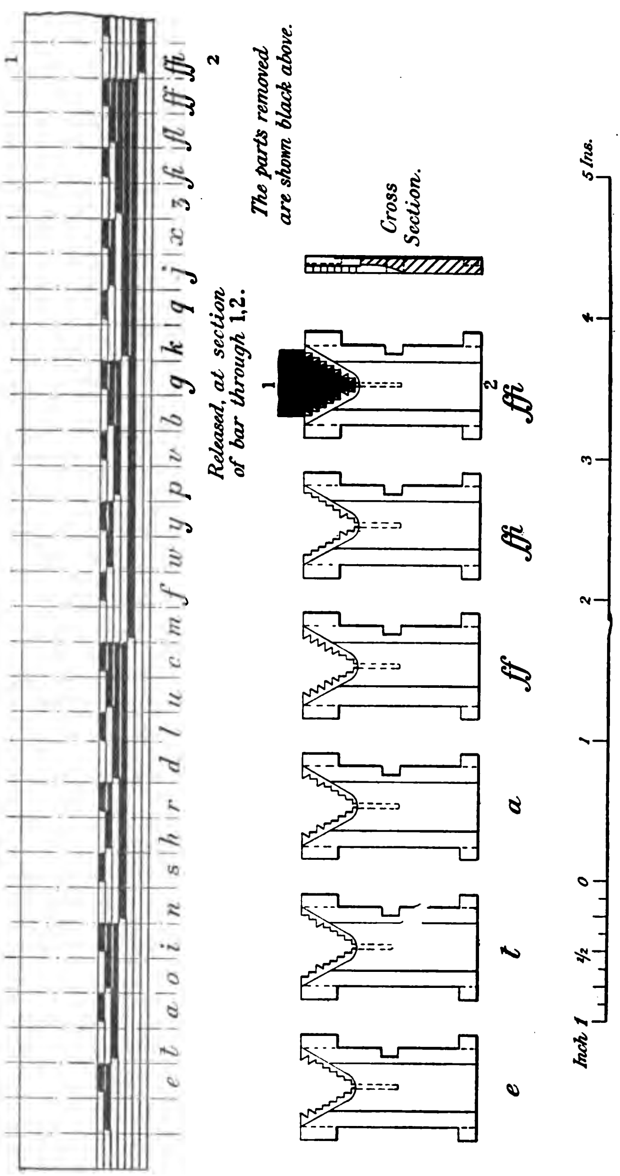
* *See* J. S. Thompson: "History of Composing Machines," pages 23 to 27.

Class IIIb. Matrix Composing Machines Casting Slugs.

The Linotype Machine, Fig. 77, Plate 35. The Linotype, which was originally produced by the Mergenthaler Linotype Company of New York, has been the subject of so much invention, it has played so important a part in the development and production of a great proportion of the newspapers of the day, and it has involved the sinking of so large a capital sum that it is really worthy of a Paper to itself. It cannot be dealt with so briefly as the preceding machines, and many interesting features must be here omitted for want of space.

At the top of the machine is the distributing bar, Fig. 78 (page 1128), which is formed with seven wards interrupted on the following system. The top ward, which may be styled No. 1, is alternately tooth and space, the length of tooth corresponding to the pitch of the divisions in the magazine mouths immediately below. Ward No. 2 is alternately tooth and space, but the length is double the tooth length of No. 1; similarly No. 3 is alternately tooth and space for four times the tooth length of No. 1, and generally No. n is 2^{n-1} times the pitch of the magazine mouths. Each matrix is formed with 7 teeth on each side of the top V nick, that combination being retained which corresponds to the wards removed from the rack at the point at which it is desired that it should fall. In every case the arrangement on each side of the V is symmetrical. The matrices of the characters which are most used travel the shortest distance, return soonest to the magazine, and the keys releasing them are most conveniently placed together under the operator's left hand. The order of release, detail of the distributing bar, and detail of some of the matrices will be seen in Fig. 78, and the keyboard in Fig. 69 (page 1114). The matrices in the magazine are retained by an escapement w, which is freed on the depression of the key k, Fig. 79. The key does not effect this directly, but releases a cam carrier q, which permits the cam c to be driven by one of two roller shafts S_1, S_2 which are kept revolving one in front of and one behind the lower verge rods v_1, which are raised by the depression of the keys. So long as the key remains depressed, the cam will roll on the roller and cause the upper verge v_2 to reciprocate vertically and

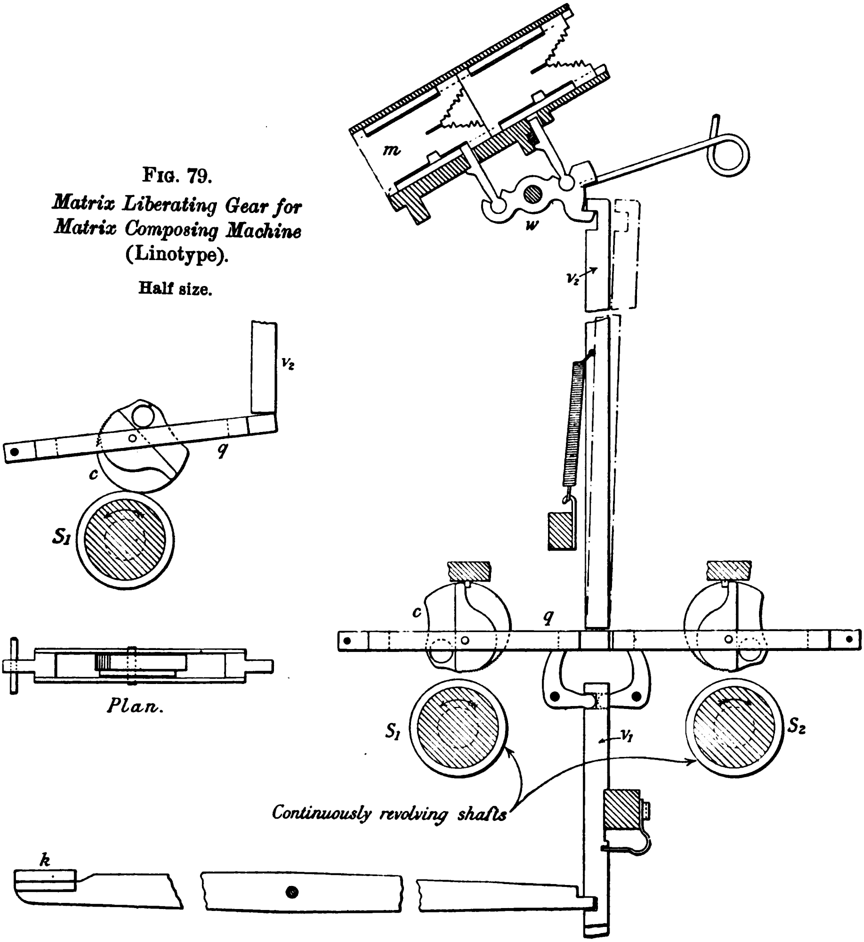
FIG. 78.—*Distributor-bar and Matrices for Matrix-Composing Machine* (Linotype).



release a matrix successively at each stroke. A very light touch of the key is sufficient, the power drive completing the release. The matrices, as they fall, travel in a curved path from the magazine, which slopes downwards and forwards, into the guide box in which

FIG. 79.
Matrix Liberating Gear for Matrix Composing Machine (Linotype).

Half size.



the left-hand grooves are nearly vertical, and the right-hand grooves rudimentary, and supplemented by a continuously-running belt which assists the matrices to the star wheel. The star wheel (of fibre) pushes the matrices through a set of pawls. In falling past the star wheel the matrix was apt to strike against the last in the line and to damage the sharp edge at the strike. To obviate this, one corner has been cut away, and the life of the matrices has thereby been greatly increased. The completed line of matrices is shown in Fig. 80, Plate 36. Some matrices are now made with two faces; when the second face is used, the lower side-tongues of the matrices travel in a groove at a higher level until the casting has been effected, Fig. 81. The line is measured directly by the total length of the group of matrices. As in other composing machines the operator is warned by a bell, set about five ems before the end, when the line is nearly full; the length set must be *short* to allow for the spaces filling out the line. Between each word a space matrix or space band is dropped; this has no teeth, consequently it is not elevated to the distributor bar at the top of the machine, but goes direct to its own magazine. The space matrix, Fig. 82, consists of two main pieces dovetailed together, yet sliding freely and fitting sufficiently well to avoid trouble from metal getting between the two parts. The line having been set up, the other parts of the machine come into operation when the operator pulls the starting handle.

At the back of the machine is a cam-shaft carrying nine cams; this shaft is belt-driven through the intervention of an internal expanding clutch. The clutch is thrown out of gear in the event of any accident jamming parts of the machine; this renders the machine practically fool proof—a very necessary precaution—not only to avoid risk of damage by a learner, but because the expert operator, once he has composed a line and pulled the lever, immediately begins the composition of the next succeeding line, and does not watch the line which he has set through the successive operations of casting and trimming, nor does he follow the matrices in the elevator and distributor.

The following is the sequence of movements made by the Linotype. A line of matrices having been assembled, it is raised by means of a lever, and passes into the delivery carriage, which

Space Matrices. Full size.

Fig. 82.
Linotype.

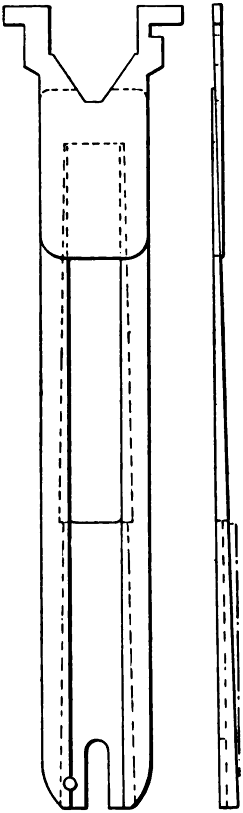


FIG. 83 —*Monoline.*
Three views of the 3 combined sliding pieces A. B. C.

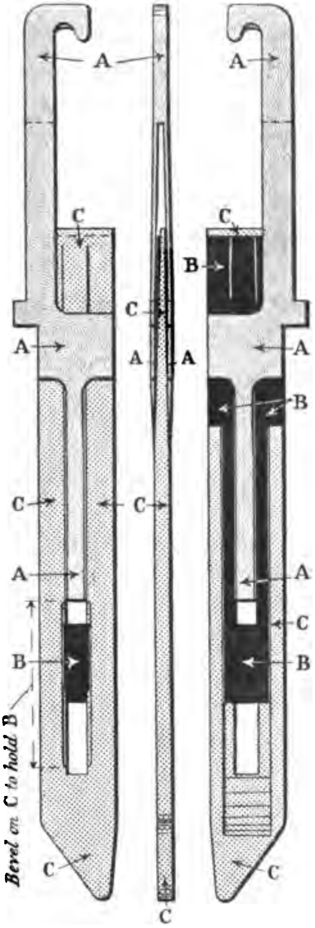
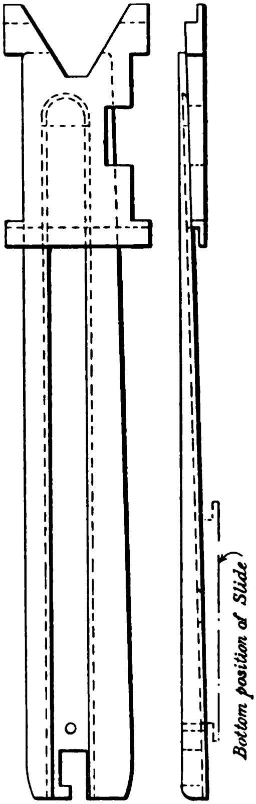


FIG. 84.
Stringertype.



carries it in to the first elevator. The first elevator descends (1).* Simultaneously the mould-wheel makes a quarter revolution (2) [turning from the ejecting to the casting position]: *see* Fig. 37 (page 1086); the matrices are now in front of the mould. The mould-wheel now comes forward (8) and engages the matrices [the alining lugs of the latter passing under the alining edge of the mould], but does not make *complete* contact. The vice-closing lever rises (3), allowing a spring to seat, which in so doing turns a screw which sets the vice block to the *correct* size of the line. The first line-justification lever (4) rises, pushing up the spaces successively from right to left in an inclined position, Fig. 85, Plate 36. Meanwhile, the delivery carriage has returned to the position of rest (9). The first line-justification lever (4) having descended, pressure is also now removed from the end of line by the vice lever returning to the position of rest (3), the partially-justified line being sufficiently held in position by the pressure of the left vice jaw. The first elevator (1) now slightly rises, causing the matrices to aline along the edge of the mould. The metal-pot (7), Fig. 86, Plate 37, now makes a *temporary* forward movement, the object of which is to press the mould against the matrix line to ensure *face* alinement. The pot having dropped back, the vice lever (3) again rises, allowing the spring-controlled vice block to determine the correct length of line. Both the first (4) and second (3) line-justification levers now rise simultaneously, and push the space bands up *evenly*. The pot (7) again advances, and is tightly pressed against the back of the mould; the plunger (6) descends, forcing the molten metal into the mould and matrices. The plunger having returned, the pressure on the bottom of the matrices caused by the first elevator is withdrawn, the line-justification and vice levers return to the position of rest, and the pot and mould-wheel (8) retreat, leaving the slug in the mould. The mould-wheel now completes its revolution by making a three-quarter turn (2), Fig. 37 (page 1086), during which the back of the mould passes over a knife which trims off the superfluous metal, Fig. 38 (page 1087) [including, of course, the locking bars].

---

* The figures in parentheses denote the cams actuating the lever or other member, counting from left to right along the cam shaft.

The mould-wheel now advances (8) on to two steady pins, the mould being in front of two parallel trimming knives, through which the line is forced by an ejector blade (8), which pushes the line from the mould, Fig. 38, and thence through the knives into the galley at the front of the machine, Fig. 87, Plate 37 [the ejector lever being returned by (9)]. Meanwhile, the first elevator (1) has carried the line of matrices upwards to the intermediate channel, where it is met by the second elevator (5). The first matrix pusher (9) now transfers the line of matrices from the first elevator to the second. The pusher having temporarily receded, the elevators return to their position of rest. Meanwhile, the first matrix pusher, acting in conjunction with the space shifter (9), again advances and causes the space matrices to be gathered by the space shifter, which returns them to their receptacle at the right-hand end of the intermediate channel. In the meantime, the line of matrices has been pushed by the second matrix pusher (2) from the second elevator into the lift box, where the matrices are lifted, one at a time, so that each successive matrix is engaged by three revolving screws, and passes on to the distributor bar, Fig. 78 (page 1128), along which it travels [by means of revolving screws engaging with the lugs]. The matrices are suspended from the distributor bar by their teeth, and when each arrives at that portion of the bar from which the same combination of teeth has been removed, it falls between guides and passes back into the magazine. The path of the matrices through the machine is shown in Fig. 85, Plate 36.

The Linotype is driven usually by belting; the main shaft carrying the clutch runs at about 72 revolutions per minute and the cam shaft at about 7 revolutions per minute. About 0·3 H.P. is required to run the machine; the maximum torque is required when making the upstroke of the pump.

The mould and the body-trimming knives can be specially arranged, so that when a suitable matrix is used the type can be kerned below the body-size, the kerned portion being entirely formed in the matrix. This is used to form the two-line letter used in newspapers at the commencement of advertisements. The beginning of the succeeding line must be set with two or more quads so as to provide the clearance for the kern, or the exact length may be obtained by using the two-line matrix reversed, Fig. 88.

The two-line and other special matrices are formed *without* nicks, and consequently are not elevated to the distributor bar; they drop into a tray near the space magazine.

The rate of output of the Linotype machine is generally taken at 6,000 ens per hour, this representing the normal rate of an average compositor. Under good conditions however the compositor can average from 7,000 to 8,000 ens. The machine is capable of greatly exceeding this speed.

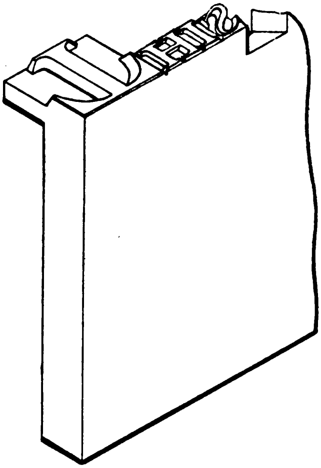


FIG. 88.

Two-line Letter

(Linotype Slug).

Twice full size.

Linotype Duplex Machine.—By a recent improvement the Linotype can be arranged with two interchangeable magazines and two moulds fitted diametrically opposite each other on the mould wheel. This enables the machine to be changed very quickly from one face and body to another.

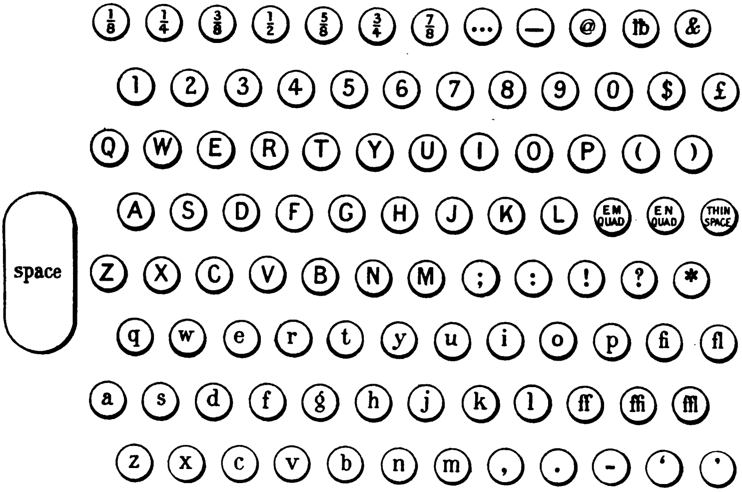
Mergenthaler Linotype.—This is the American Linotype, and in its latest form comprises some further improvements in duplex working.

Monoline.—The Monoline, Fig. 89, Plate 37, is of American origin, though manufactured in other countries, and is remarkable for its great simplicity as compared with the other slug-casting machines. Reduction in the number of parts has been carried consistently through the design, with the result that a very compact, a much lighter and much less costly machine has been evolved. (The actual cost is less than half that of the Linotype machine.)

FIG. 90.

Keyboard for Matrix Composing Machine (Monoline).

Scale: about ⅓rd full size.



The keyboard, Fig. 90, comprises ninety-six keys (and a space key) which are arranged in eight rows of twelve, the arrangement being very similar to the keyboard of the Bar-Lock or Yōst typewriters. There are, apart from space matrices for line-justification, eight different kinds of matrix, Fig. 19 (page 1070), each kind carrying twelve strikes. The characters of a group are, of course, chosen so that they come on the same *set* width, Fig. 91 (page 1136).

Fig. 91.

Arrangement of Strikes on Matrices (Monoline).

	Kind of Matrices.							
	1	2	3	4	5	6	7	8
bottom 1	7	$\frac{7}{8}$	q	!	;	Z	@	&
2	6	$\frac{3}{4}$	b	)	‘	p	...	Y
3	en quad	$\frac{1}{2}$	g	?	thin space	L	em quad	U
4	5	$\frac{1}{4}$	a	e	i	T	m	R
5	8	y	o	t	,	O	H	w
6	0	fi	n	s	l	D	W	A
7	1	ff	h	r	f	F	M	G
8	2	x	d	c	.	B	—	E
9	3	fl	u	I	-	S	ffi	N
10	4	$\frac{1}{8}$	p	z	j	C	ffl	X
11	9	$\frac{3}{8}$	v	*	’	J	K	V
top* 12	$	$\frac{5}{8}$	k	(	:	Q	℔	£

* Since in composing the matrices are added to the right, with their faces *from* the operator, it is necessary that the strikes should be inverted.

According to the particular key depressed, a matrix is released from the magazine compartment for the kind of matrix containing that sort, and is received on a stop, set by the key, so that it is at the proper level to bring the required character in line when it passes into the assembler. The space matrix, Fig. 83 (page 1131), consists of a long steel wedge sliding between two short steel wedges, and is operated in a similar manner to the Linotype space matrix, Fig. 82. The long wedge has a projection on the back against which the justifier pushes, lifting the wedges until the line is filled.

The casting, trimming, and ejection of the slug from the mould are effected in a very similar way to the same operations on the

Linotype, but the distribution of the matrices after the line has been cast is effected in a much more simple manner. The hooks at the top of the matrices are arranged in a series of nine different lengths corresponding to the eight kinds of type matrices and the space matrix. The selection to the nine magazine compartments is effected by sliding the matrices on their lower ends so that the hooks engage on a series of distributor rails, which are then lifted and bring all those of each kind of matrix (which have been used in the line) opposite their respective channels in the magazine into which each kind is pushed laterally, off the distributor rails, by a pusher.

The Monoline slugs are delivered into a galley in column.

The Monoline machine occupies a space of about 3 feet 6 inches by 4 feet 6 inches, it weighs about 800 lb. and requires about $\frac{1}{6}$ H.P. to drive it.

The adoption of a rational keyboard in which the keys most used are placed close together is, in the author's opinion, preferable to the methods adopted on some of the other machines described, in which the arrangement of keys is dependent on the *set* width of the character or on some constructional peculiarity of the machine.

CLASS IVA. FOUR-OPERATION MACHINES.

The operations of composing and line-justifying, casting a justified line and setting it, which are usually divided between two machines, are combined in the *Stringertype Machine.*

The Stringertype Machine, Fig. 92, Plate 38.—In this machine a line of matrices is composed, and the operations of line-justifying, casting a justified line, and setting are performed automatically. The Stringertype matrix, Fig. 21 (page 1070), differs from the Linotype matrix, Fig. 20 (page 1070), the strike being on the flat. The matrix is notched at the side, and this notch serves to set the mould to the correct width for the character, the dimension from the bottom of the notch across the flat being the *set* width plus a constant. The matrices are assembled as in the Linotype and measured in a vice together with space matrices, Fig. 84 (page 1131), the measurement being made on the aggregate thickness of all the matrices.

When the line has been composed, the spaces are driven up to fill the vice. The *set* width of the spaces is obtained in just the same way as with the type matrices; the Stringertype space matrix is tapered in side elevation, and the width at any point is equal to the *set* desired plus the same constant as in the type matrix. It is not essential that the thickness of the matrix should be the same as the *set* width of the type cast from it, but all the matrices of a fount may be a constant multiple of the *set* width in thickness. The space matrices must then be arranged with different tapers in front and side elevation. If θ_1 is the inclination of the wedge surface to the vertical in front elevation and θ_2 in side elevation, and C is the constant multiple in the case of the type matrices, then

$$\tan \theta_1 = C \tan \theta_2.$$

It is thus possible to set the vice and its details to the dimensions of any convenient body-size, such as pica, and the difficulty of obtaining a sufficient thickness for the matrices of the thin sorts is overcome.

The platform by which the space matrices are pushed up is L shaped in plan, and maintains the lower ends of the space matrices at the same height while passing before the mould.

The matrices having been measured are presented one by one in front of the mould, which closes to the *set* width given by the notch; the pump injects metal into the mould, which then opens, and one part acting as an elevator vertically raises the type with its tang to the receiving race, into which it is pushed by a horizontal pusher. By an ingenious arrangement of the mould the tang is carried up above the feet, two V notches being left one at each side, Fig. 42 (page 1087); the tang can thus be readily broken off, and the rough fractured part is clear above the feet. This is done automatically by the machine before delivery, the tangs falling clear down a shoot.

The type during the casting and composing operations is horizontal; when the line is completed it is automatically turned through 90° to the vertical position and placed in the receiving galley.

The matrices travel from the vice to the left of the machine after the measuring operation; they are then pushed successively one at a time into the cross race and travel from the operator in front of the mould; the last matrix cast from remains in the slide until the first of the next line comes along, when this matrix is pushed along the cross race. After the matrix has been cast from, it passes along the cross race by the pressure of the next succeeding matrix, and when it has travelled its own width past the casting point a plunger pushes it into the elevator race. On the completion of the line the elevator lifts the matrices then in the race to the slide where the space matrices are transferred to their magazine, and the type matrices elevated to the distributor bar, which operates in the same way as in the Linotype machine.

Safety cut-outs are provided, which operate under any circumstances which would involve damage to the machine, and in the event of a line being cast of incorrect length the machine is also stopped.

The advantages of casting separate type are many: corrections can be made by hand and away from the machine if necessary, whereas in the slug machines it is necessary to recast the whole of the line, even when the correction consists only of two transposed letters or a point omitted; the depth of the strike can be deeper, and therefore a clearer impression obtained, and the breakaway tang permits a hard metal to be used (similar to that employed in ordinary type for hand composition), whereas the metal used in the slug machines, and in those similar to the Monotype, must necessarily be soft.

The normal speed of the Stringertype mould is 160 characters per minute; as stated above, this does not represent the limit of output of a single mould; the total output possible of nearly 10,000 ens per hour is greater than that of any operator at work.

The machine requires about one half horse-power.

It is not generally intended to distribute the type but to remelt it; when, however, it is desired, a matrix can be left at rest in the machine and type cast from it continuously, so that sorts can be obtained from the machine for hand composition, if both machine and hand work are used.

The same degree of accuracy is required in type cast by these machines as in type cast on the simple typecaster. The test usually applied to check accuracy is that known as the "lock up," which consists of repeating the same characters for a whole page. A page thus set up is shown in Fig. 93, Plate 39; the type for this were cast at the rate of 160 per minute.

It does not appear probable to the author that the old method of casting single type and composing by hand can ever be entirely superseded by machine composition, as the bulk of display work and a large portion of scientific works cannot be so treated. In the case of most daily newspapers the whole of the ordinary matter, with much of the small type advertising, is set either in the form of slugs, or in the case of some of the more expensively-produced papers by means of other composing machines.

A very large amount of high-class work for the better weekly periodicals, for magazines, for novels and for text-books is still being performed by hand, but it is probable that this work also will be performed by machines in the near future, owing to the greater degree of perfection regularly obtainable in the product.

One word of caution is offered by the author to those who think of competing in the field covered by these machines. The detail is so complex and the difficulties met with in working out the machines are so numerous, that the time for which a patent is granted may easily be in greater part absorbed in experimenting before a commercial result is obtained.

In conclusion the author wishes to express his thanks to Mr. W. H. Maw, Past-President, for his kind assistance and for help in obtaining particulars, to his son Mr. R. L. Maw, Associate Member, for his aid in preparing diagrams, to Mr. J. F. Gilmore of the British Stringertype Syndicate, who has been connected with the Linotype and several of the principal machines, for much valuable information, and to his staff for their assistance in the preparation of many of the diagrams with which this Paper is illustrated.

The Paper is illustrated by Plates 32 to 39 and 78 Figs. in the letterpress and is accompanied by 6 Appendices with 15 Figs. and Plates 40 to 45.

APPENDIX I.

French Type.

The French very early adopted a point system, known as the Fournier system, in which the unit or point was 0·34875 mm. This system has now been almost entirely superseded by the Didot system, and the Fournier point is now in use only in Belgium and the North of France.

The Didot system now generally adopted has as basis the point of 0·376 mm.* It is to this (Didot) unit that typecasting and composing machines are designed.

The bodies in use are named according to the number of points; the sizes most generally in use are 5, 6, 7, 8, 9, 10, 11, 12, 14, 16, 18, 20, 22, 24, 28, etc. The 11 point (*corps onze*) corresponds very nearly to the English pica.

The height-to-paper of French type is 23·50 mm. and is 23·545 mm. for very fat black faces. The height of quads and spaces is from 19·18 mm. to 19·50 mm. The height of rules and furniture is about the same, the minimum being 18·05 mm.

The supplementary nick, used for distinguishing the small capitals o s v w x z and i in old style, is also employed in France.

There are certain differences between some of the characters as usually cut in France and those cut in England; for example, the Cap. C has "cats-ears" at top and bottom (C) while in England they occur at the top only; also a French fount comprises a sign for inverted commas « le guillemet » not used in England. The triple logotypes ﬃ and ﬄ are now scarcely ever used (*see* Appendix III on Logotypes).

---

* The English point is 0·35145 mm.

The following short vocabulary gives the names of the principal parts or dimensions of type, *see* Figs. 1 and 2 (page 1032).

The face	la face	Depth of strike	profondeur de l'œil
The shoulder	le talus	Serif	point d'approche
The nick	le cran	Body	force de corps
The heel-nick	la gouttière au pied	Line-to-front	distance à la ligne
The feet	les pieds de la lettre	Height-to-paper	hauteur en papier
The pin-mark	la marque	Set	épaisseur
The counter	l'œil	A space	une espace
Kerned letter	lettre crénée	A quad	un cadrat
To distribute pie	distribuer un pâté	A galley	une galée
An em-quad	un cadratin	Furniture	garniture
An en-quad	un demi-cadratin	A lead (1 to 4 pt.)	une interligne
The line	la ligne	Leaded	interligné
Side wall	l'approche	A rule (metal)	un lingot
Supplementary nick	le cran supplémentaire	A rule (1 to 12 pt.)	un filet
The tang	le jet	A rule (wood)	une reglette
The slope (of italic)	la pente	A fount	un assortiment complet de caractères

The nick in French type is placed at the back instead of in front as in the English founts.

The bill of fount for French type gives very different proportions to those of the English bill. The bill shown in the following Table (based on that of M. Rignoux) will probably be found useful. It is not usual to include italic unless specified; when italic is supplied it is usually in the ratio to roman of about 1 to 6. The author has taken 15 per cent. The quantities, for a fount of roman only, can be obtained by summing those given for roman and italic.

The superiors are used for abbreviations, such as

M^{gr} = Monseigneur, C^{ie} = Compagnie, N^{os} = Numéros, etc.

It is the custom of the trade to supply only É Ê È in capitals, small capitals, and italic capitals, but in this bill the author has included the other accented capitals which may be called for.

TABLE 9 (*continued on opposite page*).

French bill of fount for 100,000 *characters, exclusive of spaces and quads.* (*Police pour* 100,000 *caractères, les espaces et cadratins non compris.*)

Bas de casse.	
a	4,220
b	845
c	2,110
ç	90
d	2,510
e	9,250
f	845
g	845
h	845
i	4,630
j	420
k	80
l	3,820
m	2,110
n	4,220
o	3,820
p	1,720
q	1,010
r	4,630
s	5,540
t	4,630
u	4,220
v	845
x	420
y	260
z	260
æ	40
œ	80
w	40
ff	160
fi	300
fl	210
32	65,025

Ponctuations.	
.	1,500
,	1,800
;	250
:	170
?	170
!	170
6	4,060
Signes.	
-	950
’	950
»	300
*	40
†	40
(	130
[	40
§	40
—	260
9	2,750
Bas de casse accents.	
à	380
â	210
ä	40
é	1,250
è	380
ê	260
ë	40
î	125
ï	40
ô	125
ö	40
ù	210
û	125
ü	40
14	3,265

Capitales.		Petites capitales.	
A	260	A	170
B	125	B	80
C	210	C	125
Ç	20	Ç	20
D	210	D	170
E	380	E	300
F	125	F	80
G	125	G	80
H	125	H	80
I	260	I	210
J	80	J	80
K	20	K	20
L	260	L	170
M	170	M	125
N	210	N	170
O	260	O	170
P	170	P	125
Q	125	Q	80
R	260	R	170
S	260	S	170
T	260	T	170
U	210	U	150
V	170	V	110
X	65	X	65
Y	40	Y	40
Z	40	Z	40
Æ	20	Æ	20
Œ	20	Œ	20
W	20	W	20
&	125	&	80
30	4,625	30	3,310

Capitales accents.	
À	65
Â	35
É	80
È	65
Ê	20
Î	15
Ô	15
Ù	35
Û	15
9	345
Petites capitales accents.	
À	40
Â	20
É	65
È	50
Ê	25
Î	10
Ô	10
Ù	20
Û	10
9	250
Ital. capitales accents.	
À	15
Â	10
É	20
È	15
Ê	10
Î	5
Ô	5
Ù	10
Û	5
9	95

Total number of sorts 259.

(*concluded from opposite page*) TABLE 9.

French bill of fount for 100,000 *characters, exclusive of spaces and quads.* (*Police pour* 100,000 *caractères, les espaces et cadratins non compris.*)

Supérieures.	
d	100
e	200
g	100
i	100
l	150
m	100
n	100
o	200
r	150
s	100
t	100
11	1,400

Chiffres.	
1	400
2	300
3	250
4	250
5	400
6	250
7	250
8	250
9	250
0	400
10	3,000

Ital. bas de casse.	
a	650
b	125
c	325
ç	20
d	380
e	1,400
f	125
g	125
h	125
i	715
j	65
k	15
l	575
m	325
n	650
o	575
p	260
q	150
r	715
s	840
t	715
u	650
v	125
x	65
y	40
z	40
æ	10
œ	15
w	10
ff	25
fi	45
fl	35
32	9,935

Ital. capitales.	
A	40
B	20
C	35
Ç	5
D	35
E	60
F	20
G	20
H	20
I	40
J	15
K	5
L	40
M	25
N	35
O	40
P	25
Q	20
R	40
S	40
T	40
U	35
V	25
X	10
Y	10
Z	10
Æ	5
Œ	5
W	5
&	20
30	745

Ital. ponctuations.	
;	40
:	25
?	25
!	25
4	115

Ital. bas de casse accents.	
à	55
â	35
ä	10
é	190
è	55
ê	40
ë	10
î	20
ï	10
ô	20
ō	10
ù	35
û	20
ü	10
14	520

Ital. chiffres.	
1	75
2	65
3	45
4	45
5	75
6	45
7	45
8	45
9	45
0	75
10	560

APPENDIX II.

Characters and Signs required in Scientific and Other Works.

MATHEMATICAL.

$>$ is greater than
$<$ is less than
$\propto$ varies as
∞ infinite
$\angle$ angle
∟ right angle
$\perp$ perpendicular to
$\parallel$ parallel
$\pm$ plus or minus

○ circle
△ triangle
□ square
▭ rectangle
$\surd$ square root *
$^{123\ldots n}$ exponents or powers †
$_{123\ldots n}$ suffixes †
$\int$ integral
$\underline{\lvert n}$ factorial ‡

∴ therefore
∵ because
° degree
′ minute
″ second
$\equiv$ identical with
$\backsim$ difference
∂ used for partial differential coefficients.

And those characters of the Greek lower case and capitals which differ from the Roman. $\alpha, \beta, \gamma, \delta, \epsilon, \zeta, \eta, \theta, \lambda, \mu, \nu, \xi, \pi, \rho, \sigma, \tau, \phi, \chi, \psi, \omega, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Sigma$ Φ, Ψ, Ω.

MEDICINE.

℞ recipe
℥ ounce
ʒ drachm
℈ scruple
♏ drop

ASTRONOMICAL.

AR right ascension
☊ ascending node
☌ conjunction
☍ opposition

---

* The radix must in some instances be made of ⌊⌉ section to receive the figure or sign thus $\sqrt[3]{(A+B)^2}$. Owing to the great difficulty to the compositor involved by this sign it should when possible be replaced by the fractional index thus $(A + B)^{\frac{2}{3}}$. The solidus or diagonal stroke (/) is now frequently used to save work in composing, thus we read $(D - 1)/D$ instead of $\frac{D-1}{D}$. The author suggests that greater legibility would be obtained by the use of the diagonal stroke in fractional indices, e.g. $(A + B)^{2/3}$.

† Known in printing as superiors and inferiors.

‡ The factorial sign ($\underline{\lvert\ \ }$), which also gave great trouble, has now been superseded by the exclamation (!), thus we now read $\frac{n!}{m!\,(n-m)!}$ instead of $\frac{\underline{\lvert n}}{\underline{\lvert m}\,\underline{\lvert n-m}}$.

SIGNS OF THE ZODIAC.

♈ Aries
♉ Taurus
♊ Gemini
♋ Cancer
♌ Leo
♍ Virgo
♎ Libra
♏ Scorpio
♐ Sagittarius
♑ Capricornus
♒ Aquarius
♓ Pisces

SOLAR SYSTEM.

☉ Sun
☿ Mercury
♀ Venus
⊕ Earth
● New Moon
☽ First quarter
○ Full Moon
☾ Last quarter
♂ Mars
⚳ Ceres
⚴ Pallas
⚵ Juno
⚶ Vesta
♃ Jupiter
♄ Saturn
♅ Uranus
♆ Neptune

MISCELLANEOUS.

HP Horsepower
℟ response
✠ Maltese Cross
℣ versicle
✝ Latin Cross
☞ ☜ fists
☓ St. Andrew's Cross

APPENDIX III.

Logotypes.

The subject of logotypes, or combinations of characters cast together, has not yet, so far as the author is aware, been studied in its bearing on typesetting. The very early patent (1782) of Henry Johnson was bought by John Walter, the founder of *The Times* newspaper, and was probably the only extensive application which the system has met with.

The advantage of the use of logotypes in the case of hand (or machine) composition lies in the reduction of movements to be made by the hand of the operator; thus a combination of three letters, e.g. "the," will save two lifts or key depressions, and a combination of four letters, e.g. "tion," will save three lifts or key depressions. It appears obvious that if a certain combination occurs so frequently that it is commoner than any individual letters of the alphabet, a saving of labour would result from the adoption of logotypes for such combinations without additional strain on the memory of the operator. On the other hand, where hand-composition is concerned, the number of case divisions would increase for each added combination, and consequently the size of the cases would be increased also. Moreover the number of compartments or keys to be memorized by the compositor would increase, as also would the distance to be travelled by the hand of the operator.

A further objection to the use of logotypes in hand work is that, owing to the larger mass of the combination, the face of any of the characters is more easily damaged, and damage to any one character necessitates replacement of the whole logotype.

In view of the absence of statistics on the subject of the recurrence of the commonest combinations of characters, and with the further view of testing the accuracy of the proportions in the ordinary bill of fount, the author, after some preliminary trials, has examined 100,000 characters (exclusive of spaces), occupying rather more than two pages of matter from *The Times* of 30 April 1907, selected from: Leading Articles, Foreign Intelligence and Parliamentary Debate (this latter amounting to nearly 60 per cent.

TABLE 10.

Number of Logotypes in 100,000 *Characters.*

the	1933	ther	132	who	85	car	44
and	800	pro	176	able	63	ple	43
of	910	ess	171	der	82	eve	43
tion	428	us	244	he	122	ert	42
in	843	all	160	oun	81	age	40
er	806	wh	236	ance	59	rec	39
ing	536	ate	155	out	78	very	29
ed	776	ere	147	will	55	ng	58
to	716	ter	140	his	73	He	58
re	667	ill	136	int	72	tor	38
that	314	not	135	so	107	miss	26
it	546	ion	134	end	71	ble	34
on	522	had	134	one	71	if	48
al	519	est	134	por	70	It	44
is	450	ly	201	aid	69	col	27
ould	220	com	125	per	69	Con	27
be	433	our	119	qu	103	than	19
for	285	ist	117	some	49	—	—
was	282	by	169	are	63	—	—
or	404	pos	111	man	63	—	—
ar	380	ted	106	art	62	—	—
at	366	igh	102	ough	44	—	—
ment	182	sh	153	ade	57	—	—
as	364	un	151	but	54	—	—
an	355	ence	75	Com	54	—	—
th	344	have	73	day	54	—	—
ch	336	pre	97	ever	40	—	—
ent	220	ant	97	act	49	—	—
en	311	ver	97	has	48	—	—
st	310	from	71	ace	46	—	—
The	202	ect	93	cha	46	—	—
con	196	ear	89	him	46	—	—
with	140	ish	86	its	45	—	—

of the whole). The following method was adopted in counting the combinations: first the matter was gone over and all the four-letter combinations (chosen from the preliminary trials) counted; then the three-letter combinations were taken, and to avoid overlapping treated in order of precedence, thus in the word "expressed" the combination "pre" was counted but "ess" was not counted; then on the remainder the two-letter combinations were similarly eliminated.

The number of each of the combinations counted in the 100,000 characters is shown in Table 10 (page 1149), in which the combinations are arranged in order of importance according to the total number of separate characters employed.

From this Table the total number of times any combination occurred can be obtained by adding together the figures opposite the different combinations in which it occurs. Thus the combination "th" occurs in "the," "that," "th," "with," "ther," "than," or in all 2,882 times, while "Th" occurs in "The" 202 times.

By summarizing the totals successively it will be found that the first combination "the" accounts for over 6 per cent. of the whole matter; the first three combinations for over 10·4 per cent.; the first eight for over 20·2 per cent.; the first fifteen for over 30·3 per cent.; the first twenty-six for over 40·5 per cent., and the first fifty for 50·1 per cent.

Logotypes are actually in use for the seven combinations æ, œ, ff, fi, fl, ffi and ffl; they are also used for the italics of these, and for the caps Æ, Œ, roman, italic and small capitals. In all twenty different logotypes are actually supplied with every complete fount. All these combinations are rare, and, for the bulk of printed matter, could be abolished without seriously offending the eye, or orthography; in France the ffi and ffl are no longer generally used, ffi and ffl being substituted.* Why should not the seven commonest

---

* These combinations were originally necessary owing to the f being made to kern in the earlier type; the combined letters had to be cut specially to avoid fouling. With machine-cast characters (which usually do not kern) the necessity for the special combinations ceases to exist, and combinations such as ff and fl do not offend the eye.

logotypes be substituted for these, and while performing the composition of nearly 20 per cent. of ordinary reading matter, at the same time save lifting type (or depressing keys) to the extent of nearly 12 per cent. of the total work? The answer is probably to be found in the conservatism of the printing trade, and in the fact that the tendency is to abolish rather than adopt these combinations. The long s (ſ) with all its combinations, ſi ſl ſſ ſt, still found in German, to the illegibility of which language it largely contributes, the ct and qu with several others have been generally dropped in this country, the ct alone being still occasionally supplied with some old style faces. It is difficult to understand why the logotype "qu" should have gone out of use, for with the exception of algebraical expressions (and occasional quotations involving the occurrence of a very few foreign words) the "q" practically never occurs except in the combination "qu."

The Table of frequency of logotypes given (page 1149) would have proved of considerable utility in the design of the Wicks Composing Machine, the keyboard of which is shown in Fig. 56 (page 1104). In this machine the inventor attached special importance to the possibility of obtaining many frequently occurring combinations just as chords are struck on the piano. With the keyboard shown in the figure, chords can be struck for 34 of the logotypes given in the Table accounting for nearly 33 per cent. of ordinary reading matter. With the following arrangement b t w p c h e a i o u r s n g d l y , . sp. qd. for the front row, chords could be struck accounting for 51 of the logotypes given in the Table, and for over 44 per cent. of the ordinary reading matter.

It may be asked how far does the above Table show the true proportion of logotypes in general, or how far may they have been affected by the particular character of the matter selected for the statistics. In the Leading Articles and Foreign Intelligence (40·8 per cent. of the whole) and in the Parliamentary Debate (59·2 per cent. of the 100,000 type), the first eight combinations as given in the Table occurred in the following numbers (reduced to per 100,000).

Logotypes per 100,000 *Characters Roman Lower Case, Capitals, and Points.*

	On 40·8 per cent. Per 100,000.	On 59·2 per cent. Per 100,000.	On 100 per cent. Per 100,000.		On 40·8 per cent. Per 100,000.	On 59·2 per cent. Per 100,000.	On 100 per cent. Per 100,000.
the	1,958	1,915	1,933	in	897	806	843
and	635	914	800	er	981	684	806
of	1,040	821	910	ing	549	527	536
tion	532	356	428	ed	816	748	776

The counting of the single letters gave the result shown in the following Table, in which the actual number found is compared with that calculated from the bill of fount. (In Table 11 the figures for the individual letters are reduced in the ratio of 100,000 to the total Roman lower case, Capitals and points = 812,540.) *

TABLE 11.

Comparison of Observed and Calculated frequency of Occurrence of Individual Characters per 100,000.

	Observed.	Calculated.	Per cent.		Observed.	Calculated.	Per cent.
e	11,520	9,638	119·5	s	5,442	5,502	98·9
t	8,832	6,885	128·3	r	5,880	4,819	122·0
a	7,078	6,195	114·3	h	4,990	4,130	120·8
i	6,225	6,195	100·5	d	3,524	3,441	102·4
o	7,161	5,502	130·2	l	3,407	3,441	99·0
n	6,231	5,502	113·2	u	2,483	3,098	80·2

---

* In computing the number of points, it must be remembered that in the bill of fount about 10 per cent. of the quantities of full point and comma respectively belong to the italic fount.

It will be seen that there was a considerable variation between the observed and calculated frequency of occurrence, and the total observed characters in the Table exceeded the total calculated by some 13 per cent. This is in a great measure due to the matter selected consisting of long sentences. It is probable that if a much larger number of characters were taken and a greater diversity of printed matter selected the result would agree more closely with the fount bill.

Modification of the Alphabet.—There are in the English language several sounds which are represented in writing and printing by combinations of consonants and in shorthand by single signs. The author has investigated the frequency of occurrence of these, and has found that in the 100,000 characters counted above the following combinations occurred which could be represented by single characters if the alphabet were modified.

TABLE 12.

Sounds represented by Two-letter Combinations per 100,000 *Characters.*

th	2,882	wh	321	sh	239
Th or TH	259	Wh	27	Sh or SH	8
ng	594	st	490	ch	382
NG	5	St or ST	34	Ch or CH	50

The author suggests that a saving of about 3½ per cent. in writing, typewriting, printing, and reading would be effected by adopting two new letters for "th" and "ng" respectively. The early English thorn ð could be used for "th," or, if considered more legible, the Greek θ could be adopted; for "ng" a hybrid letter could be easily designed resembling both its components (like the Greek η). It would also be very easy to design simple longhand letters to replace the two separate letters now used; this saving does not only apply to the printer and compositor, but affects equally all who write and read the English language, and, moreover, it is a change which could be introduced first in the daily press and become gradually universal.* The author does not consider that it would be easy to carry his proposal further than the two new letters mentioned, which would increase the alphabet by two characters. The "th" (θ) would rank eleventh in order of demand and the "ng" (ŋ) twenty-third in this new alphabet of twenty-eight letters, the "ng" being in greater demand than k, q, x, j and z. The adoption of the two new characters named could moreover be effected readily on nearly all composing machines by the elimination of some of the existing unnecessary logotypes, such as ﬃ, ﬄ, æ and œ.

---

* This change has been already predicted by Mr. H. G. Wells in his novel "When the Sleeper Wakes.

APPENDIX IV.

On the Methods employed in correcting the Division Plates for producing the Wicks Machine.

The division plates used were of the form of a circular disk with a central boss scraped to fit a central column. The divisions were 100 in number and cut in the periphery of the disk with the ordinary dividing gear supplied with one of the best makes of milling machine. The form of division was such that the working face of each was radial and the other face inclined to the tangent, Fig. 94 (page 1156); the locking bolt was accurately ground and lapped to fit in a slide on the base of the division plate. At an early stage in the manufacture of the Wicks machine it was found that the division plates were not sufficiently accurate for the grinding processes on the segments to be carried out so far that segments could be manufactured to stock as components. ' The *maximum* error permissible, so that the segments could be prepared up to the stage at which lapping would begin, was found to be about equal to an error of 0·0007 inch at the periphery of a circle 20 inches in diameter or less than 15 seconds of arc. This corresponds to about 4½ inches at a distance of one mile; to ensure the result it was considered necessary to make the measurements to less than one-fourth of this amount.

(1) In the first method employed the author used a theodolite with two micrometer microscopes reading to 10 *seconds centesimal.* One side of the plain end of a lightning conductor on a distant chimney was used as the distant object, and the angle moved through from one setting of the division plate to the next obtained by direct reading on the graduated circle of the theodolite with the micrometer microscope, the reading obtained being of the form:

4·000 grades ± difference.

After taking the reading the theodolite was reset to zero, set on the distant object, and the plate moved another tooth; the second angle was then measured. By this means the total of the readings

FIG. 94.—*First Method of Correcting Division Plate.*

Each division is compared with the arc $0^g - 4^g$ of the theodolite circle by aid of a distant object X.

Scale $\frac{1}{8}$th.

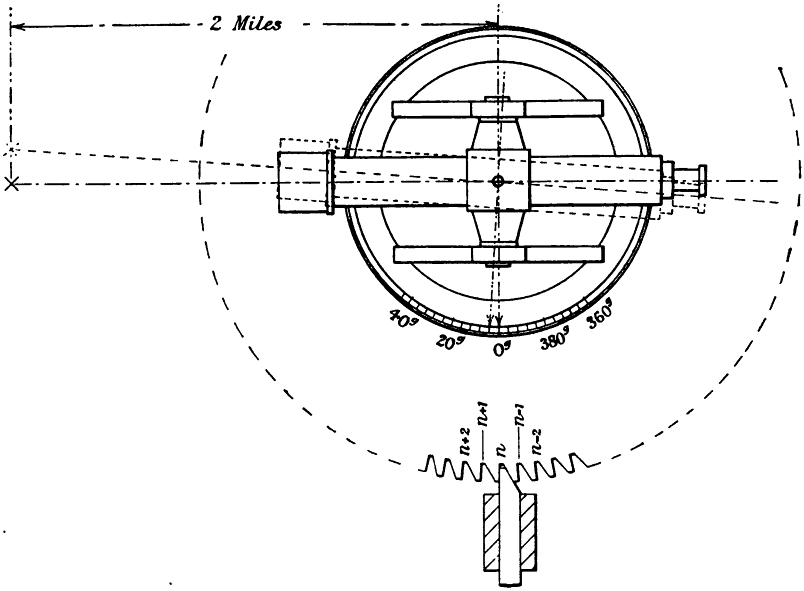
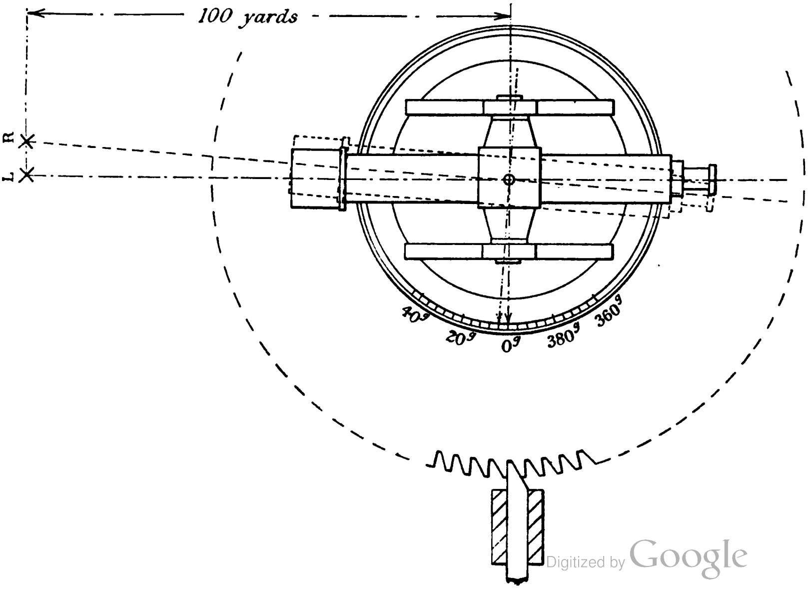


FIG. 95.—*Second Method of Correcting Division Plate.*

Each division is compared with the angle subtended by the two fixed wires L and R at the centre O.

Scale $\frac{1}{8}$th.



should have equalled 400 grades, but the errors of personal equation and of the standand arc of the theodolite were found to be equal to say 0·00045 grade (4·5 seconds centesimal).

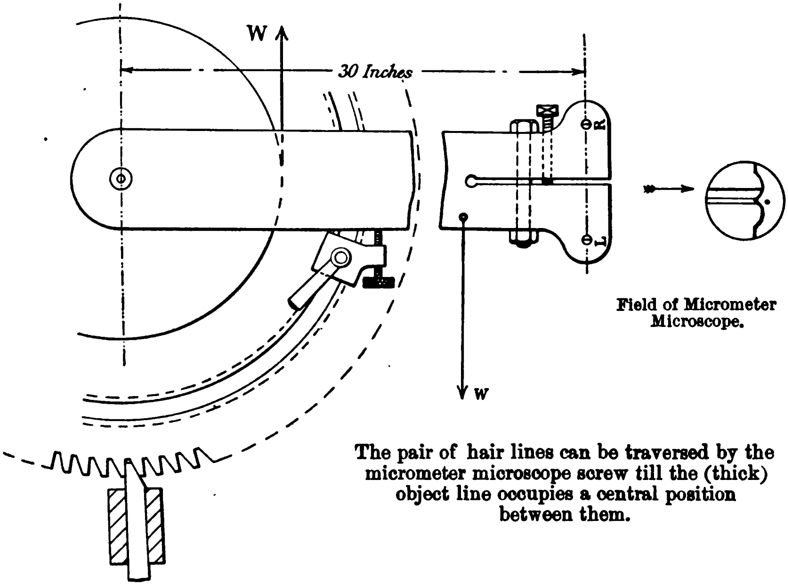
It was then possible to determine the actual difference from the standard angle for each angle moved through by the division plate and, by continuously summing the differences, the maximum positive error (or from the workshop point of view, the lowest tooth) could be determined. The excess of the maximum positive error above the sum of errors at any particular tooth gave the cut to be removed from that tooth.

FIG. 96.

Third Method of Correcting Division Plate.

Each division is compared with the standard angle LOR by the micrometer microscope.

Scale $\frac{1}{8}$th.



Field of Micrometer Microscope.

The pair of hair lines can be traversed by the micrometer microscope screw till the (thick) object line occupies a central position between them.

The method adopted for performing this work was devised by Mr. Colebrook; it consisted in mounting the division plate on a horizontal spindle between centres on a milling machine and applying a constant torque by means of a wire fastened to the periphery of the boss, passing over a pulley and loaded with a weight.

A micrometer screw was fitted so that it could be engaged with the flat radial surface of any tooth in succession. An angle mill mounted on the spindle of the milling machine could be fed across the face of the tooth to be reduced. This micrometer screw was set in contact with a different tooth of the plate, so that the cutter came inside the gap corresponding to the tooth to be reduced; the micrometer screw was then slacked back till this tooth, following it under the action of the weight, just touched the revolving mill. The mill was then traversed to one side and the micrometer screw turned through the amount desired to be removed plus a constant. This constant was $\frac{1}{1000}$ inch which represented the least amount that could be removed with certainty by a cutter without risk of refusal and glazing of the surface.

The single distant-object method of measurement did not require any particular accuracy in centering the theodolite on the division plate. It proved however a very troublesome method in practice owing to the rapid and frequent variations in light and atmosphere near London, and further owing to the yielding of the clay strata under the passage of trains on adjacent railways.

(2) As several plates were required, the author next tried a different method, Fig. 95 (page 1156), in which the chief troubles noted above were diminished. The same centesimal theodolite was used. Two pieces of fine piano wire were stretched by suspended weights from a slide and slide-rest some 200 yards from the instrument. The wires were blackened, a clean white paper background placed behind them, and the suspended weights were immersed in water to damp out any vibration. The screw of the slide-rest was worked till the readings obtained, using the side of each of the two wires, gave a close approximation to the desired angle of the division plate (4·000 grades).

In this case it was necessary to set the theodolite more nearly central with the division plate, an eccentricity of $\frac{1}{16}$ inch only being permissible.

The mode of operation was as follows:—

(i) The bolt being inserted in the space *n* of the division plate of the theodolite, the telescope was first set on the left wire L and the reading L_n noted.

(ii) The telescope was then turned on the right wire and the reading R_n noted; thus by difference the angle LOR was obtained $R_n - L_n$).

(iii) The plate was turned till the bolt engaged in space $(n + 1)$ and the reading of the left wire L_{n+1} was taken.

(iv) The telescope was turned and another reading of the right wire R_{n+1} was obtained; from these again the angle LOR was obtained as $(R_{n+1} - L_{n+1})$.

Thus the angle LOR was measured 100 times and from these measurements its error was obtained. (For example $d = 0 \cdot 000031$ grade.)

If d and e are the differences from the angle of $4 \cdot 000$ grades in the readings of the left and right wires respectively, then the readings are of this form (where n is the starting point):—

$$\begin{array}{llll} L_n & = (n) \quad 4\cdot000^g + d_n & R_n & = (n+1)\ 4\cdot000^g + e_{n+1} \\ L_{n+1} & = (n+1)\ 4\cdot000^g + d_{n+1} & R_{n+1} & = (n+2)\ 4\cdot000^g + e_{n+2} \\ L_{n+2} & = (n+2)\ 4\cdot000^g + d_{n+2} & R_{n+2} & = (n+3)\ 4\cdot000^g + e_{n+3} \end{array}$$

and $R_n - L_n = 4\cdot000^g + e_{n+1} - d_n = 4\cdot000^g + \delta - \eta_{n+1}$
where δ is the mean error of standard angle and η_{n+1} is the error in the theodolite arc over the portion used from space n to space $(n + 1)$.

Now taking the alternate readings,

$$\begin{aligned} L_{n+1} &= (n+1)\ 4\cdot000^g + d_{n+1} \\ R_n &= (n+1)\ 4\cdot000^g + e_{n+1} \end{aligned}$$

and subtracting we get $L_{n+1} - R_n = d_{n+1} - e_{n+1}$ where η, the error of the theodolite arc, is eliminated, and if α represents the actual error of the angle from space n to space $n + 1$,

$$\alpha = d_{n+1} - (e_{n+1} - \delta).$$

The actual arithmetical work can be reduced to about six columns of figures and the corrections obtained without difficulty.

The degree of accuracy attained can be judged by the following result after three series of corrections had been applied.

Errors at periphery of wheel 10 inches radius expressed in millionths of an inch:—

Errors.	0 to 70	70 to 140	140 to 210	210 to 280	280 to 350	350 to 420	420 to 490	490 to 560	560 to 630	630 to 700	700 to 770
Number of divisions	10	21	15	19	7	7	7	6	4	0	4

It will be seen that the errors had only just been reduced to the desired amount after the division plate had been corrected three successive times.

(3) The next method devised, Fig. 96 (page 1157), gave far better results, and did not involve the necessity for making so many observations continuously.

The column of the division plate was fitted with centres and a long bar of mild steel suspended between these. This lever was forked at its outer end some 30 inches from the centre. A bolt and set screw were provided for springing open the forked part or closing it. Each arm of the fork was drilled and a plug of silver wire inserted in each. A very fine radial line was drawn on each silver plug with a diamond. A micrometer microscope was arranged on a fixed support fast to the base of the division plate so that the horizontal lever could swing under it. A stop was fitted on the division plate with an adjusting screw with long stem to enable the horizontal lever to be set so that either the left or right wire could be brought to zero; the lever was kept under a constant pressure against the screw end by means of a weight and fine cord. Further means was arranged for enabling the stop to be moved through approximately 4 grades after the reading had been taken. The gear was boxed in so that variations in temperature, and radiation from the operator, did not affect the readings appreciably.

The method adopted was as follows: in the plan of the lever, R is the right hand radial line and L the left. The line R was brought under the micrometer microscope and set to zero, then the plate was moved one tooth and the reading on the line L taken, the reading being the difference between the angle LOR and the angle moved through by the plate. After the reading had been taken the stop and lever were moved so as to again bring R to zero; the plate was then moved another tooth and the next reading of L taken.

The readings of R were always zero. The readings of L gave the differences d_1, d_2, d_3 ... from the standard angle.

Moreover, since the plate moves through 400 grades when it completes its revolution,

$$\Sigma\, d_1 + d_2 + d_3 + \ldots d_{100} \text{ should} = 0.$$

Actually it was found to equal Δ, and $\frac{\Delta}{100} = \delta$ was the error of the standard angle between the lines on the silver plugs.

The corrected differences $d_1 - \delta$, $d_2 - \delta$, $d_3 - \delta$ ... were then tabulated as D_1, D_2, D_3 . . . D_{100} and summated continuously thus:—

$$D_1, D_1 + D_2, D_1 + D_2 + D_3, \ldots D_1 + \ldots D_{100},$$

the calculation being of a form which makes checking very easy.

These totals were then each multiplied by a constant so as to reduce them to the scale of the micrometer adjustment for milling. The new values being $\sigma_1, \sigma_2, \sigma_3, \sigma_4 \ldots \sigma_{100}$, of which the maximum value σ_m corresponded to the lowest tooth; adding 0·001 inch to this and subtracting $(\sigma_m + 0{\cdot}001)$ from each term in succession, the negative value obtained gave directly the amount of cut to be taken.

The results obtained can be seen from the following Table, in which the error in millionths of an inch at the circumference of a wheel 10-inch radius is given in the top line, and the number of teeth falling between the limits is given in the succeeding lines, as shown by measurement after the first, second and third cuts had been taken.

Measured error.	0 to 100	100 to 200	200 to 300	300 to 400	400 to 500	500 to 600	600 to 700	700 to 800	800 to 900	900 to 1000	1000 to 1100	1100 to 1200	1200 to 1300
After 1st cut .	15	18	22	16	10	7	4	0	2	3	1	0	2
After 2nd cut .	10	20	17	14	13	10	4	4	3	2	1		
After 3rd cut .	16	26	30	16	9	2	1						

The methods adopted may appear troublesome and complicated, but actually the calculation was merely of a simple arithmetical character. These division plates, it should be remembered, were not light measuring apparatus, but had to serve for carrying numerous drilling and other jigs, and required sufficient surface to bear setting hundreds of times each day in continuous regular work.

APPENDIX V.

MACHINES NOT DESCRIBED IN THE BODY OF THIS PAPER.

(The same classification is adhered to as in the Paper.)

CLASS IA (page 1092).

The Bhisotype.—Since this Paper was written the author has received particulars of a multiple mould typecasting machine known as the Bhisotype (Prof. S. A. Bhisey). This machine is stated to be arranged to cast from thirty to sixty different characters per revolution, and to run at 40 revolutions per minute. The speed claimed for it is, therefore, even greater than that of the Wicks machine, being 2,400 type per minute in the larger size machine. The type are stated to be turned out with the full depth of strike and with nicks and groove finished.

It is intended to work this machine in conjunction with a composing machine, the characters cast on the casting machine being conveyed by chains to a group of from eight to ten composing machines.

The Bhisotype machines are not at present in general use.

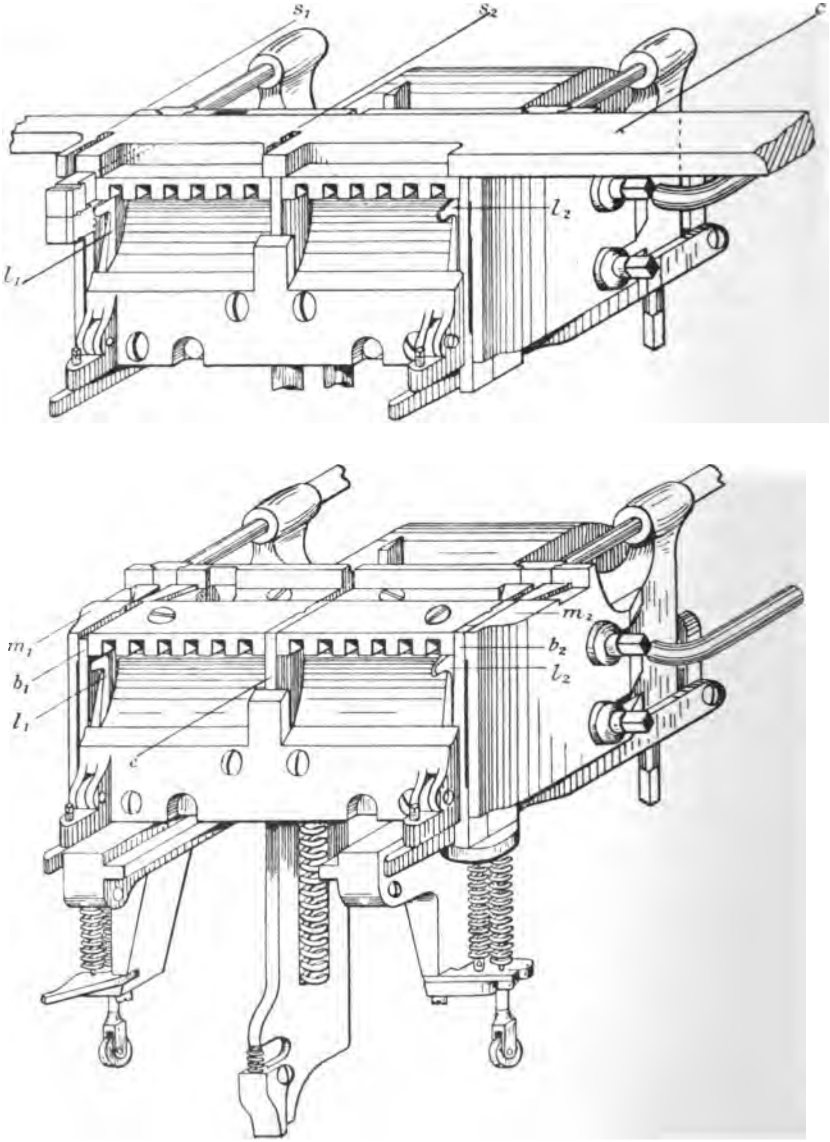
CLASS IIB (page 1092).

The Pinel Dyotype.—Since the Paper was written the author has received from Mons. R. H. de la Colombe particulars of a new machine, the Dyotype (J. Pinel). This machine has recently been constructed in Paris, and differs in several respects from the other machines described of this class.

The matrices, Fig. 97, Plate 40, are of trapezoidal shape, and a number of them are built up into a wheel, Fig. 98, having solid longitudinal dividing bars of the same section as the matrices. These solid dividing bars serve for casting spaces of the various thicknesses and for quads. The matrices are secured in the matrix-

Fig. 99.

Arrangement of Moulds for Typecaster (Pinel Dyotype). About ¼ size.



wheels by cylindrical pins which lock them to each other, to the dividing bars formed on the solid portion of the matrix-wheel, and to the ends of the matrix-wheels.

Each matrix is provided with a small steel plate at one side; the upper end of the bellcrank levers l_1 l_2 takes against this, when the matrix-wheel is presented to the mould, and the other end of the lever depresses the body-slide against the pressure of a spring, so as to give the characters a proportional *set* width to the distance moved by the upper end of the bellcrank, Fig. 99.

Each matrix-wheel contains twelve solid dividing bars with four rows of matrices arranged circumferentially between each pair of dividing bars. There are six circumferential rows of matrices, each of which contains 48 matrices arranged thus: the first row for lower-case roman; the second row roman capitals; the third row lower-case italic; the fourth row italic capitals; the fifth row small capitals; and the sixth row the various signs and figures. Thus each matrix-wheel contains 288 matrices for characters, apart from the twelve solid dividing bars upon which spaces can be cast. There are two matrix-wheels on each casting machine.

The moulds on the Pinel Dyotype casting machine are, in construction, somewhat similar to those already described in the Lanston Monotype and the Stringertype machines, in so much as each comprises a movable body-slide which takes up a position corresponding to the *set* width of each character to be cast.

There are two moulds m_1 m_2, Fig. 99, in the casting machine, and a collector-slide c which has a to-and-fro movement over them. This collector-slide forms one side of the mould; it also contains two slots s_1 s_2, of the same section as the type, into which the type is received when the collector-slide has moved (after the casting has been effected), so as to bring one of these slots over a body-slide b_1 b_2. Each slot is in turn then brought over the elevator-slide e placed centrally between the two moulds, and this moves the type successively out of the collector into the guide clip, from which it passes to the composing stick.

The body-slide is made in two portions which move together, with their upper surfaces at the same level when type are to be cast, but when a space is to be cast the portion nearest the face does not move, but acts as the matrix end of the mould, so that spaces are cast of trade height instead of shoulder height as in other machines of this class.

The two moulds are closed simultaneously by the collector, and the two type are cast at the same moment. At the end of its movement to the left the collector-slide pauses and receives the type cast in the left hand mould m_1; it pauses again when it has brought this type over the elevator e; the type received from the left mould is now ejected into the guide clip and the type from the right mould m_2 is received in the right slot s_2 of the collector, to be removed by the elevator e when the next successive type is being received in the left groove of the collector-slide.

It appears that the idea of the inventor of this machine is to be able to cast up to double the speed obtainable in a single mould, but of course there is some attendant complication in arriving at this result owing to the doubling of a large number of parts essential for each mould. Unlike the Lanston Monotype in which compressed air is employed, or the Graphotype, in which electro-magnets are used, the selecting needles are caused to enter the perforations by means of spring blades.

The perforated ribbon is very similar to that prepared in the Graphotype perforator. There are, however two lines of guide perforations, one on each side of the strip, Fig. 100, Plate 40, which are made by the keyboard itself. The strip may receive perforations on thirteen longitudinal lines, of which the perforations on lines 1, 2, 10, 11 and 12 indicate the kind of type fount (and consequently the lateral position of the matrix-wheel), while perforations on lines 4, 5, 6, 7, 8 and 9 indicate the different characters, letters, or signs and control the rotational movement of the matrix-wheel. Perforations on line 3 control the casting of spaces, giving a middle space when there is a perforation on line 3 alone, and a justifying space when the perforation on line 3 occurs in combination with another perforation. The perforation on line 13 is of larger diameter than the others and sets in operation the trip gear for transferring the line to the galley.

A very important feature of the Pinel Dyotype is that it avoids the disadvantages of requiring the use of unit systems or self-spacing type. The keyboard is arranged to effect the summation of any widths of characters, this being performed by a metal piece which is changed for each fount used. The wheel, which is used for the summation, is a toothless ratchet, driven and held by friction. This arrangement allows the matrices to be struck from existing punches, and therefore permits the work to conform to the faces already in use by the printer, a matter of considerable importance.

The line-justification of the line when composed is the same for all bodies and permits any shortness of length from one point up to twenty-four points to be made up. This is performed by an arrangement connected with the keyboard.

At the end of the line, the operator presses the line-justifying lever, and the machine modifies the space perforations already made, the strip being held in readiness for the purpose, without the further intervention of the operator.

Unlike the other two machines of this class described,* the justifying perforations occur at the beginning of the line and the strip is put into the machine so as to start at the beginning of the matter. In order to obtain the requisite total of combinations, the number of perforations varies for different characters, some characters being formed by one perforation and others by two, three, four or five perforations respectively.

The first Pinel Dyotype casting machine is shown in Fig. 101, Plate 40.

Class IIIb (page 1093).

The Double Magazine Linotype (Fig. 102, Plate 41).—Machines of this pattern are now in use both in America and England. As stated in the Paper (page 1134) there are two magazines which are placed one above the other; the lower magazine has its escapement below as shown in Fig. 103, Plate 42. The upper magazine has its escapement

---

* The *Goodson Graphotype* is described by Mr. P. W. Davis in the Discussion (page 1203).

above with separate upper verge rods. By means of a lever on the right of the keyboard either series of verge rods can be thrown into gear, the lever performing a similar function to the shift key on typewriters; thus any portion or portions of a line may be set in matrices from the upper magazine and the remainder from the lower magazine. Each magazine may contain two-letter matrices so that, with a keyboard of 90 keys, a total of 360 characters can be obtained. The return of the matrices to their respective magazines is effected by means of a central notch in the bottom of those matrices which belong to the upper magazine, Fig. 104, Plate 42. The matrices after leaving the arm or second elevator are received on a short rail and those without notches engage with the lower distributor bar, whereas the notched matrices straddle this short rail, travel between guides below the top ears and drop sufficiently to clear below the lower distributor bar; they then fall into an elevating device which transfers them to their own distributor box above the other. The return of the matrix to its proper place in its own magazine is therefore perfectly automatic. The magazines can be thrown backwards and raised clear of the escapements at the front end by means of an arrangement of levers; in this position they can be changed very quickly.

The American machine has the same difference in the matrices, but the notched matrix in this case falls down a shoot to its distributor box and enters the *lower* magazine. The escapement of the upper magazine is below and that of the lower magazine is above. Thus in the American machine the additional magazine has been added below, and in the English machine above, the original position. With the American arrangement the lower magazine can be changed while the machine is being operated with the upper magazine in use.

The new machines comprise a number of improvements for facilitating, in particular, the access to the mould wheel and to the trimming knives.

CLASS IIIB (page 1093).

The Typograph (Fig. 105, Plate 43).—This machine was originally produced in America. It was bought up so far as that country was concerned by the Mergenthaler Linotype in order to acquire the rights of the wedge space invented by J. W. Schuckers. The Typograph continued to be made in Canada and Germany, and since this Paper was written has been introduced into this country.

Matrices.—The Typograph matrices are struck in one face of a bar of rectangular section; this bar has let in, and silver soldered to it, an eye of steel by which it is suspended from a steel wire throughout the operations of composing, line-justifying, casting, and distributing. As the matrix never leaves the wire, distribution is a very simple matter; the whole of the upper portion of the machine rocks on an axis and is balanced by a spring so that a very small force only is required to tilt the top of the machine comprising the magazine, escapement, and keyboard until the magazine is at so low a level that the matrices slide back into place along the polished steel wires from which they are suspended, Fig. 106. The matrices may be of two kinds; in the single-letter machines they have a rigid eye at the upper end and are cut away to a hooked form at the lower end, Fig. 108 (page 1170), and in the two-letter machines, they have two notches at the lower end on the same side as the strike and two parallel notches on the opposite side above the strike, Fig. 109. In the former case the matrices are pulled down to justify for alinement, the upper surface of the hooked end being used for this purpose. In the case of the two-letter matrices, Fig. 107, Plate 43, these slide along the upper surface of one or other of the back parallel notches, and the justification for alinement is obtained by the gripper pressing the matrices upwards by means of one or the other of the front notches so that the lower face of one of the parallel rear notches bears against the setting bar which has been clear in the groove during the period of composition. The matrices do not bear against the faces used for alinement either during composition or distribution, consequently the tendency to wear and so produce irregularity of alinement is a minimum.

Fig. 108.

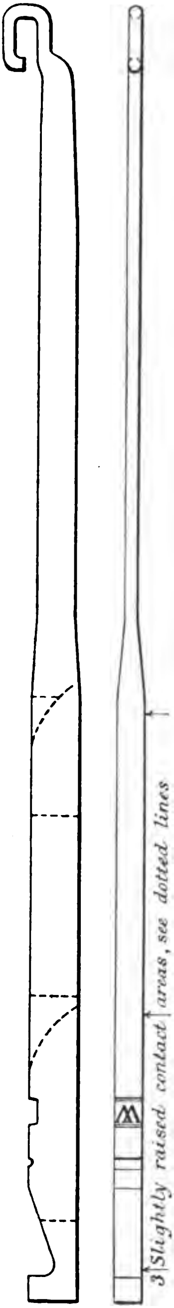
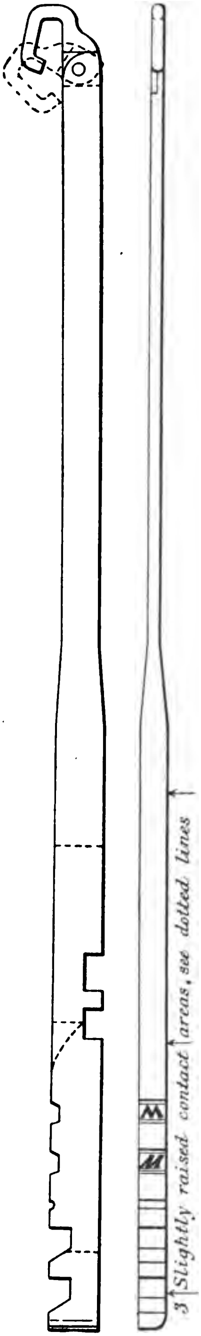


Fig. 109.

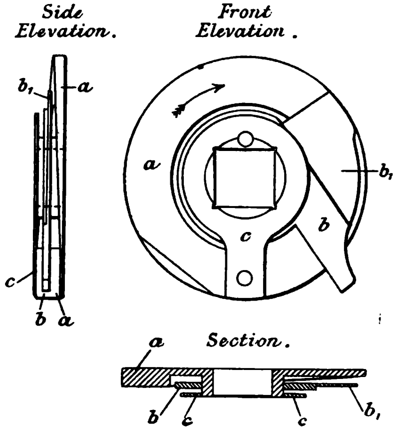


Matrix Composing and Slug-casting Machine (Typograph).

Fig. 108.—*Single-letter Matrix.* Full size.

Fig. 109.—*Double-letter Matrix.* Full size.

Fig. 110.—*Space-disk.* Full size.



The space-disk, Fig. 110, is of circular form made up of three pieces; the main piece *a* is plane on one side and on the other is formed with a helical face and a cylindrical boss; a loose plate *b* with a projecting arm turns freely on this boss; the portion of this plate b_1 which acts in making up the variable space is also made helical on the face next to the main part so that the outer face is parallel to the back of the main part when both helical surfaces are in contact; the plate is retained on the boss by a cover-plate *c* riveted to the main portion.

Assembly Channel of Matrix Composing and Slug-casting Machine.

(See also Plates 44 and 45.)

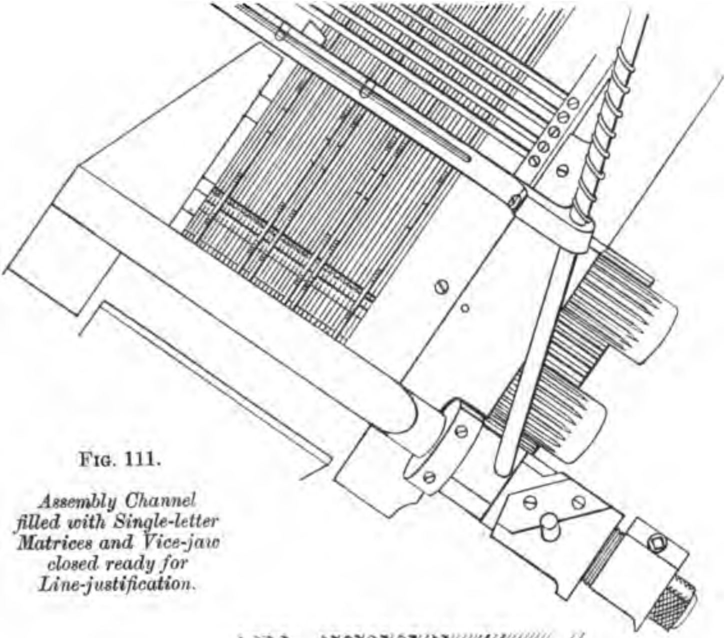


FIG. 111.

Assembly Channel filled with Single-letter Matrices and Vice-jaw closed ready for Line-justification.

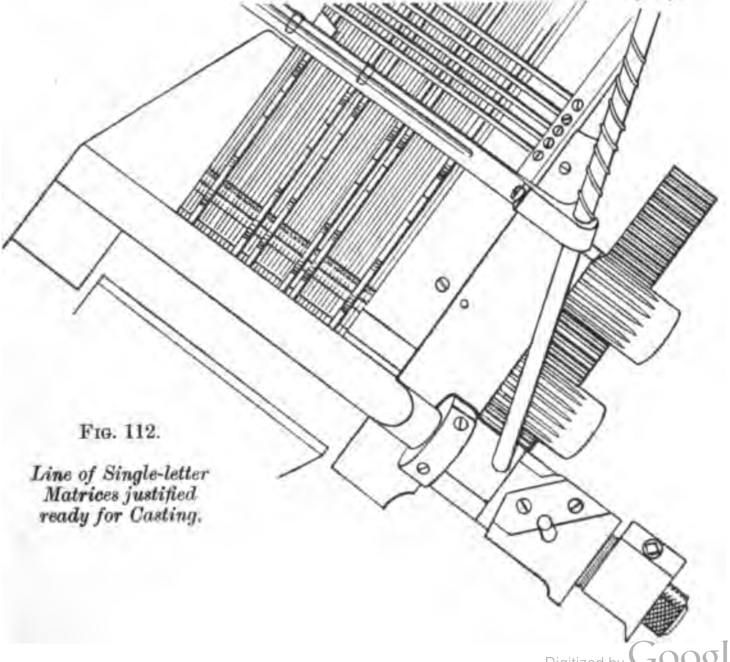


FIG. 112.

Line of Single-letter Matrices justified ready for Casting.

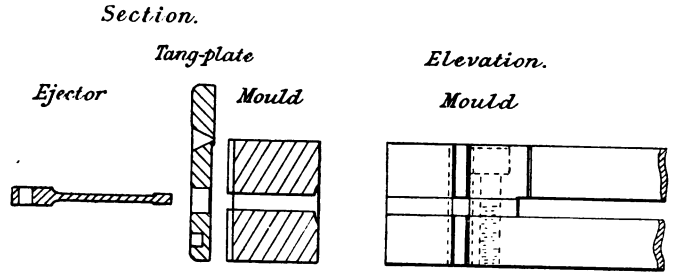
The space-disks, Fig. 110 (page 1170), are used in pairs one above the other, and are rotated equally so that the long stems of the letter matrices are kept parallel. Two steel bars of square section form the magazines for the space-disks; each of these bars is separate from, but forms the continuation of, the end of one of the square steel line-justifying shafts. In the normal position of these shafts relatively to the bars the space-disks can be made to slide freely from the one to the other in either direction. The hole through the centre of the main part of the space-disks is square, which enables this piece to be rotated relatively to the plate *b*, the arm of which is held in a groove in a brass guide. The letter matrices on each side of a pair of space-disks are thus wedged apart by the action of the helical surfaces; equal rotation of the two square shafts is effected by spur gears on the overhung ends of the shafts engaging with a rack which is spring-propelled on the line-justifying stroke.

Fig. 111 (page 1171) shows a line of single-letter matrices ready for line-justification and Fig. 112 shows the line after the shafts have been partially rotated to the requisite extent to fill the line.

Mould.—Owing to the form of the space-disk the Typograph mould, Fig. 113, is concave where it comes in contact with the space-disks which project slightly in front of the letter matrices. The hole formed by the various portions of the mould for the body of the slug is plain and rectangular, there being no beads, grooves or projections in this portion; the back is however recessed to a small depth, but only over a part of the length and width, so that the tang joins the slug below the level of the surrounding portion, Fig. 114. The tang is formed by a separate tang-plate interposed between the mould and the pump mouth. The tang-plate moves upwards after the slug is cast, and the metal pot has receded, shearing off the tang. The shearing is actually effected by the steel tang-plate against the typemetal of the recess in the slug and thus wear is avoided. The slug is then ejected towards the matrices by an ejector acting through a hole in the tang-plate; this takes place in two stages, at the end of the first the fins on the shoulder of the slug, Fig. 114, are removed by a pair of trimming knives which travel in the direction of the length of the slug and towards the back of the machine. The

Matrix Composing and Slug-casting Machine (Typograph).

Fig. 113.—*Mould, Tang-plate, and Ejector.* Half size.



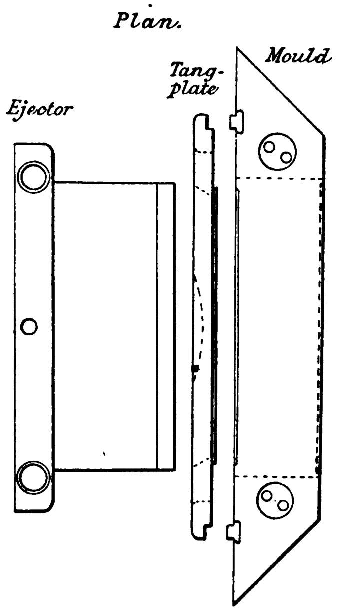


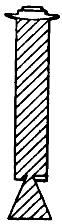
Fig. 114.

Type-slug as cast. Section through a space.

Fig. 115.

Type-slug trimmed and tang cleared off. (section)

Full size.



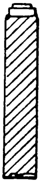
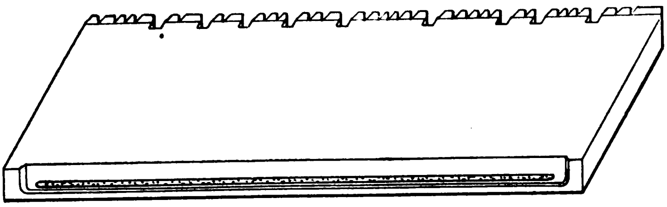


Fig. 116.—*Type-slug finished.* Full size.



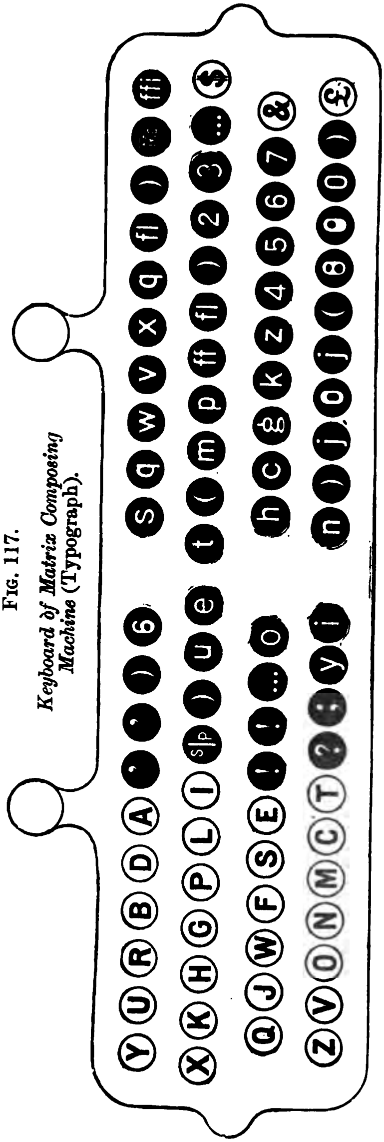


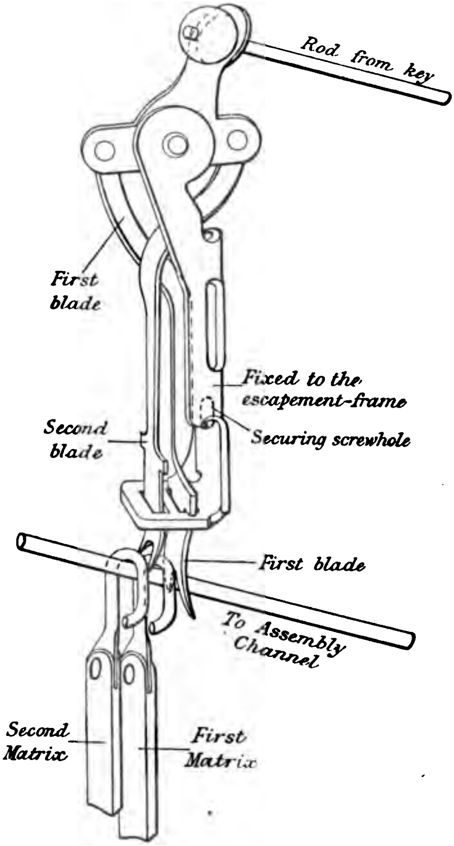
Fig. 117.

Keyboard of Matrix Composing Machine (Typograph).

Fig. 118.

Escapement for Matrix Composing Machine (Typograph).

Full size.



second movement finally ejects the finished slug which is shown in Fig. 116 and in section in Fig. 115. A second and smaller ejector removes the tang from the tang-plate and it falls into a shoot. The finished slug is delivered into a galley.

The pump plunger is spring-propelled on the casting stroke with a pause on completion of the cast to allow the metal to solidify. This process is assisted by the circulation of water through the water-jacket which surrounds the mould and keeps it cool.

The Typograph Machine.—At the top of the machine, Fig. 105, Plate 43, is the keyboard together with the escapements and magazine. The keyboard comprises eighty-four keys, the arrangement of which for the English language is shown in Fig. 117; since the matrices do not leave the wires it is possible to adapt the machine to any other language without either the necessity for specially designing the faces to any particular system of *set* widths or the need for modification of the magazine, escapements, etc. It is, in fact, as easy to adapt the machine to use other characters as it is to so adapt a typewriter. The escapement, Fig. 118, is operated by a rod from the key; it is of the shears variety, the pull on the rod raising the first blade and releasing the first matrix after the second matrix has been checked by the second blade of the shears. On the return of the key, the second matrix is allowed to come forward to the place occupied by the first matrix after the first blade has descended far enough to check its further movement. When the upper frame of the machine is tilted back the escapements, which are carried on a separate frame, are raised clear of the wires by a lever having an eccentric movement, so that the matrices can return freely to the ends of their respective wires. The escapement-frame comes back into position on commencing the return movement, so that the escapements are in place before the wires reassume a horizontal position.

The operation of tilting the upper portion of the machine back also ensures the return of the two sets of space-disks to their respective places on their magazine-bars, this being effected by a cam on the magazine shaft operating a rack, which turns a pinion on a vertical shaft carrying two levers; these act respectively upon the two space-disk shafts upon which the former are threaded. These space-disks are released by a key button just above the keyboard proper.

The operations of assembling and line-justifying are shown in the four Figs. 119–122, Plates 44 and 45, the reference numbers in each of these being the same.

In Fig. 119 the machine is shown at rest, neither the matrices, nor the space-disks being in the assembling place which is open ready to receive them; the vice-jaw 1 is in the open position and the square shaft 2 is empty. The part 3 is a removable stop piece which can be changed when the mould is altered for varying the length of line. The two bars 4, 4 serve as a bearing to carry the matrices while being assembled, and to support them against the pressure of the metal pot when the cast is being made. The alinement bar 5 provides the bearing surface for the feet of the matrix-bars to rest on during line-justification. The vice-jaw 1 connected to this bar closes the assembling place when the composition of the line has been completed, and keeps the line of matrices in position during the casting operation. There is an adjustable mark 6 above these parts which shows the width of line to which the machine has been set to correspond to the mould in use. This mark warns the operator when he must finish the line and start the casting operation. The part 7 shown below the alining bar is called the gripper; it is mounted on the shaft carrying the mould arm and bears against one of the notches in the matrix-bars pressing them up so that one of the back notches bears against the alining rib. This operation takes place at the same time that the space-disks revolve and spread the line,* the final justification of the line being performed after alinement has been effected.

Fig. 120 shows the assembling block with a line of two-letter matrices composed but free; the space-disks, nine of which are shown

---

* The operations described here relate to the two-letter matrix. It will be seen from the description of the single-letter matrix how the position and action of the alining bars must differ in the single-letter machine. In the two-letter machine the gripper moves up to aline the matrices; in the single-letter it moves down.

between the ten words composed, are barely visible as they occupy that position which presents the narrowest face towards the mould.

Fig. 121, Plate 45, shows the vice-jaw in its erect position ready for closing in to the proper length of line indicated by the mark 6. This closing is effected automatically on moving the starting handle. When the vice-jaw 1 has reached the position corresponding to the proper length of line the space-disks, which have up to this time remained stationary, rotate by the action of the rack on the two pinions. The space-disks can assume any width from two to nine points.

Fig. 122 shows the arrangement of the matrices after line-justification has been completed. The increased width occupied by the space-disks, as compared with that shown in Fig. 121, is easily seen. The gripper 7 holds the matrices in position for alinement. The mould is then brought up and held against the matrices pressing them against the back bars 4, 4. The metal pot with its mouthpiece is then brought to face the tang-plate of the mould making the whole space to be filled with metal airtight, except for the small air ways ground in on the face of the mould. The pump now operates and the slug is cast. After a slight pause, the pump and mould return to their original position and the line of matrices is then unlocked.

While the above operations are taking place the compositor is reading his copy, and so soon as the casting has taken place he can tilt the top of the machine back distributing the line of matrices. This done, he can commence the composition of the succeeding line. The upper portion of the machine is locked from the moment of moving the starting handle until the casting has taken place.

After the matrices have been unlocked the tang-plate rises, cutting the tang clear from the slug; when the tang-plate has reached its upper position the slug-ejector comes into operation partially ejecting the slug ready for the trimming knives to operate. After the knives have completed their stroke the slug is ejected and travels down a shoot to the galley; the tang is ejected from the tang-plate by the small ejector, and the various parts return to their positions of rest in readiness for the next casting operation.

The time occupied in performing the cycle is three seconds, during half of which time the magazine is locked while the casting takes place. Immediately this is released, the operator, who in the meantime has been reading his copy, distributes the line of matrices just cast from and proceeds with the next, simultaneously with the operation of trimming and ejecting the slug. It is stated that it is found in practice that the time occupied by the casting operation is that required by the operator for reading his copy and that consequently no time is actually lost; the copy holder remains fixed in its place while the upper portion of the machine is tilted.

Where repetitions of a line are required, it is merely necessary to leave the line of matrices standing and move the starting handle as soon as each slug is turned out, which is done at the rate of 20 lines per minute, being more than double the speed of the other slug casting machines.

The output of the Typograph is stated to average from 6,000 to 12,000 ens per hour.

The metal pot is stated to hold about 40 lb. of metal; it is heated by town-gas, the quantity required being about 11 cubic feet per hour.

The machine weighs about 9 cwt. It occupies a floor space about 2 ft. by 2 ft. and stands about 5 ft. high, the space required for machine and operator being about 6 ft. by 6 ft.

The power required to run the Typograph is about 0·25 H.P.

APPENDIX VI.

Bibliography.

Fry, E. Pantographia. London, 1799.

Johnson, J. Typographia, 2 vols. London, 1824.

Hart, C. Machinery for Composing and Distributing Type; Journal of the Society of Arts, Vol. 10. 1862.

Lefevre, T. Guide Pratique du Compositeur, 2 vols. Paris, 1880.

Drs. F. Lippmann and R. Dohme. Druckschriften des fünfzehnten bis achtzehnten Jahrhunderts in getreuen Nachbildungen (in ten parts). Berlin, 1884–1887.

Waldow, A. Illustriertes Wörterbuch der graphischen Künste. Leipzig, 1886.

Southward, J. Type Composing Machines of the Past, Present and Future. London, 1890.

Southward, J. Machines for Composing letterpress printing surfaces; Journal of the Society of Arts. London, 1895.

Southward, J. Modern Printing, 4 vols. London, 1898.

Landi, S. Tipografia, 2 vols. Milan, 1892–1896.

Ballhorn, F. Alphabete orientalischer und occidentalischer Sprachen. 14th edition. Würzburg, 1895.

Clodd, E. The Story of the Alphabet. London, 1900.

Hodgkin, J. E. Rariora. London, 1900.

Jacobi, C. T. Some Notes on Books and Printing. New and enlarged edition. London, 1902.

De Vinne, T. L. The Practice of Typography. Vol. I: Plain Printing Types. New York, 1900. Vol. II: Correct Composition. New York, 1901.

Hermann, C. Geschichte der Setzmaschine und ihre Entwickelung bis auf die heutige Zeit. Vienna, 1900.

American Type Founders' Company. Twentieth Century Desk Book of Type and Printing Materials. New York, Philadelphia, Boston, St. Louis, Cincinnati, and Chicago, 1902.

Thompson, J. S. The Mechanism of the Linotype. Chicago, 1902.

Thompson, J. S. History of Composing Machines. Chicago, 1904.

Collins, F. Howard. Author and Printer. 2nd edition. London, 1905.

For short papers in the engineering press see *The Engineering Index*, Vol. III 1896–1900, and Vol. IV 1901–1905, under Typefounding and Typesetting Machines.

See also the life of Sir Henry Bessemer for interesting information on early typefounding and setting machines; it is entitled "Sir Henry Bessemer, F.R.S. An Autobiography." Published by "Engineering," London, 1905.

Discussion.

The **President**, in moving a vote of thanks to the author, said the Institution owed him a deep debt of gratitude for a most interesting, voluminous and clear Paper. Many of the members believed that the Institution of Mechanical Engineers should be the receptacle of all classes of information connected with Engineering, and heartily welcomed a Paper on typographical work, because it certainly was very instructive and could not fail to be of interest and use to the Institution, both to the present members and to those who would join the Institution in the future.

The resolution was carried with acclamation.

The **President** had pleasure in calling upon a gentleman to open the discussion who had been to a considerable degree connected with the Institution for many years. He referred to Mr. Maurice Clowes, whose firm had been concerned with the Institution printing and had produced the Proceedings not only with credit to themselves but with credit to the Institution.

Mr. **Maurice Clowes** (of Messrs. William Clowes and Sons) said that one of the great problems in typecasting machines was the cost of the metal to the printer. Some machines needed a more expensive metal than others, and he thought attention should be turned to the subject of cheapening the price of metal in connection with mechanical composing. In many of the machines the metal could not be made to run, unless of an expensive character. A cheap metal would neither run nor cast solid, and therefore it was a serious question to the printer. As he saw several gentlemen present who had studied the question, perhaps they might be able to throw some light upon it.

Mr. J. F. **Gilmore** (British Stringertype Syndicate) said a large number of people hardly realised how serious the question of the metal was, and he quite agreed with what Mr. Clowes had said, as to typecasting machines, that the ordinary metal without a good flux would not flow. The great question was to know how to mix the metal. There was no real secret as to what was generally used, but there was some difficulty in mixing it and using it afterwards. The old type-founders used to test the temperature of the metal in the pot by putting in a piece of paper and seeing how it burned, and the man who was engaged in looking after the typecasting in this crude way judged whether the metal in the pot was too hot or too cold. Even now this old method was adopted by some type-founders. Engineers, however, who measured to a ten-thousandth of an inch knew the necessity of being correct in typecasting and composing machinery, as an error in the casting of single type as to body by the multiplication of such error would at the end of a page of printed matter throw everything out. A type-founder had to deal with very minute divisions of an inch, and mechanical engineers knew the necessity of keeping the metal at an even temperature. If they were casting at one time at a temperature between 600° F. and 800° F. and at another at over 1,000° F., there would be a marked difference in the resultant product. It was absolutely necessary to know the exact conditions they were working under to obtain the best results. It was also essential that the metal should be kept properly mixed and should flow freely. Phosphor-bronze (phosphorus, copper and tin) was now used as a flux. This made the metal much cheaper and tougher than that used by the old-fashioned type-founders. A man might, however, experiment with this for months before he was able to obtain thoroughly satisfactory results.

Mr. W. Worby Beaumont said he wished to record his very high appreciation of what he considered a remarkable Paper, a splendid monograph on a subject that was interesting to a very large number of those who enjoyed the products of the inventions the author had described. It showed what might be done in the future, not only towards the production of type of characters most pleasing, and produced in a way to assist in the cheapening—even if that were necessary—of literature, but also the directions in which improvements might be looked for.

(Mr. W. Worby Beaumont.)

In the first place, he wished to remark that the Paper, from the mechanical engineering point of view, showed the immense diversity of the knowledge of materials and mechanics that had to be possessed by a mechanical engineer who, as in the case of the author, took up different fields of occupation at different times. He had worked with the author in connection with tramway construction, in connection with gas-engine construction, and in connection with motor vehicle construction, and he was glad to be able to say that he passed through the mill of exaction by the machinery he had been describing that evening, and had not only come out unharmed, but was able after all that to produce one of the best designs of English motor vehicles.

He himself had had some experience with printing machinery and with printing, but not with type-making. When visiting the author at the Wicks works he was very much surprised to find him occupied in making a sort of trigonometrical survey. He knew that he was engaged on some kind of mechanism for the making of type, but as he had not then inspected the machinery, the trigonometrical survey was somewhat surprising to him. At the end of the Paper would be found the reason for that use of the theodolite that he had found the author using to set out accurately the circumference of a 20-inch disk. He had, in fact, brought into play a method which would have delighted Bugge or Roemer, Hooke, Airy, or Rosse, and some of the others who in early days found very great difficulty in setting out certain divided circles required for astronomical purposes. When engaged in considering certain questions of printing he had often found himself gently warned off when he asked the printers to make this or that modification of methods or practices commonly adopted, and he could therefore sympathise with the remarks of the author with regard to some of the old forms of type and certain of the things that had been felt to be necessary, simply because of the romance of the survivals of what probably were the wishes of the great penmen with regard to forms and shapes of letters. The Paper, for example, referred to kerns and various other details in the forms of letters, hair lines, and so on, and the author advocated the selection by the reading public of types that would be an improvement so far as eyesight was concerned, and an improvement so far as the casting of the type itself was concerned, and would lessen the difficulties in making the different kinds of punches and tools for milling the punches. It was not that the author made in any part of his Paper any objection to the difficulties that had been experienced; otherwise there would have been mentioned some of the objections to the extreme minuteness, almost objectionable minuteness, which had become necessary in order to make the moulds of the types for the speeds mentioned. But the author did say that although there were improvements still desirable, the engineer had broken down a great many of the old reverences or arguments of the type-founder of the "always-has-been-so-and-therefore-should-be-so-in-future" kind. Until the author read the Paper, it was probable that very few even of the members of the Institution realised the degree of absolute accuracy necessary to the production of type to produce that printing which everybody saw every day and thought nothing of. One of the remarks made by the author with regard to the matter was quite noteworthy. He pointed out that practice with readers, just as practice with artists or handicraftsmen in any particular craft, brought about a wonderful power of detecting inaccuracies, and mentioned as a proof the manner in which the eye could instantaneously and without conscious effort detect any inaccuracy in the alinement of a line of type or any other imperfection. He showed how necessary it was to provide for the acuteness of that observation by purposely producing an accurate inaccuracy. He stated, for instance, that it was necessary to make type not of certain sizes with regard to each other, but so that the relative depths should appear to be so, so that not only had a type-founder to make things accurately, but he had also to judge of the amount of inaccuracy as to form which the public might demand as a means of pleasing the observant eye.

With regard to many of the requirements arising from the form of type being simply the survival of the demands of old penmanship, it would be noticed that on pages 1047 and 1048 the author referred to another phase of that important question where he spoke of type

(Mr. W. Worby Beaumont.)

faces, and gave excellent examples of different forms of type, those which were the product of the expert in type-designing in modern times, those that were of the older form made before type with very fine hair lines was possible, and also an example of type which was very easily readable, but perhaps not considered by the type-designer as having the same perfection. He would especially draw attention to that particular type, given as an example of "fancy faces," in connection with the importance of the statement made by the author in the sentence printed with the type face marked (*c*) (page 1048).

With regard to the constitution of the metal, there was evidence in the Paper of one of the difficulties that had been met with not only in typefounding but in various other kinds of founding, and there again could be seen the importance of the extreme accuracy which had been the aim of the author and others, that the type metal which would flow into the finest possible line should not be able to make fins by flowing along the edges of the mould into which the metal was driven at the necessarily somewhat high temperature in making the type. The difficulties were enhanced by the necessity for getting the cooling to take place, as the author put it, in three hundredths of a second with metal hot enough to run into the corners. He had touched on a few of the points in the Paper, and would only repeat his very high appreciation of the book which the author had written on a subject about which very few knew much.

Mr. A. E. Gibbs (of Harrison and Sons) wished first of all to thank the Institution for their invitation to printers to be present that evening. Though he was not familiar with mechanical engineering himself, he knew something of printing and about one well-known type-setting and casting machine. Something had been said with regard to cost of metal, but as far as his experience went that did not enter into the question very largely. When the firm with which he was connected was taking up machine composition six years ago the metal was a trouble, the reason being that the general run of printers knew very little of the type-founder's art. There was difficulty in getting the metal to run freely in the mould ;

sometimes the metal was too hard and at other times too soft and sluggish. The trouble arose partially from the proportions of the ingredients being scarcely suitable and partially from the indifferent mixing. It was thought at first, at any rate by his firm, that anybody could mix metal, and it was relegated to an odd man, who took little interest in his work, with the consequence that the mixing was neglected and the heavier metals got to the bottom, and the lighter to the top, and the metal varied very greatly causing endless trouble on the casting section of the machine. Since then the firm had taken up typecasting largely, and thus with better knowledge and practical men to deal with the matter very little trouble was now experienced.

With regard to the actual cost of the metal, he could not give the exact figure, but he had made a rough calculation, and had come to the conclusion that in the firm to which he referred it did not exceed 3*d.* per lb., a cost which certainly would not seriously handicap machine composition as compared with hand setting. His remarks referred to the Monotype, working all types from nonpareil up to small pica, and, with the larger types predominating, little or no alteration was made in the metal used. There was only one peculiar thing about the majority of his work; the runs were rather short, and in consequence very hard type was not needed.

There were three things that most appealed to the printer. He must be absolutely certain of his height-to-paper, or he would experience endless trouble on the printing machines; he must be equally assured of the correctness of his alinement, or he was bound to get into trouble with his customer; and, thirdly, his type must be solidly cast, true to body and *set*, and with a clean-cut and readable face. Alinement on the Monotype machine, and he had no doubt on any other single-letter machine, was dependent on a number of details, and a very sharp look out had to be kept to make sure it did not go wrong. On all single-letter machines there were a great many advantages, the principal being that it was possible to deal easily with authors' corrections, the bugbear of the printer. With a single-letter machine the corrections could be made by hand quite apart from the machine, and consequently that type of machine

(Mr. A. E. Gibbs.)

appeared to have immense advantages for the general printer. He did not however decry the slug machine; that also had its advantages, and undoubtedly one was the ease with which the solid lines could be handled for newspaper work.

With regard to the effect of high quads and spaces, if high quads and spaces could be got rid of, half the printer's trouble would be over. They were a serious objection in the composing room, and a still worse trouble in the machining department, and the printer would value any aid which mechanical engineers could render in the direction of reducing the height of these very necessary types. There was always a difficulty, however much care was taken over the locking up of the formes, in keeping the quads down and more particularly where blocks were included in the make up of the pages. With very open table work, which of course it was policy to run on the machines, the only thing to do was to lift the quadrats out bodily and substitute metal furniture or something of that sort. In connection with a table job he was running that day, with the first column very open and fairly wide, he had come to the conclusion that the best thing to do was to run the three or four remaining rather solid columns on the machine, leaving the composition of the first column entirely to the men making up the work. In that way he saved time in the operating room and time in the casting room, the hand-compositors' work became more remunerative, and blacking of quads when machining was avoided. If only the mechanical engineer could invent a means of securing low quads and spaces it would add largely to the commercial utility of the machine, and would prove an immense advantage to the printer.

Mr. W. H. LOCK said the Paper, in his view, represented a tremendous amount of work, and he had been very much interested in it, but it was not a Paper—he was sure the author would appreciate the spirit in which this was said—that justified the title. The author laid himself open to this criticism when, for this Paper, he selected the title "Typecasting and Composing Machinery." Reading it as a specialist, it appeared to him that it was not a Paper that *covered* the subject. It seemed to be a Paper written by an engineer who had come in contact with typecasting and type-composing machinery as one of the incidents of his profession, a Paper by an engineer who had thoroughly understood the subject just where he happened to have touched it, but not a Paper which would justify its title. He mentioned that because he was rather proud of the subject, with which he was most intimately associated, and he should not like the mechanical engineer, on whom typecasting and composing machine men depended so much, to think that the whole subject was exhausted by this Paper. He would have liked to see the author dealing with something of the history of typecasting and composing machinery, with the mechanical problems that commercial men had from time to time put to engineers, and with the different attempts that engineers had made to solve these problems. He would also have liked the author to put before the Institution some idea of the mass of patents existing on the subject.

However, coming to the Paper as it stood, there were one or two things he wished to correct. He was associated with the Linotype machine, which came under the heading in the Paper of slug casting machines. Engineers had attempted in many ways to solve the problem of producing a printing surface by mechanical means as opposed to the old hand-setting of type. There were two classes of machines which stood out from the rest: one, producing a line of type made up of separate types, a separate piece for each letter, and the other producing a line of type made of a solid block. As a believer in the latter class of machine, he wished to say a word or two to mechanical engineers who were not necessarily composing machine men or users of type composing machines. On page 1072 the author spoke of the depth of the strike, and said that the depth of the strike in ordinary matrices was usually 0·045 to 0·050 inch, according to the particular type-founder producing it; and then went on to say that it reached its minimum of depth in the Linotype and Monoline machines where the depth of the strike—the distance the punch pentrated into the copper or brass piece into which it was struck—had a minimum of 0·02 inch. The author had overlooked the fact that in the Linotype matrix the punching, which was 0·025 inch deep, was struck on the edge of a piece of brass in a

(Mr. W. H. Lock.)

routing of 0·050 inch deep, so that the routing and strike together gave a depth of seventy-five thousandths. It was necessary to point this out as, as the statement appeared in the Paper, it would give the idea that Linotype type was much shallower than ordinary type.

Another point was that the author said the Linotype mould was so constructed as to cast a line of type having an overhang at the back. There again he wished to put him right on a detail of construction. The mould itself was perfectly plain, and the overhang was cast in the pot mouthpiece that came up against the mould. Those were points that the author might possibly put right in the Paper.

On page 1134 the author spoke about the output of the Linotype machine as being generally taken at 6,000 ens per hour, or, under good conditions, 7,000 to 8,000 letters per hour. Under good conditions, however, the actual working output of the Linotype machine would be, roughly, 75 per cent. greater than the figures given; that is to say, 13,000 to 14,000 letters per hour.

On page 1139 the author summed up apparently in favour of single type machines, and, in addition to claiming a greater depth of strike, a point which he (Mr. Lock) had already dealt with—stated that corrections could be made by hand and away from the machine in the case of single type machine, whereas in slug machines it was necessary to recast the whole line even where the corrections consisted only of two transposed letters or a point omitted, thus conveying the idea that corrections on the slug machine were more difficult than on the single type machine. That idea was all very well in theory, and might, unless corrected, appeal to mechanical engineers, because mechanical engineers understood the mechanics of the machine, but did not, he apprehended, understand much about the practical typesetting part. Therefore, he would say that, while these advantages claimed for the single type machine were all right in theory, they in practice proved otherwise, and corrections could be made quicker on the Linotype and other slug machines than with the older method of separate types.

Lastly, the speaker referred to the end of the Paper, where the author offered a word of caution to those who think of competing in the field covered by composing machines. Here the author had said the detail is so complex, and the difficulties met with in working out the machines were so numerous, that the time for which a patent was granted might easily be in greater part absorbed in experiment before a commercial result was obtained. He (Mr. Lock) thought that a truer statement than this had never been made.

Mr. H. A. LONGHURST drew attention to the fact that the author mentioned (page 1090) that Sir Henry Bessemer created a vacuum in the mould of his typecasting machine immediately before casting, and went on to say that "although this method appears to have been successful in his case, it has no practical application at the present time so far as the author is aware." It seemed to him that the question of creating a vacuum in a mould was a very important one, and if it could be applied in a practical way to the machines in use today it would be a very great advantage. Perhaps the author would explain how that vacuum was produced, and why it had gone out of use if it was really a success.

The author described a method of engraving matrices instead of cutting punches (page 1074). Probably the real reason why matrices were not engraved, instead of going to the extent of cutting punches, was because such a good result was not obtained from engraved matrices as was obtained from the punch and the driven matrix. On that subject he would also like to have the author's opinion.

On page 1139 the author, referring to machines in which the tang of the cast was broken away instead of being trimmed by a cutter, stated that ". . . . . . the breakaway tang permits a hard metal to be used (similar to that employed in ordinary type for hand composition), whereas the metal used in the slug machines, and in those similar to the Monotype, must necessarily be soft." The Typograph Composing and Slug Casting Machine was apparently unknown to the author at the time of writing this Paper, as the system of casting and breaking away the tang, employed in this machine, was practically identical with the system he described. The tang was broken away from the base of the slug and the rough fractured part was left in a recess, clear of the feet. This system not only enabled a harder metal to be used,

(Mr. H. A. Longhurst.)

but it also ensured dead accuracy with regard to height-to-paper. The importance of this latter fact could not be overestimated, and was fully appreciated by the high-class book printer, whose requirements in this direction were of the most exacting nature, for he thus obtained all the advantages of the slug, in ease of handling, etc., combined with the highest degree of accuracy that could be obtained in movable type. In establishments where Typographs were in use, matter might be set on one machine and corrected on another with the absolute certainty that the slugs from each machine would be exactly the same height. The mouthpiece of the metal pot in this machine was also specially designed with a view of enabling hard metal to be used, being in the shape of a wide slot instead of a line of small holes, which rendered it far less liable to "freeze" or become corroded.

The slugs cast in the Typograph, again, differed from those cast in other machines, from the fact that no trimming ribs were provided on the side. The mould being encased in a water-jacket ensured perfect uniformity of body and rendered trimming unnecessary, with the exception of removing the slight beard formed by the junction of the mould with the matrices. The slugs being smooth on both sides, lines of single type were readily used alongside of the former.

Referring to Appendix III (page 1148), in which the author considered the adoption of logotypes of frequently recurring combinations such as "the," "tion," "ance," etc., the adoption of such a system in mechanical composition no doubt offered many advantages at first sight, but had its limits. One serious drawback to such a system was that the keyboard would have to be enlarged, as, with the exception of the combined characters such as ff, fi, fl, ffi, ffl, which might well be replaced by some more useful combinations (since the necessity for these ceased to exist upon the abolition of the "kerned" sorts), additional keys would have to be provided for the logotypes, as, obviously, all the single characters comprised in the latter would still be required. Any great addition to the number of keys already necessary was detrimental to speed as it increased the distance that the operator's hands had to travel.

The advantage to be derived from the use of logotypes was therefore offset to a certain extent, that is to say, the gain in minimising the number of key depressions for certain words was discounted by the fact that the hands of the operator would have to cover a greater distance to touch the keys corresponding to the logotypes than would be necessary in the case of the keys carrying the single characters. It seemed, therefore, that unless limited to the present number of keys, or thereabouts, the use of logotypes in composing machines offered very little advantage. The logotypes ff, fi, fl, ffi, ffl, however, might well be replaced by such combinations as "the," "and," "in," etc., and there was no doubt that, but for the conservatism of the printer, this would have been done long ago by the composing-machine manufacturers. Any innovation of this sort was not looked upon with favour by the printer, who, as a rule, preferred to stick to the old ideas and retain the ancient usages of the craft.

The proposal advocated by the author of adding two new characters for "th" and "ng" respectively to the English alphabet did not lead to any difficulty of the kind mentioned, since it merely involved the use of two capital and two lower-case letters which could replace four of the practically useless f combinations, and could be adopted on such a machine as the Typograph without altering the keyboard; the whole extent of the change, in fact, would amount to the substitution of four new key buttons and of four kinds of matrices for the new characters, the total cost of the change amounting to only a trivial sum on existing machines, while it could be made without any expense whatever on new machines. So large a saving as three-and-a-half per cent. in length of matter as well as in the labour of composing, conclusively shown by the author to be obtainable, was well worth the careful consideration of the printing trade.

It was possible that this suggestion had applications in other languages, and it would be of interest to know whether in French or German the author had found any parallel case.

The average reader of books, newspapers, etc., would be none the wiser if the ffi were produced by single matrices instead of a

(Mr. H. A. Longhurst.)

logotype; it was only the printer who would detect it. Composing machines have had to be made to conform to these long-established customs of the printing trade, which in many cases had ceased to be a necessity, whereas, with a freer hand, their designers could increase the efficiency of the machines, without in any way detracting from the appearance of the composition produced by them.

The designing and construction of typecasting and composing machines has presented the mechanical engineer with some of the most complicated and interesting problems he had ever been called upon to solve, and it was an undoubted fact that once a man had taken up this subject he became so engrossed in it that he could not relinquish it, and it became a life study with him.

There was no doubt that hand composition so far as solid work was concerned, even for the very highest class books, was rapidly becoming a thing of the past. The results obtained in this class of work on the Typograph compared most favourably with the best hand setting.

Mr. **FREDERICK WICKS** thought the best contribution he could make to the subject of the evening would be not in the form of criticisms of minute details in the Paper, which was very comprehensive and excellent in all its departments, but in the form of adding something which would give a more clear idea of the difficulties surrounding the processes of construction of any machine designed to record written speech by typography. When the subject first came under his consideration some thirty-five years ago as a journalist and parliamentary reporter and later as a newspaper proprietor and printer, matrix composing machines had no existence. The only mechanical contrivance for producing a printing surface available in 1870 was the Kastenbein composing machine which was being experimented with in *The Times* office and was supplied by hand distribution, a slow and costly process. He watched the machine composing some of his own copy, and by later calculation found that the difference in time between composing by picking types from a case and by the manipulation of keys was a saving of 83 per cent. in favour of the latter. This 83 per cent. was at that time almost wholly absorbed by the cost of dividing up into lines, known as justification, and by the cost of distribution and arranging the letters in line for the tubes of the machine. It was obvious that the value of the loose-type composing machine was small unless a more speedy and cheaper service of type could be provided. The result was the Rotary Typecasting Machine after some five and twenty years of experimental work in the region of mechanical engineering. Distribution by hand could be realised at a speed of 5,000 per hour. Boy labour could arrange distributed letter in line at some 10,000 per hour, type was cast in *The Times* office prior to 1900 at an average of 4,000 per hour in the hope that new type could be supplied to the composing machine. Mr. J. C. MacDonald, then manager of *The Times*, who conducted these earlier experiments in the endeavour to cast a new fount of type for each day's paper, concluded his efforts by the reflection that the more he pursued the inquiry the more he was struck with "the glorious simplicity of the compositor and a pair of cases." In the Paris Exhibition of 1878 was exhibited the invention of Delcambre, whose machine was really the foundation of all the loose-type composing machines subsequently devised, and was used in composing the first number of the *Family Herald* in 1842 (page 1103). A visit to that exhibition and a conversation with Mons. Delcambre in company with Mr. MacDonald started the series of ideas which resulted in the Wicks composing machine, which set many combinations and several short words with a single touch, and afterwards in the Rotary Typecasting Machine, which put in line 60,000 finished types per hour. The realisation of the rotary scheme solved the question of supplying loose type to a composing machine, seeing that it produced the finished letter from molten metal at a speed twelve times faster than the hand or mechanical distribution of the manufactured type.

In the course of the mechanical development of the rotary machine it was found that the chief difficulty in the way of casting type rapidly arose from an imperfect knowledge of the thermal problem involved as distinguished from the mechanical. The mechanical difficulties had been described in the Paper, but these were aggravated by the fact that while the machine was being

(Mr. Frederick Wicks.)

constructed in a shop temperature of, say, 60° F., it had to deal with molten metal at a temperature of about 700° F. and a point of congelation of about 500° F. As the product had to be delivered with a limit of error of 0·002 it was necessary not only that the mechanical construction should be precise and accurate, but that it should withstand the expansion and contraction involved in the reception and cooling of these thousands of castings, and allowance had to be made for contraction on cooling. The problem was sufficiently novel to excite the eager interest of Lord Kelvin who was present on the occasion of some of the early experiments, and particularly at one, when, in demonstrating the pump force, it was shown that the metal jet of one-tenth of an inch in diameter penetrated a sheet of copper one-eighth of an inch in thickness in twenty seconds—the resultant orifice being a third of an inch in diameter. The proposition, as submitted in this conversation with Lord Kelvin, was this:—How to project a jet of molten metal the distance of an inch in a space of time less than 200° F. could be given up to a cold mould. The casting machines originally in use had been worked on the theory that the mould must be hot. A hot mould, he believed, that is a mould of a temperature above blood heat, was required in all casting processes dealing with results in which fine lines and sharp surfaces were required.

In typefounding for three or four hundred years, ever since Gutenberg invented separate types, the practice had been to cast "dummies" until the heat of the mould had reached about 400° F., and then satisfactory casts began. After a few hundred had been cast the mould became too hot, and the operator had to refrain from casting for a time until the mould had cooled down. Later machines introduced concurrent automatic cooling by a wind blast or water channels, but none of these was equal to the cooling down of castings produced at the rate of a thousand per minute, and a uniformly cold mould became a necessity. The problem resolved itself into the simple question as to how the metal could be injected with sufficient rapidity, and that was a pump question. The pumps in common use had been and were now intermittent in their operation and practically exact in their delivery. The temptation to synchronise the stroke of the pump with the presentation of the moulds in the rotary was considered and abandoned. It would have involved 100 strokes in ten seconds, and the moulds being only a half inch apart, more or less according to the width of the letter to be cast, the mechanical scheme of synchronisation would have been difficult. A continuous and equal projection of metal was resolved on as the simplest solution of the difficulty, and the result has given statistics of unusual interest respecting the passage of heat through metals. The metal being at 700° F. and the point of congelation 500° F., it was projected at a speed of 28 miles per hour through a tenth of an inch orifice under a pressure of 250 lb. on the square inch, and resulted in the passage of 80 lb. weight or 240 cubic inches per minute. The moulds in this way were filled each and all in the 530th part of a second and cooled in something less than the 300th part of a second. How much less, the apparatus was not suited to disclose. There was in any case the 130th part of a second to spare, and the casts were ejected in four seconds at a temperature of 80° F. showing that 620° F. had been removed in four seconds.

The foregoing results were shown in a machine that had been running for two years uninterruptedly, and had cast 250 million types which had been used in the production of *The Times* or *The Morning Post.* These figures would be of interest not only as an exposition of the solution of the thermal problem in connection with this process of rapid typecasting, but of general interest in supplement to what is found in the books on the subject of the conduction of heat.

It was somewhat a matter of regret that a machine which in the course of its construction had resulted in so many interesting mechanical excursions should have become practically obsolete by natural development on the lines of the principles it had demonstrated. The very perfection of the machine made improvements necessary. The great cost of building it obliged a revision of the scheme of construction and it was not probable that any more rotary casting-machines would be built. The time had not arrived for describing the newer form of machine now under construction, beyond stating

(Mr. Frederick Wicks).

that the disk with all its attendant difficulties in the formation of the moulds and the process of cooling was abandoned, and the casting would be proceeded with in a straight line. The machine would also be capable of adjustment so as to cast all sizes and widths of type at will from a single machine. In addition to this the new method of casting would be applied to the Linotype machine, so that the line instead of being cast in a solid slug would be produced in separate words or groups of words or single letters at the operator's will, thus disposing of the criticism that the Linotype line could not be corrected apart from the machine, and giving to the Linotype, which now held the ground, all the qualities claimed by its competitors without detracting from its own.

Much more might be said upon the subject of typefounding, which had hitherto been a secret industry confined for some four hundred years in the hands of some half dozen firms who had jealously guarded what they believed to be their secrets. Probably the Paper was the first comprehensive description of the practical working of the art, and yet it was mainly composed of descriptions of machinery produced within the last thirty years. The metallurgy of typefounding would form material for a Paper by itself. The information contained in the text books was meagre to a degree, and quite insufficient as a record of present-day practice. It would be impossible and inappropriate adequately to deal with it in the course of a discussion on the mechanism of the subject, but it was a matter well worthy the attention of members of the Institution, because it involved consideration of that important question of the evaporation and oxidisation of metals, which entered so largely into the question of the strength and density of castings.

Mr. Legros, after thanking the Institution for the kind manner in which the Paper had been received, referred first to Mr. Clowes who had touched upon a very important point, the cost of the metal. Mr. Gilmore had pointed out that there was something to be done in the way of increasing fluidity by the use of phosphorus. It was certainly important that the metal should flow readily, but not too readily; if it flowed too readily a fin was developed, and yet it must flow readily enough to fill a hair line; therefore it was necessary to keep between reasonable limits.

Mr. Worby Beaumont had alluded to the methods employed for correcting the division plates (page 1182); at the present day there was probably little necessity for originating graduations, but, if the author were required to originate a graduated circle of say 360 main divisions, he would prefer the last method he had described (modified if necessary to suit any special conditions) to that of obtaining 256 equal divisions by continual bisection and the subsequent elimination of errors described by Troughton.

He had also mentioned the question of necessary inaccuracy, and the author did not think this had been alluded to before in anything that had been written on the subject. He had tried to make it clear that it was necessary that the face of the type should be made inaccurate, and if it was desired to produce type pleasing to the eye the inaccuracies had to be standardized as well as the accuracies.

A feature in modern printing which was very bad for the eyesight was the use of high-surface paper for the text in magazines, in periodicals, and even in books. It would be far better for the reading public if the process blocks were printed on calendered paper, interleaved, and the whole of the text on a rougher paper.

It was of interest to note that Mr. Gibbs, as a practical user of one of the machines described, did not appear to lay very much stress on the question of the metal, and had found that this could be managed very cheaply on the Monotype, a single-type machine, but he had also pointed out that there were various things liable to occur if there was the least carelessness (page 1185). If the height-to-paper was not looked after there was trouble with the machine, and if the matrices were not well kept up, or were loose in the frames, the customers objected to the product. Mr. Gibbs had also pointed out a matter mentioned in the Paper, authors' corrections, to which Mr. Lock took exception. He thought their different points of view were due to the use of different machines. He had not attempted to exhaust the subject in the Paper, having endeavoured only to point out a few important facts. Not much had been written on the subject

(Mr. Legros.)

and there was plenty of opportunity for Mr. Lock and other people to read other Papers. In the Paper he had already stated that there was enough in the Linotype to make a very good Paper by itself, and probably no one would be better able to do this than Mr. Lock himself.

With regard to the depth of strike, Mr. Lock had rather criticised that portion of the Paper, but the counter in the Linotype matrix was no deeper than the depth given in the Paper, and it was the counter that sometimes took the ink. Of course there was no difficulty with high spaces or quads on the Linotype or other slug machines, since the depth of routing, alluded to by Mr. Lock, left the spaces low; this was shown clearly in Figs. 39, 40 (1087), Fig. 88 (page 1134), and Fig. 116 (page 1173). In regard to his remarks as to the mould casting a line with an overhang at the foot, this overhung portion was actually formed in the metal-pot mouth, which at the time of casting, and until the metal had set, formed a portion of the mould, though probably Mr. Lock was terminologically correct in not considering this piece a part of the mould. The author could not, however, agree as to the mould being perfectly plain; in the first place there were internal projections at the foot to prevent backward movement, and in the second place there were the raised ribs for trimming to body-size. The slug cast on another line-casting machine, Fig. 116, was cast in a mould free from either of these kinds of projections and one which could more properly be called plain.

Mr. Lock had also called him to account with regard to speed, and probably Mr. Lock knew the speed of the Linotype very much better than the author, who had not worked one practically; he had taken the ordinary figures given to him, figures which he believed to be correct.

Mr. Lock did not mention one reason, which tended to minimise the disadvantage of having to reset the lines for corrections; this was the ease with which the complete slugs could be handled. Recently some inventive effort (A. W. Hanigan) had been expended in the direction of securing loose type when composed and line-justified so as to form it into a bar.

Mr. Longhurst asked a very interesting question about the use of vacuum in the mould. He did not know what Bessemer did exactly, because it was only alluded to very briefly in his life, but he knew that it was re-invented subsequently by somebody else, although he did not believe that it was actually put to practical use. The air in the mould was a constant trouble, and there was usually some sort of provision made for getting rid of it. In the Typograph mould some very fine depressions could be found, ground in just deep enough to let the air escape, and grooves for the same purpose were shown on the foot of a Linotype slug before trimming. Mr. Longhurst also raised a very interesting point with reference to engraving matrices. When a matrix was engraved the actual depression corresponding to the strike of the punch had the same appearance as the surface run over by an end-mill; it looked like the engine turning on the case of a watch, and therefore the same polished appearance was not obtained that could be obtained with any struck or electro-deposited matrix.

The author wished to express his appreciation of Mr. Longhurst's remarks on logotypes (page 1191). The author was not in favour of carrying the idea beyond the strictly practical limit. Where a language comprised certain well recognised sounds represented by two or more characters in that language and by a single character in some allied language, it would generally, the author believed, be a problem worthy of careful investigation.

Mr. Wicks had alluded to the cold mould as a very recent invention. He did not think many people used it before Mr. Wicks. It had been used in one of the slug machines, the Typograph. If the slugs cast in the Typograph and in the Linotype were compared it would be seen that the cold mould produced a considerable difference in the appearance of the slug, though he would not say greater accuracy, except in height-to-paper. Water-cooling was now used on a number of other machines, in particular on the Lanston Monotype.

The author shared the regret of Mr. Wicks that the field of utility of the Wicks machine had been so limited. If these machines

(Mr. Legros.)

had been put to the task of supplying only the commoner sorts of character, say the first twelve in order of demand, over 50 per cent. of the total production would be so dealt with; or, if the whole of the lower case were taken, together with the two commonest punctuation marks, about 72 per cent. of the total could be dealt with by a Wicks rotary caster, using only thirty-two kinds of matrices. The stock could be kept balanced by other and slower machines, but machines in which there was not the same loss on stoppage or due to over-production of some sorts. It was to be hoped that the new machine, of which Mr. Wicks had spoken, would prove as interesting as the various machines of his invention, which the author had described in the Paper.

Communications.

Mr. A. S. **Capehart** (Monoline), of Paris, wrote that he had made numerous experiments, extending over a period of several years, in the attempt to produce a type-metal which should have greater stability of composition than that generally employed. These experiments had demonstrated that from 1·8 to 2 per cent. of copper was the maximum which it was possible to alloy with type-founders' metal.

Line-casting machine type-metal underwent a wastage or depreciation; he had found from trials and observations, made during a period of two years, that this depreciation amounted to an average of 2 per cent. each time the metal passed through one complete cycle of making and using. The metal was mixed and melted in large quantities so as to ensure uniformity, it was then cast into ingots, then passed once through the line-casting machine and stereotyped from; after this it was returned direct to the mixing pot when it was found to have depreciated to the extent of 2 per cent.

There are advantages in manufacturing matrix-bars or matrix-plates by electro-deposition. The writer had invented a process for electro-deposition which had the advantage that the intaglios (corresponding to the strike in a punch-struck matrix) could be placed in the bars or plates *after* these had been machined to the necessary degree of accuracy for the machine requirements, whereas in the ordinary process used in typefoundries the matrix-bar or plate required to be machined, or justified to shape, after the intaglio had been formed or put in place. By the writer's system the twelve intaglios required for each matrix-bar, in a line-casting machine like the Monoline, were electro-deposited in the edge of the bar after this had been machined to the requirements of the casting machine. It was found in use that the thin copper edges would not stand the machine-handling and contracted, giving rise to "fins" between the letters. With compound matrix-plates, presenting flat surfaces to the mould, this would not occur, nor would it take place in the case of individual intaglios under conditions where the thin edges of the intaglio were protected by the mechanism holding the matrix in position.

The German method of depositing nickel, instead of copper, might make this or some similar system of producing matrices commercially advantageous to those engaged in typefounding or in the construction of typecasting machinery, as it obviated the expense of manufacturing and maintaining steel punches.

Mr. E. J. CROSIER forwarded a communication from Mons. R. H. DE LA COLOMBE giving a description of the Dyotype Machine, which has been added to the Paper in Appendix V (page 1163).

Mr. GEORGE DAVIS wrote that it might be of interest to show the means employed by practical mould makers and type-founders for the last 150 years to ensure the requisite degree of accuracy in type without the use of the, then unknown, micrometer. The instrument used for this purpose was known in the trade as the Turning Gauge and was shown in Fig. 124 (page 1202). The upper jaw of the gauge was fixed to the stem by screws and the lower jaw, which was made a good sliding fit on the stem by grinding and lapping, could be secured in any desired position by the thumb-screw. The jaws

(Mr. George Davis.)

were made with a small amount of taper, the inclination being usually 1 in 300, but finer if required. The sides of the jaws had lines engraved $\frac{1}{6}$-inch apart; each division ordinarily, therefore, equalled 0·0005-inch. To use the gauge the type were rubbed free from grease and gently pushed into the taper-opening of the jaws, the position of the type being as shown in Fig. 124; the type was turned end for end to compare the sizes at head and foot; a variation of 0·0001 inch could be as easily detected by feel as variation in the size of a shaft when compared with a Whitworth gauge by means of calipers. The gauge was also used for checking parallelism in *set* as well as the definite *set* width produced by the type-founder. Still greater delicacy of comparison could be made by

Fig. 123.

Height-to-Paper Gauge. Full size

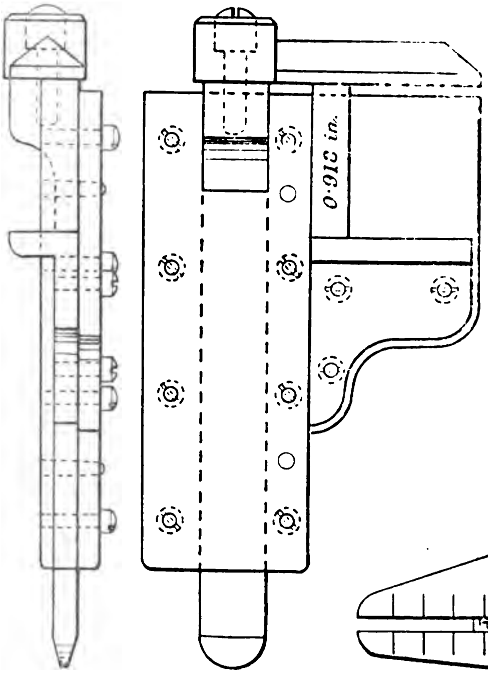
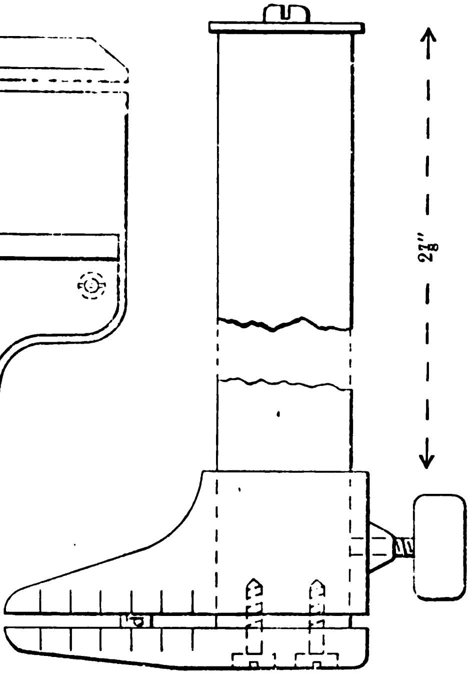


Fig. 124.

Turning Gauge. Full size.



using three or four type together in the turning gauge. This was actually the usual practice in typefoundries. Commercially perfect type should fulfil the following conditions:—

(1) The face must be true for flatness, i.e. its plane must be normal to the four sides of the body; the degree of accuracy was governed by condition (4).
(2) The face must be true for position, i.e. in plan the vertical main-strokes must be parallel to the *set* and the line parallel to the body; the degree of accuracy was governed by condition (3).
(3) It must also be true for alinement; i.e. within a total of 0·0003 inch the dimension line-to-back must be correct to gauge.
(4) The height-to-paper must be correct to within 0·0003 inch.
(5) The body must be parallel within a total of 0·0001 inch at head and foot.
(6) The *set* must give the correct side-wall on both sides.

The height-to-paper gauge in ordinary use by the type-founder was shown in Fig. 123. This gauge was generally employed for testing flatness of face for compliance with condition (1) above, and, unlike the turning gauge, the jaws were made parallel. The type was placed in the gauge and sighted against the light in two directions in the plane of the face of the upper jaw at right angles to each other and inclined each at 45° to the faces of the body. The ordinary lining-gauge was somewhat similar to that shown by the author of the Paper, but was less elaborate.

Mr. Percy W. Davis wrote that he had been connected in the past with the Goodson Graphotype, and that he considered this machine to be in many respects superior to other machines which the author had referred to in his Class II b (page 1092).

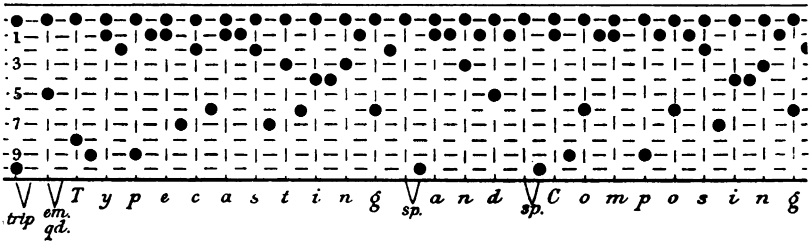
In the *Goodson Graphotype* the keyboard was similar to that of the typewriter and comprised 100 keys; these operated a typewriter which gave a written record of the work of composition as it proceeded, and, in addition, made certain electrical contacts by

(Mr. Percy W. Davis.)

which any one or any pair selected by the key from two sets of ten perforating punches could be operated by electro-magnets. The perforated strip was narrow and had guide perforations on one side only, Fig. 125; the perforations corresponding to any character or space occupied two consecutive transverse units of its length. The typewriter had connected to it a dial scale to show the amount of line to be made up by increasing *or decreasing* the spaces. The face of type employed was of the self-spacing kind having six units to the em-quad, described by the author on pages 1044 and 1045. Five different *set* widths were used comprising two to six units. Corrections, should any be required, could therefore be very easily made by hand.

Fig. 125.

Perforated Ribbon for Typecaster (Goodson Graphotype). Nearly full size.



The line-justification was effected by pairs of perforations similar to those used for the characters; a single hole at the left of the ribbon (as composed) and in the upper of the two possible positions formed the space, while another single perforated hole, in the lower position, formed the trip for the end of the line. As in the other ribbon machine described, the ribbon must be put into the machine in reverse order. The increase or decrease in *set* of the spaces was controlled by an electrically operated escapement.

The matrices were all combined in a square matrix block which differed from that described by the author, inasmuch as it was produced by electro-deposition. The counterpart of the matrix block was set up in type and accurately justified, so that all the characters were correctly placed both for body and *set*. The matrix block, after removal of the type from it, was finished and secured to a steel back with conical holes for setting the respective matrices truly in position; the moving parts were much lighter than in the machine described by the author. The stop mechanism for the grid was somewhat similar, but the perforations in this case enabled certain electrical connections to be made which brought electro-magnets into play, and these operated the stops. The matrix grid comprised ten rows each of ten matrices, but some of these were used for quads. There were one row 2-unit, two rows 3-unit, three rows 4-unit, two rows 5-unit, and two rows 6-unit. The arrangement of matrices in the block was shown in Fig. 126. The matrix block being in one solid piece enabled the characters to be placed very close together. This saved weight as well as saving distance for the matrix block to travel.

FIG. 126.

Typecasting Machine: Graphotype.

Arrangement of Matrix Block.

	sp.	Q	P	(	[	0	qd.	$\frac{7}{8}$	qd.	q
	W	R	O	)	I	9	‘	$\frac{1}{8}$	S	p
	ffi	T	N	]	?	8	’	$\frac{1}{2}$	J	k
	—	U	L	£	!	7	l	$\frac{1}{4}$	u	ff
	M	V	G	*	:	6	f	$\frac{3}{4}$	g	o
	em qd.	Y	F	en qd.	;	5	j	$\frac{1}{3}$	fl	d
	H	&	E	.	z	4	i	$\frac{2}{3}$	fi	b
	ffl	X	D	$	t	3	-	$\frac{5}{8}$	x	n
	w	Z	B	s	c	2	.	$\frac{3}{8}$	v	h
	m	C	A	e	r	1	,	K	y	a
Units	6	5	5	3	3	4	2	6	4	4

The mould was adjustable for *set* width according to the position occupied by the grid demanding one of the *set* widths enumerated (or occasionally in the case of spaces the single unit width). The mould was water-cooled, and special precautions, peculiar to this machine, were taken to keep the temperature down. The pump was placed at some distance (about 15 inches) from the mould, and the metal tube connecting it to the nozzle was heated by means of a

(Mr. Percy W. Davis.)

low-tension electric current; this arrangement had been found to work very well in practice, enabling the metal temperature to be kept very accurately within the desired limits; while the removal of the metal pot to a distance permitted adjustments of the mould and adjacent parts to be made with ease and comfort.

The above brief description related to the small machine, constructed under the writer's supervision in England; as originally made it ran at 140 revolutions per minute, and was capable of casting up to pica. By modifying the shape of the cams it was enabled to cast type at the rate of 170 per minute, which it effected with but little noise and without evidence of undue wear. The writer had since been informed that, in America, a larger class of machine had been built with 225 characters and designed to run at the same speed. The alteration had, however, necessitated dispensing with the typewriter portion of the machine, which, in the writer's opinion, was of considerable value, particularly when corrections had to be made.

Mr. J. CAMERON GRANT wrote asking the author for his opinion upon the following points:—

(1) Upon the troublesome fringes that one got between the matrices in slug machines, the Linotype, for example, when the matrices became worn or when dirt, oil and waste, etc. were squeezed up between the matrices when being locked by the pressure of the wedge spaces. Was there any way, apart from renewals, of modifying this disadvantage, with its resultant disfigurement to the printed page; or had the Linotype user, so far as the mechanical engineer was concerned, to put up with it?

(2) The writer heard it stated by one speaker, who seemed particularly interested in the Linotype, that corrections were practically as easily made on a mass of slugs from a slug machine as upon a page of loose type, and nearly as quickly. Surely this could hardly be the case; and passing over simple corrections within the line, could it be meant that this applied to overrunning? At times the greater part of a column might have to be re-cast to make a correction. He would like the author's opinion upon this point.

(3) While on the subject of corrections in slug casting machines, if these corrections came back to the compositor and he had to re-cast slugs under different condition of mould temperature, did not variation in height-to-paper ensue and spoil the appearance of the column owing to the different condition under which its component parts were cast?

(4) Was it not the case that the use of composing machines using loose type had been so limited, because none had been fitted with a satisfactory justifying apparatus? All composing and justifying machines described by the author seemingly made a much rougher approximation to the length of the line than that ordinarily obtained in general hand work.

(5) He would like the author's views upon the difficulty alluded to by one of the speakers who asked for low spaces upon the composing machine. The trouble with high spaces, which occurred with those machines casting separate type—the Lanston Monotype, for example—consisted in the spaces rising; this was of course less liable to occur with spaces of trade height than with spaces of shoulder height. The difficulty was particularly noticeable with type with no heel-nick, as cast on some casting and composing machines, for example, the one already mentioned.

(6) Had the author considered the disadvantage of using type over and over again, when it practically always meant a resultant mixture of worn and new characters which produced an uneven appearance. Ought there not to be some escape from this state of things?

(7) It was true that the author had in the course of his remarks pointed out the desirability of using fresh type every day, but would it not be a matter of great practical difficulty to equip a suitable typefoundry owing to the very large stock of punches, matrices, and moulds which would require to be provided? Moulds were not only wanted on account of the various body sizes, but also on account of the difference in nicks required for distinguishing different founts.

(8) The last matter to which he would like to call attention was to Mr. Legros' original work upon Logotypes. He did not think this was appreciated at its right value by any of those who took part

(Mr. J. Cameron Grant.)

in the discussion. The conclusion to be drawn was very simple, namely, that one did a great deal of unnecessary work both in writing and printing. The saving that would result from the mere introduction of two new letters into the English alphabet was very remarkable. It was a change that could be made gradually, both old and new characters being used in the same papers and periodicals at the commencement, and a gradual introduction thus taking place through all printing. These new letters could be introduced later on in typewriting, and still later in handwriting, in which the tendency in the case of the "ng," the less common of the two proposed letters, was visible already in the handwriting of many people. The other letter whose introduction was proposed, was "th." The use of these two logotypes alone would mean a saving of at least from three to four per cent.—more than ten days' work to every daily paper in the year. The value of this saved space would at once appeal to everyone who had anything to do with the advertisement departments of any of the great daily newspapers. The saving in time in the composing room alone would be considerably over a quarter of an hour in the eight-hour day. The same saving which alike applied to fast and slow operators would occur also in the case of typewriters, though in their case the saving in space would be of no account. Some saving to the reader, when not reading aloud, would also be produced; the eye, when once accustomed to the novelty, taking in words composed with the combined letters faster than those printed with the present characters. He would suggest that the author in his reply should give a few lines or a paragraph set up in type using the ordinary characters, and the same amount of matter set up in a fount embodying his proposed new characters, as an example to demonstrate its feasibility and to show the saving effected by his proposal.

Mr. ROLLS P. LINK wrote that to cover the points in typecasting and composing machinery which were in need of improvement, and to deal with the suggestions received from the operators of the present class of machines and the printers who have used and have discarded every existing composing machine owing to its lack of efficiency and who set the whole of their work by hand, would mean the drafting of a Paper of even greater extent than that of the author. The systems he so ably cited and illustrated were those which were most universally known, and probably represented the limit of present-day inventive capacity, except perhaps such knowledge as it was the privilege of experimentalists to possess. Anyhow, so far as the public understanding went, the latest machine generally represented that which was the most fully developed. It was evident when one took into consideration the number of machines, together with the many thousands of improvements that had been made, that the line the inventors' ability had taken had not been that of originality and initiative, such as was the case with the first discoverers of new methods and principles. The whole trend of present-day thought in connection with typecasting machinery seemed to have been applied to either the modification or elaboration of existing parts, whereby the number of movements to effect a given result had, in the majority of instances, been greatly increased, but with little improvement occurring so far as the type itself was concerned, which was the vital principle involved. The development of the mechanical compositor had been very rapid, and the strides it had made went without question. But real and progressive invention in this particular branch of mechanics seemed for the moment to have ceased, the stream of inventive effort dividing itself into the two main channels of single type and solid slug casting, neither of which represented the ideal form of composing machine.

What was demanded by the modern typographer was merely a printing surface perfect in all respects and which might be easily and quickly produced and, after production, rearranged with equal convenience for proof correction. The machine to give the required result must be light in design, of the simplest mechanical construction consistent with mechanical efficiency, and moderate in price.

The surface produced, as well as the justifying of the type, was the main and, practically, the only consideration in connection with it; whether it were a sixteenth, an eighth or a quarter of an inch in thickness and whatever the manner of its support might be, were

(Mr. Rolls P. Link.)

matters of indifference so long as it performed the required functions. But inventors had drifted with the current into the two channels he had named, and were now painfully comparing merits and demerits of machines which produced "type high" single types with those of machines producing "type high" solid slugs, to the abandonment of true creative effort. With their productions they turned what was originally solely a composing room into a combined composing room, foundry, and machinery hall filled with machines of huge proportions providing (in the case of single typecasting machines, such as the Monotype and Stringertype) a mass of machinery weighing over a ton to produce something weighing less than an ounce.

Mr. **Albert Pidgen** wrote forwarding two photographs of the latest development of the Thorne machine, Fig. 127, Plate 46, in which the type was delivered positively, and not on to the revolving disk and belt as mentioned in the Paper. The Thorne machine was not an experimental thing in so far as being an automatic distributor and setter (leaving out the line-justifier), which latter was an addition. The machine, taken simply as a distributor and setter, packing up into line (in a galley), had been manufactured for many years, and was the oldest machine of its kind on the market; it was in use in many cities in the United States for small country newspapers. This new machine was designed in order to make the delivery of type positive, so that a justifying machine could be attached. The construction of the machine was roughly as follows: There were two cylinders "upper and lower" with ninety-six longitudinal grooves or channels. The upper cylinder channels were plain, while the lower cylinder channels were warded, to correspond with each character. The upper cylinder was known as the distributor and the lower cylinder as the stationary cylinder. The distributor was kept turning by a worm which allowed a rest every time the channels in the two cylinders came over one another, long enough for the bottom characters in the distributor channels to drop into the stationary cylinder (when the ward in the channel corresponded with the character). At the same time, when the distributor channel indicated empty, a whole line of characters was pushed in to be sorted out as it went around.

In this way the distributor was kept working continuously sorting out the characters into their respective channels, so that columns were obtained of a, b, c, etc., all around the ninety-six channels of the machine in the lower cylinder.

The distributor together with the lower cylinder and the cone attached to the latter were mounted on a stationary shaft in the centre of the machine. Around this shaft a cam was revolved at 300 revolutions per minute (inside the cone); the function of this cam was to carry up and down a plunger, as follows: When a character was called by the key, a catch was released which allowed the plunger to engage into the revolving cam. The plunger going up caused the bottom character in the stationary cylinder to be pushed off, the character falling by gravity down the surface of the cone in a groove; while this character was dropping, the plunger came down much faster (viz. $\frac{1}{10}$ of a second) and pushed the character that had been waiting at the bottom of the cone (from a former operation) into a circular channel or raceway, positively; by this means the time that it took a character to fall down the surface of the cone was saved. A revolving sweep cleared the channel or raceway, and picked up any character that might be there. This sweep was met by a packer which in turn picked the character from the sweep and pushed towards the galley, Fig. 128, Plate 46. The keyboard was so arranged that combinations could be played, such as "and," "of," "tion"; this was effected by arranging the characters so that they fell into the channel in their correct position (relatively), the sweep and packer picking up the combination instead of a single character. The sweep revolved at 300 revolutions per minute, so that it was impossible to play the keys quicker than the machine could deliver, that is, one-fifth second for each character; and a speed of 10,000 ens per hour had been recorded quite easily. The playing of combinations or chords was not however liked, practically, for the reason that the time consumed in playing "the," for instance, by playing each character singly was so very small compared with what

(Mr. Albert Pidgen.)

might be lost in fixing or rectifying an error; and for this reason it was very seldom used by operators.

Thorne Machine and Line-Justifier.—The principle of line-justifying, described on pages 1125–1126, never got beyond the experimental stage. However, the writer believed that line-justifying by using four spaces, namely, 0·024 inch, 0·030 inch, 0·036 inch, and 0·042 inch, for 8 point type, by selecting any combination, was accurate enough. It has been possible by this system to get the length of the line to within a possible error of 0·006 inch, which was close enough in practice; in fact, the spring of a line of type when measuring was at least twice this amount, more or less, according to the number of characters in the line, and the author's remarks on the greater accuracy to be got by using ten brass spaces, as in the Dow machine (page 1116), might be true, but the greater complexity more than vitiated the usefulness of a larger variety to choose from.

When the writer last saw this machine Mr. Johnson was applying his line-justifier, which acted on a better principle than that of selecting by means of brass spaces. It was as follows: a space of the required width was cut off from a timber or slug of type metal by a straight saw arranged vertically, one stroke of which would cut off the space with very little burr. This saw was controlled (for position) by a screw which was actuated by the measuring mechanism. If the space broke during the operation of pushing it into the line, a second similar space would be cut off and pushed up. The advantage of type-metal spaces was the fact that they could be melted up after use, which was an important item from a distributing point of view.

One serious difficulty with the Thorne machine or any other machine that set up and line-justified individual lines of type was the fact that thin characters, such as "i" or "t," broke very easily in hard type metal, and this breakage was likely to occur in the distribution, in the typesetter, or in line-justifying. When this breakage occurred, so much time was wasted in getting the machine started again that the efficiency of this kind of machine was greatly impaired.

The compressible space, shown in Fig. 62 (page 1110), was tried thoroughly on a Thorne machine, and the chief reason why it was abandoned was the impossibility of sorting it out when distributing automatically. The writer did not know exactly what success the Thorne machine had had with the automatic justifier attachment, commercially, although it was perfect, experimentally. It was manufactured by the Unitype Co., of Brooklyn, New York, and the few remarks that he had made were from the experience gained as a designer for the Unitype Co. about five years ago.

Mr. H. SELL sent the following remarks from the operator's point of view. He wrote that the Lanston Monotype did the work of five men, and it would cast a galley full of 10 point, 24 ems wide, in one hour and a quarter; the average of a week's working could be put down at about 5,500 to 5,750 ens per hour, as there were a good many set-backs with trouble on the caster, such as a pin sticking, a splash, face pulling off, a broken latch in the loose wall, etc. It was a very handy machine to the small jobbing printer, as he could become his own typefounder, and cast all his sorts, ornaments, fancy borders, etc.

One disadvantage with the Monotype was that it cast spaces and quads nearly as high as the letters, and in working balance sheets, or any job where there were many whites (or quads), the quads printed as well, causing a waste of time in cutting and smashing the quads down. When printing the quads rose and rolled, causing the sheet to flick the face of the quads which were inked, thus leaving their impression on the paper. Machine minders did not like the sight of Monotype matter, especially on rush jobs. It was more suitable for the jobbing printer than was the Linotype, because it cast each type separately, and all corrections were done in the usual way by hand, away from the machine itself; there was no waste of metal, because the formes were broken up and melted into small square ingots and used again and again for other jobs. There was now an appliance for making quads lower, but it was rather a complicated affair. The machine always required watching, keeping very clean, overhauling once every week, and the speed should be kept even, for if the machine were forced, there was trouble with the metal pump at once. The writer did not find the machine he worked to be very accurate in justifying the lines of type, as there was a slight

(Mr. H. Sell.)

variation in the length of the lines which, in high-class work, made re-justification by hand a necessity.

Mr. LEGROS wrote, in reply to Mr. Capehart, that the author considered the data given as to wastage of metal would help to give information in reply to some of the questions raised. The process described for preparing matrix bars was one of great interest to those who had to deal with this class of work; a matrix comprising several strikes in one small piece of metal, all of which must be in position to the requisite degree of accuracy, presented a much more difficult problem to the engineer than that of a single or even a double strike, particularly when the low cost for which these matrices must be sold (about 7 cents, Canadian, each) was taken into consideration.

Mr. G. Davis had given a very practical note respecting the older appliances used in the trade for making comparative measurements (page 1201); he had, moreover, shown in figures how these appliances compared with those used by the engineer in fineness of measurement. It was frequently urged in disputes between engineers and inventors that the appliances in practical use by type-founders accepted a lower standard of accuracy. Mr. Davis had clearly shown that the standard degree of accuracy had been arrived at by practical experience and could be obtained equally well with either appliance; for comparative purposes probably the old appliances were quicker to work. The standard degree of accuracy given by Mr. Davis represented first-class work in each respect.

The remarks of Mr. Percy Davis on the Goodson Graphotype were of much interest, and it was a matter of regret that more information was not obtainable in respect to this machine. Mr. Davis had at one time been connected with the Wicks machines, and had had considerable experience in this class of work. The author believed that generally the removal of the metal pot to a distance resulted in a tendency to cast hollow type; the arrangement described for heating the metal tube appeared to present considerable advantages, but the author did not believe that this method for obtaining a constant temperature had been applied on any other machines of the kind.

In reply to Mr. Grant's various questions the author would say:—

(1) There was so much difference between good and bad Linotype work that it was difficult to say how much of the hair-line between characters, seen in the cheaper newspapers, was due to dirt and carelessness and how much to wear. It was certain that where the matrices were renewed in good season this appearance could be largely done away with.

(2) The question of overrunning appeared to be largely influenced by the local conditions; probably with Linotype machines at hand the corrections were made more readily than the older school of compositors would imagine; but, on the other hand, it must frequently be necessary to re-cast a number of slugs.

(3) The author had heard it stated by printers that when corrections had been made in the Linotype matter with slugs cast on different machines, or under different conditions, there was some difference in height-to-paper and consequently a want of uniformity of colour in the printed page.

(4) The use of composing machines supplied with loose type had undoubtedly been restricted by the absence of a satisfactory line-justifying apparatus. There was no more perfect method of line-justifying than that employed on the slug machines, whether in the form of the screw, as devised by Schuckers and used on the Typograph, or that of the folding wedges of the Linotype space-band. These gave equal spacing throughout and filled the line correctly; whereas nearly all the appliances described only approximated roughly to this.

Two machines had been devised for dealing with the justification of loose type; instead of operating in the line, so as to divide the deficiency of length over the number of spaces, these machines operated by means of outside apparatus which prepared spaces of the correct width determined by the machine. The one machine had been described in the Paper (page 1110); the other (F. A. Johnson) attained the same end by sawing or cutting pieces of type-metal of

(Mr. Legros.)

the correct *set* width required from a slug or timber and inserting these in the line.

(5) The difficulty with high spaces, also alluded to by Mr. Gibbs, appeared to the author to be a very real trouble. It was recognised by the inventor of the Dyotype, who had made a special provision for casting low spaces by dividing the body slide into two parts, one of which reduced the effective length of the mould when casting spaces. Where type had no heel-nick it was rather more liable to rise when being planed down, as water could get below an individual space and work it up under the action of the blow.

(6) The author had frequently had occasion to notice the poor results obtained by the mixture of old with new type; this result was quite avoidable by the use of composing machines and fresh cast type either in the form of slugs or in that of loose type. During the period over which *The Times* was supplied with fresh loose type for each issue, from the Wicks machine, he thought that journal had the cleanest appearance of any printed sheet of the kind. Probably the advent of cheap accurate type with a simple composing machine and a thoroughly practical automatic line-justifier would enable such a result to be obtained in the future in face of the competition of the slug machines.

(7) The writer here touched on the biggest question affecting such a scheme as that outlined above. If there were only three widths of faces, condensed, standard and extended, for each body there would still be some twenty-one type-moulds and seven space-moulds required for ordinary work, from nonpareil to pica; but there are modern and old style and other varieties of face required which must be suitably distinguished from each other by a different arrangement of nicks, so that, in all, the number of moulds may soon exceed a hundred and the matrices will run to many thousands. Apart from the capital outlay on these, there is the work of originating faces, so that considerable time, as well as money, must be spent in achieving any tangible result.

(8) The paragraph set up, Fig. 129, with the proposed new characters would show clearly what practical result was arrived at by the change. The new characters could be read with absolute

FIG. 129.

THE SAVING EFFECTED BY REFORMING THE ALPHABET.

The one thing, above all things, that seemingly is required in the printing of newspapers, is the saving of time in going to press. In the second place, the saving of time, and therefore the saving of money in composing, is of the greatest importance and ever-increasing interest to the trade. Thirdly, the mere altering or adding of a unit ensures a saving in space well worth the publisher giving it serious attention. This saving in the case of newspapers affords more space for the advertising, and in the case of the best books and the best periodicals, there would be quite an appreciable saving in paper. The introduction of the two proposed letters θ and ɡ means a three and a half per cent. saving of matter in composing and printing throughout England and America. By dividing this saving between the operators and the proprietors, the aggregate sum gained by each of them yearly would in itself amount to a fortune.

ΘE SAVIƔ EFFECTED BY REFORMIƔ ΘE ALPHABET.

Θe one θiɡ, above all θiɡs, θat seemiɡly is required in θe printiɡ of newspapers, is θe saviɡ of time in goiɡ to press. In θe second place, θe saviɡ of time, and θerefore θe saviɡ of money in composiɡ, is of θe greatest importance and ever-increasiɡ interest to θe trade. Θirdly, θe mere alteriɡ or addiɡ of a unit ensures a saviɡ in space well worθ θe publisher giviɡ it serious attention. Θis saviɡ in θe case of newspapers affords more space for θe advertisiɡ, and in θe case of θe best books and θe best periodicals, θere would be quite an appreciable saviɡ in paper. Θe introduction of θe two proposed letters θ and ɡ means a θree and a half per cent. saviɡ of matter in composiɡ and printiɡ θroughout Eɡland and America. By dividiɡ θis saviɡ between θe operators and θe proprietors, θe aggregate sum gained by each of θem yearly would in itself amount to a fortune.

(Mr. Legros.)

facility by people who had never seen them before and knew nothing of the suggestion. The value of the saving to be effected in space could be directly estimated by those responsible for the advertisements, because, as Mr. Grant pointed out, it was equivalent each year to the space occupied by the whole of the reading matter in ten copies of any daily paper.

It was difficult to arrive at the figures for the earnings of the compositors, but it would appear that in the London district alone upwards of £1,000,000 per annum was paid to compositors in wages (taking only society men into account); probably in the whole of Great Britain and Ireland about £3,000,000 per annum was so paid. In America, with Canada and with the other English-speaking colonies, the amount would be considerably larger, so that the annual wages earned in composing the English language might well exceed £10,000,000 per annum. The saving in this item alone would, consequently, amount to about £350,000 per annum, apart from savings effected in materials, in typewriting, time occupied in handwriting, etc.

Mr. Longhurst had also alluded to this question and had raised the further point as to whether a similar saving was to be effected in other languages. The author had not been able to find any parallel case in French, but in German it would appear, from a preliminary examination which he had made, that the substitution of three new letters for the combinations sch, ch and ng would enable a saving of more than 4 per cent. to be effected. The Russian letter Ш should not be adopted for sch as it only differed slightly from the lower case m in the serifs and hair-line; it would be desirable that new characters should be designed which should be very plainly dissimilar from all those in present use.

The remarks of Mr. Rolls P. Link (page 1209) as to the increasing size and complication of typecasting and composing machines were full of truth, but the author was of opinion that much of this complication was due to the conservatism of the printing trade and the desire to make the machines do all sorts of things which had previously been done by hand. It was only necessary to compare the new duplex Linotype with its two sets of escapements, two magazines each filled with two letter matrices, and its double distribution gear, with the earlier simple pattern, in order to realise the amount of work which had been done recently with a view to increasing the scope of these machines.

The author agreed with Mr. Link that the printing surface was after all that which interested the printer most; several inventors had endeavoured to simplify the operations by the direct production of a matrix in flong from which a stereotype could be cast. There were, however, two almost insuperable difficulties to be met with in this field, namely, line-justification and correction of proofs. The author quite agreed with the writer as to the change which had taken place in the composing room, but thought that a system of machine composition from new loose type, similar to that in use by *The Times* till recently, if aided by accurate machine line-justification would give a better result than that obtained from the highly complicated machines of the present day.

Mr. Pidgen had given (page 1210) very interesting additional information on the evolution of the Unitype from the Thorne machine; the difficulty of breakage of thin sorts which he mentioned had not been found by the author to be so much a cause of trouble in composing as in distributing machines. The difficulty which gave most trouble, with some kinds of composing machines, consisted in "turned sorts," that is, some of the characters would turn through 90° or 180° between leaving the magazine and arriving in the line; he believed this had been a very serious trouble in the case of some composing machines.

In the observations of Mr. H. Sell (page 1213) one had the views of a man who had first-hand user's experience with one of these machines in composition, and it was of interest to note that he had raised the same objection as other speakers had done to the high space, and had also alluded to the ease of effecting corrections in loose type. It was interesting to find that the line-justification effected by the machine did not, in practice, avoid some hand-work where accuracy was required.

The author desired to thank Mons. de la Colombe for much valuable information on French type which he had incorporated in Appendix I (page 1142).

TABLE 13.

Amount of Beard expressed in Points.

Type body.	American common line.	American point title line.	S. B. & Co. point common line.	S. B. & Co. point title line.	Type body.	American common line.	American point title line.	S. B. & Co. point common line.	S. B. & Co. point title line.
5	1	1	1	1	18	4	1	4	2
6	1	1	1	1	20	4	1	4	2
7	2	1	2	1	24	5	1	5	2
8	2	1	2	1	30	7	1	6	3
9	2	1	2	1	36	8	1	7	3
10	2	1	2	1	42	8	1	8	3
11	3	1	3	1	48	8	1	10	3
12	3	1	3	1	54	8	1	11	—
14	3	2	3	1	60	8	7	12	4
16	3	1	3	1	72	14	—	14	4

The late Mr. C. Colebrook had pointed out to the author the desirability of standardizing the line; this had been done in America and the American practice had been followed by the Blackfriars and Caxton Typefoundries, Mr. Walter Haddon, of the latter firm, having been from the first a staunch advocate of standardizing this dimension. Unfortunately the ring founders had not adopted the American point system unaltered for either of the two systems of line in use. Table 13 showed the amount of beard (page 1220) corresponding to the different body sizes in the true American line and in other cases.

It was to be hoped that either the American or the ring standard line would be adopted throughout the trade, as this would prove of great ultimate benefit to the printer.

In conclusion, it might be of interest to record the approximate number of machines of the two most important classes in use at the present time.

LANSTON MONOTYPE: casters, 2,200; keyboards		3,200
LINOTYPE MACHINES	about	17,000
MONOLINE MACHINES	about	2,000
TYPOGRAPH MACHINES	over	2,000
Total about		24,200

These machines alone represented a capital outlay of over £14,000,000, apart from the sum invested in the works for producing the machines and their accessories.

Of these machines some 17,000 were employed in the United Kingdom, America, and other English-speaking countries, while the remainder were mainly used for other European languages, amongst these being French, German, Dutch, Italian, Spanish, Danish, Norwegian, Swedish, Bohemian, Russian, Roumanian, Polish, Slavonic, Hungarian, Hebrew and Yiddish.

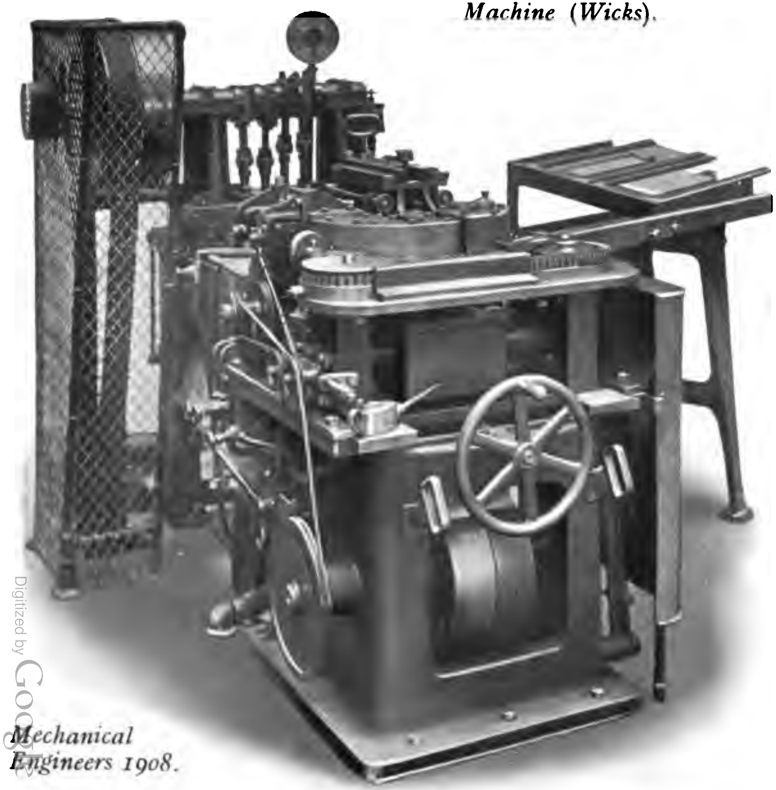


Fig. 47. *Rotary Typecasting Machine (Wicks).*

Fig. 55. *Type Composing Machine (Wicks), with Automatic Line-justifier (Stringer).*

Plate 32.

Mechanical Engineers 1908.

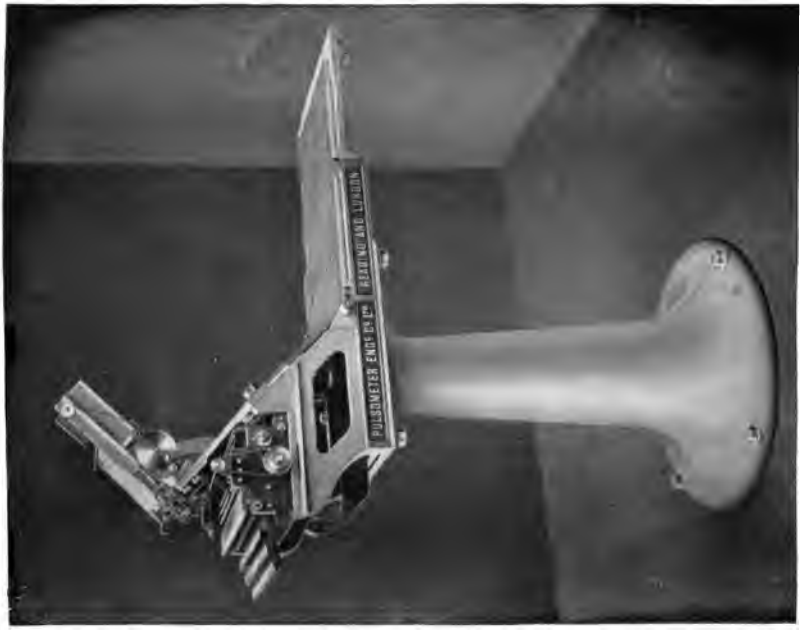


Fig. 64. *Distributing Machine (Pulsometer).*

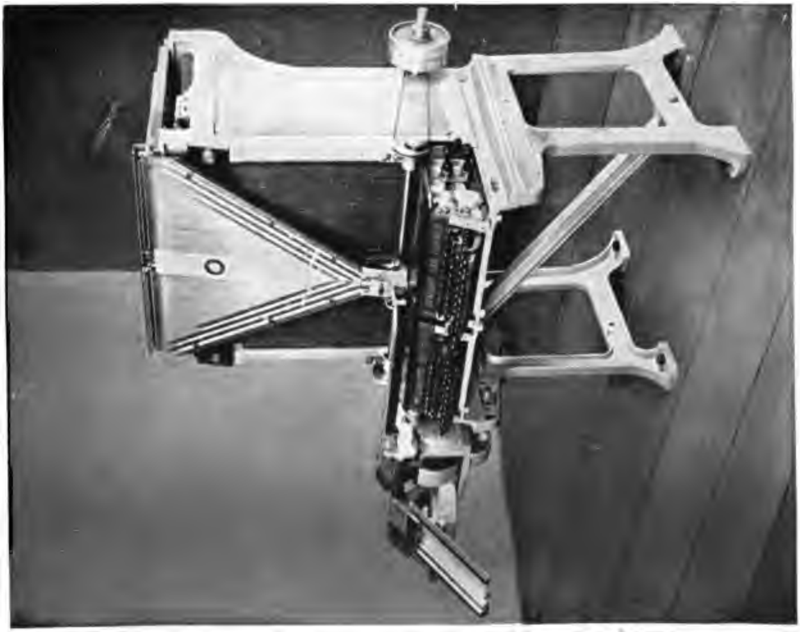


Fig. 59. *Composing Machine (Pulsometer).*

Fig. 70.
Keyboard Composing and Line-justifying Machine (Lanston Monotype).

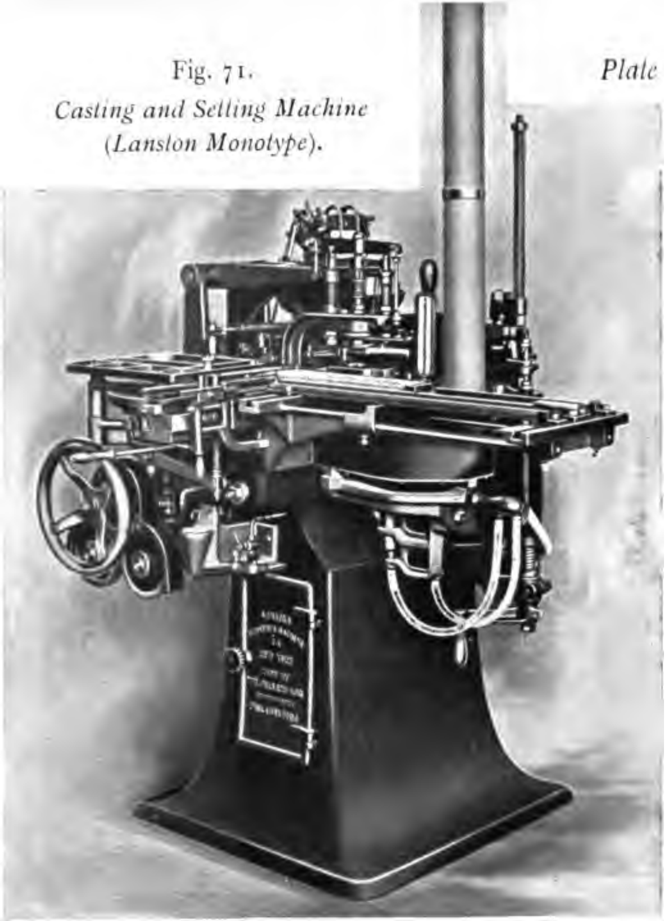


Fig. 71.
Casting and Setting Machine (Lanston Monotype).

Fig. 77.

Matrix Composing and Slug-casting Machine (Linotype).

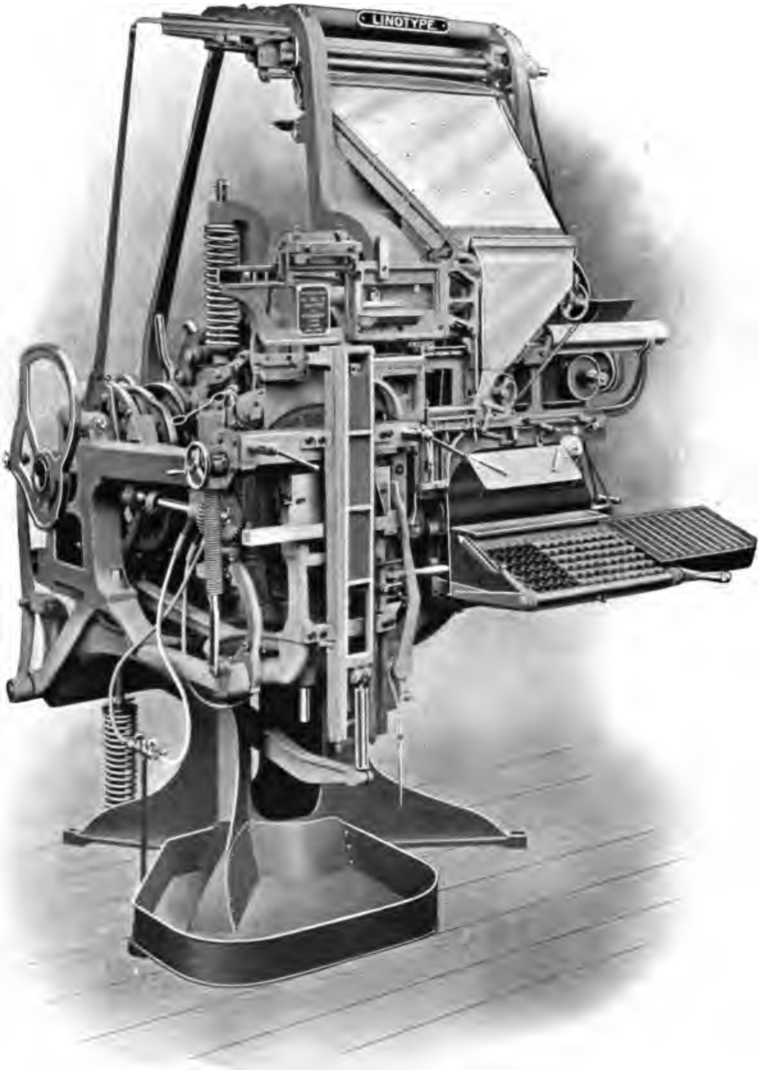


Fig. 80. *Line of Matrices composed ready for casting the slug. (Linotype).*

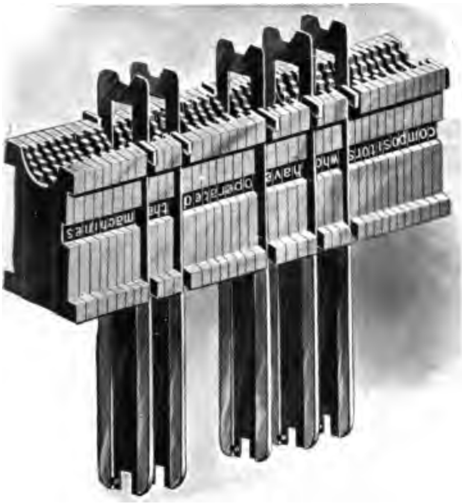
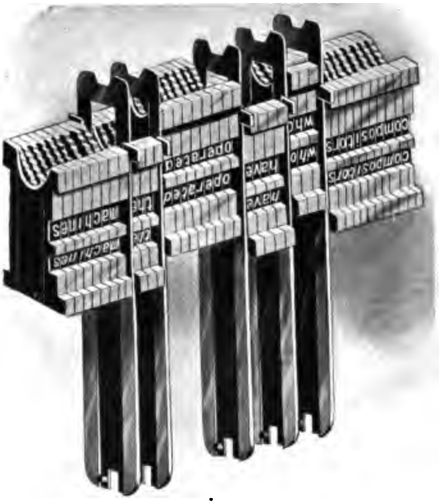


Fig. 81. *Line of two-letter Matrices casting part of the line in roman and part in italic.*



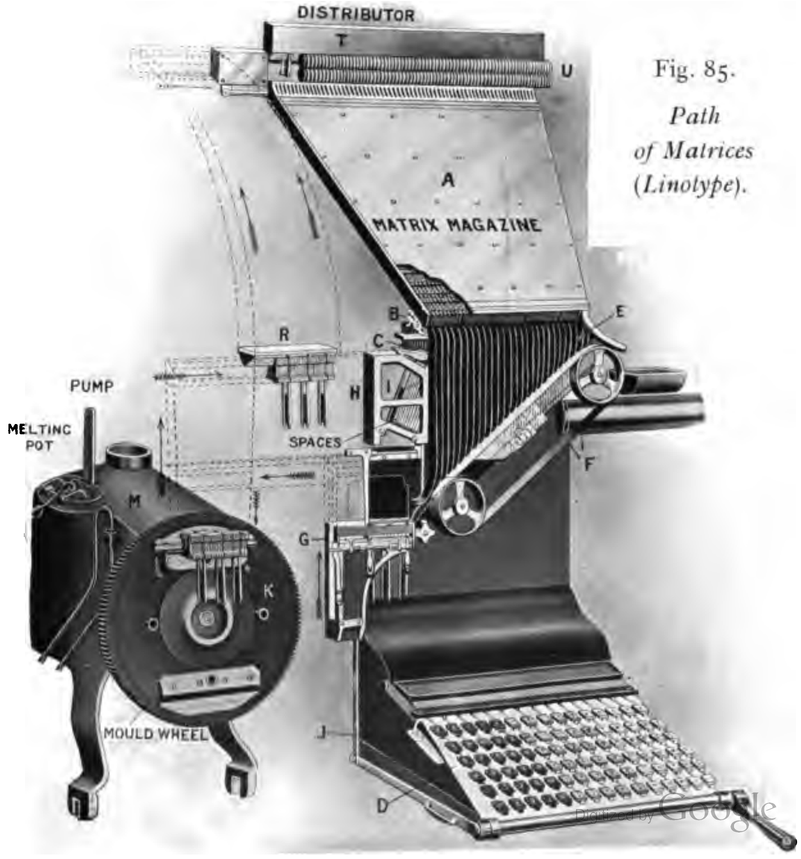


Fig. 85. *Path of Matrices (Linotype).*

Fig. 86. *Metal-pot, Pump and Mould (Linotype).*

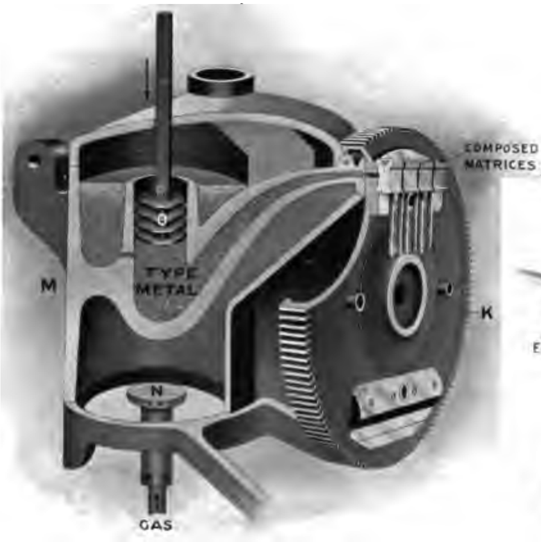


Fig. 87.
Ejector, Mould-wheel and Galley (Linotype).

Fig. 89. *Matrix Composing and Slug-casting Machine (Monoline).*

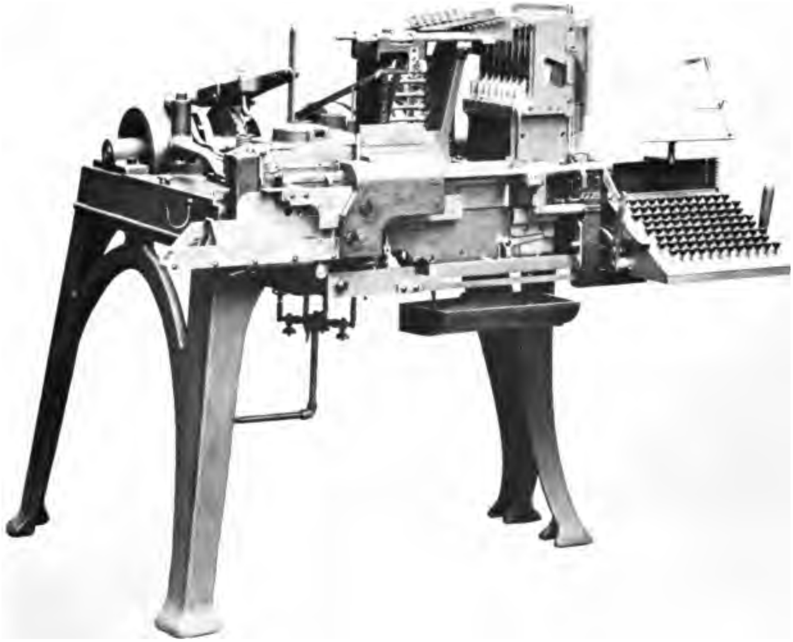


Fig. 92.

Matrix Composing, Line-justifying, and Typecasting Machine

(Stringertype).

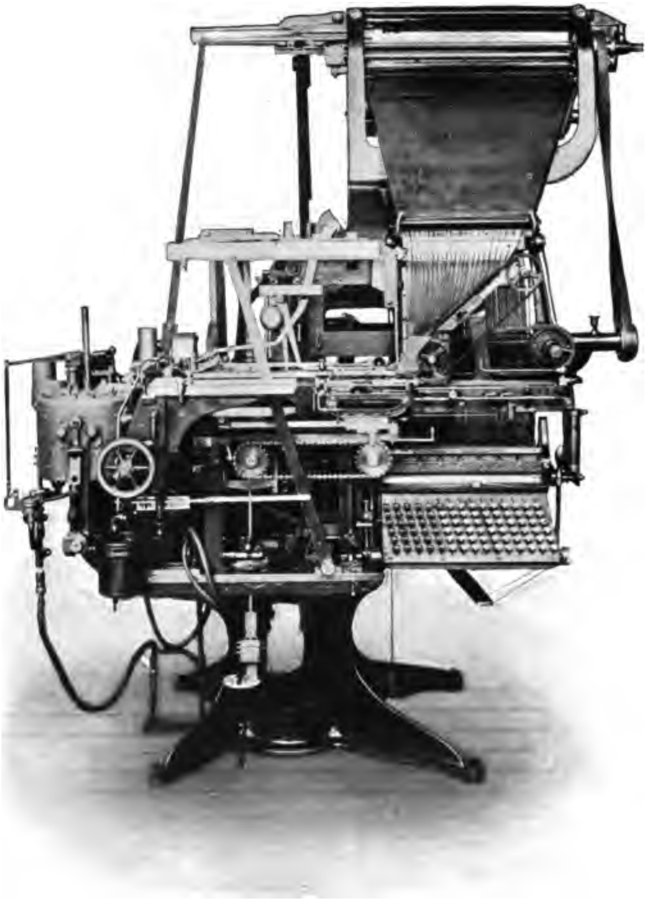


Fig. 93. *The Lock-up Test for Accuracy of Type.*

Fig. 1234567890.

THE LOCK-UP TEST FOR ACCURACY OF TYPE.

TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers. London, 1907.
TYPE CASTING AND COMPOSING MACHINERY. The Institution of Mechanical Engineers, London, 1907.

Typecasting and Setting Machine (Pinel Dyotype).

Fig. 98. *Matrix-wheel.*

Fig. 97.

Single Matrix. For 50 divisions. Full size.

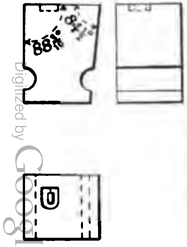


Fig. 100. *Perforated Strip. Half size.*

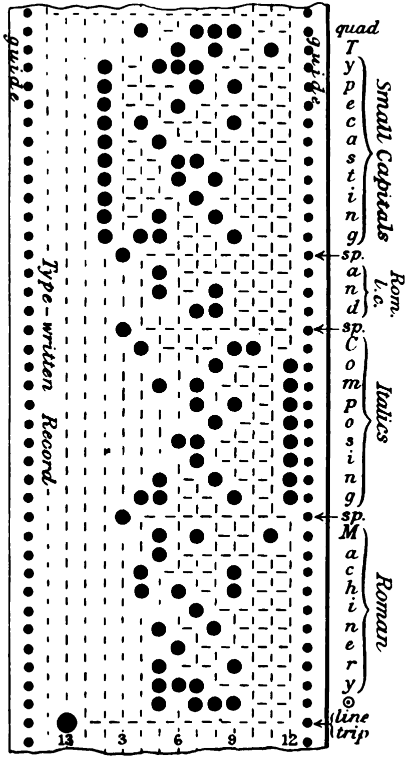


Fig. 101. *First Machine.*

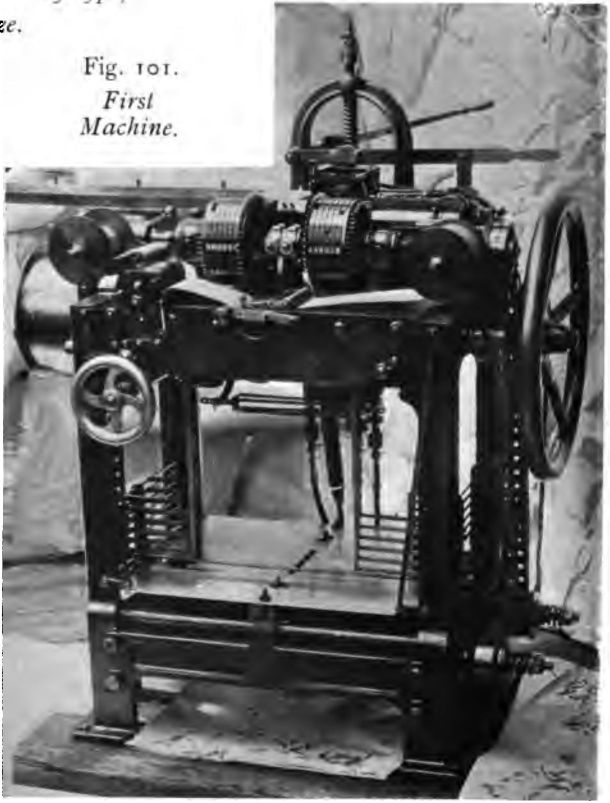
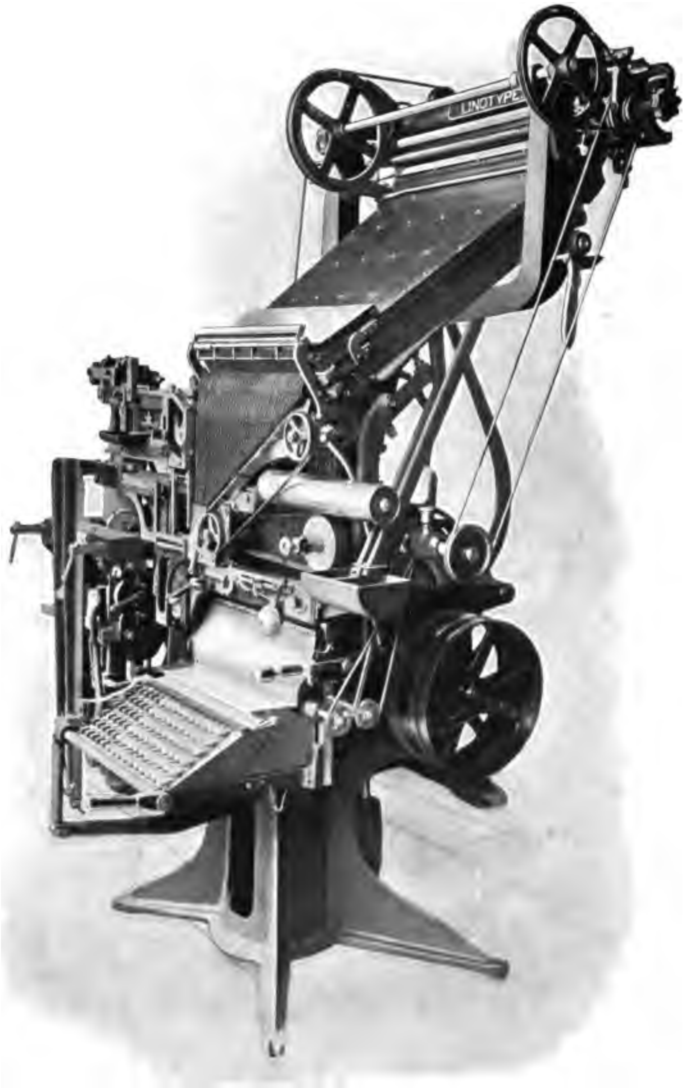


Fig. 102. *Double Magazine*

Matrix Composing and Slug-casting Machine

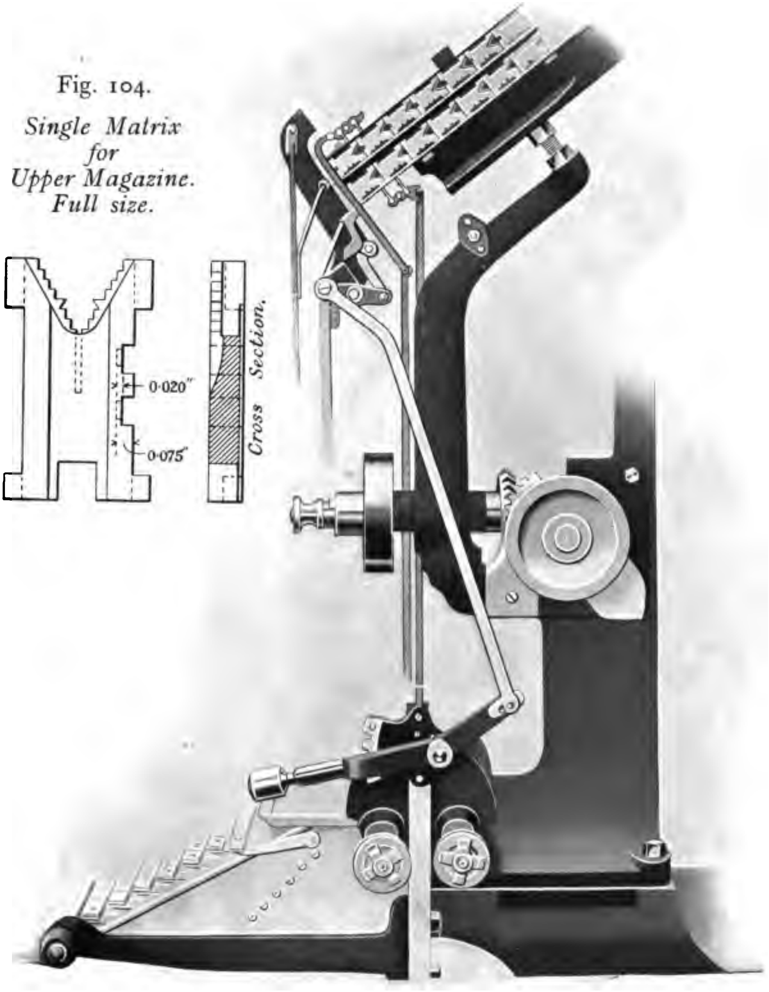
(Linotype).



Double Magazine
Matrix Composing and Slug-casting Machine
(Linotype).

Fig. 103. *Arrangement of Escapements and Shift Key.*

Fig. 104.
Single Matrix
for
Upper Magazine.
Full size.



Matrix Composing and Slug-casting Machine (Typograph).

Fig. 105. *Normal (Composing) position of upper part.*

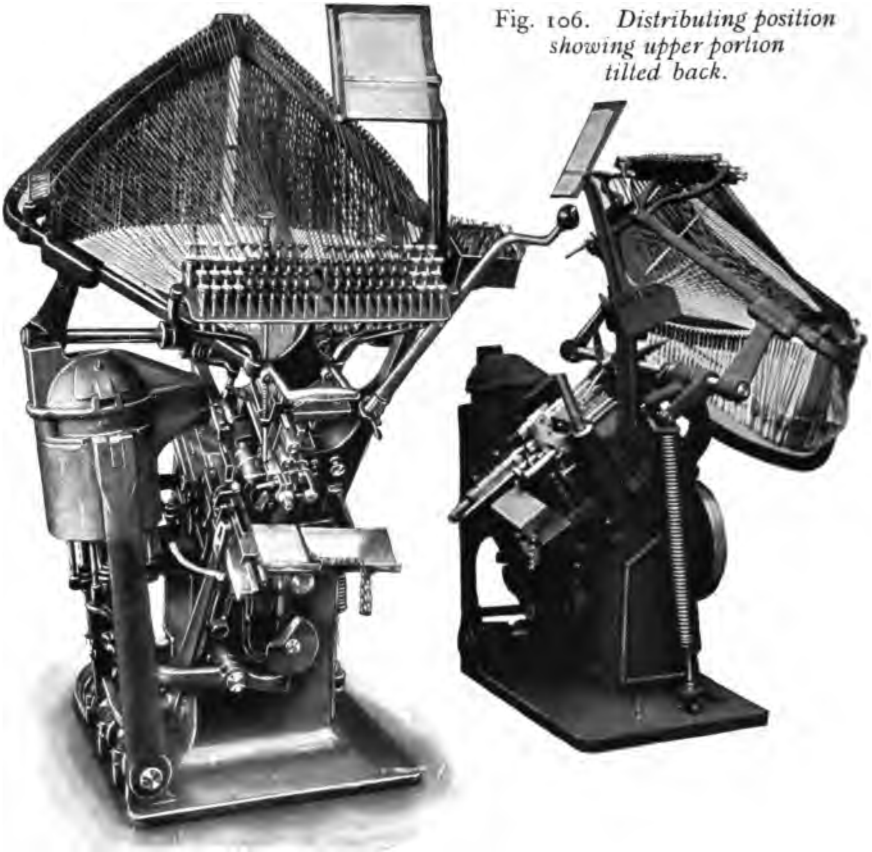
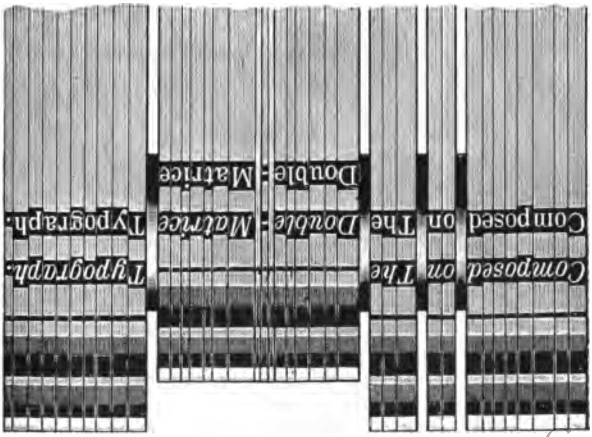


Fig. 106. *Distributing position showing upper portion tilted back.*

Fig. 107. *Line of Two-letter Matrices Composed and Line-justified.*



Figs. 119—122. *Assembly Channel of Matrix Composing and Slug-casting Machine (Typograph).*

Fig. 119. *Assembly Channel Empty.*

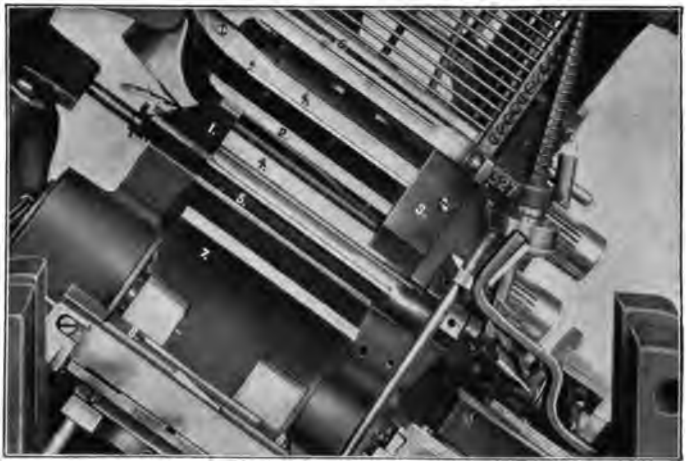


Fig. 120. *Assembly Channel filled with line of Two-letter Matrices.*

(Continued on Plate 45).

Matrix Composing and Slug-casting Machine (Typograph).

(*Continued from Plate 44*).

Fig. 121. *Vice-jaw closed but Line not yet justified.*

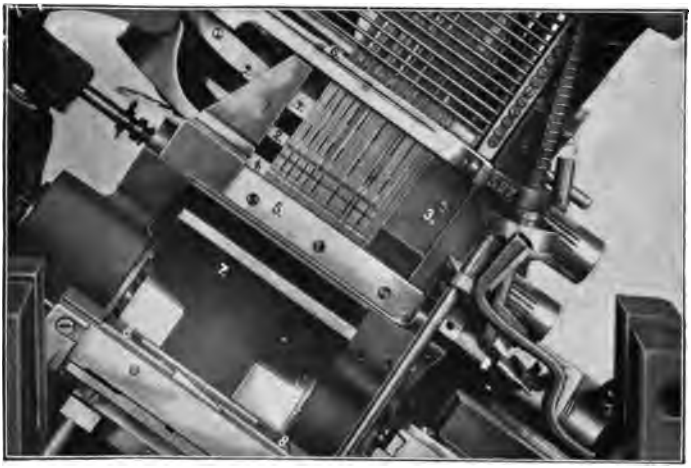
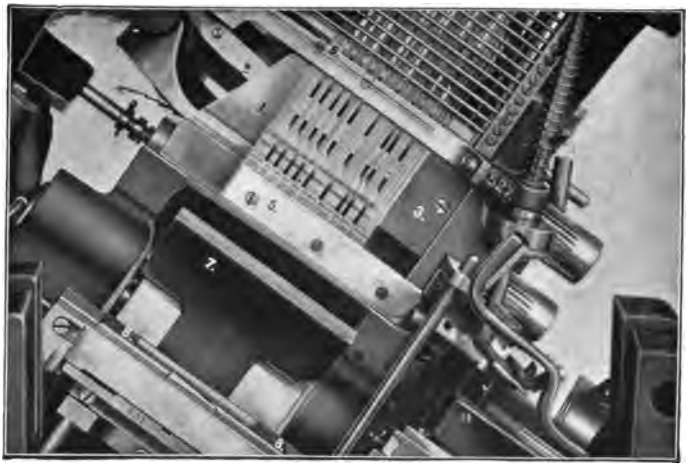


Fig. 122. *Line-justified ready for Casting.*



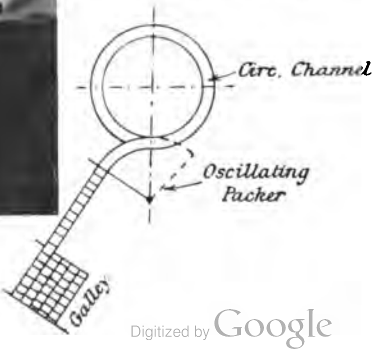
(*Mr. Albert Pidgen's communication.*)

Fig. 127.

Unitype
Type distributing,
Composing,
and Line-justifying
Machine
(Thorne).

Fig. 128.

Thorne Machine.



Legros
Typecasting...