



# INTRODUCTION TO GRAPHIC COMMUNICATIONS Section No. TYPE AND IMAGESETTING 202

A printed piece is made up of two essentially different elements: (1) type matter and (2) various kinds of illustration and decoration. The first four sections of this chapter deal with the nature and production of type matter.

Graphic symbols form the basis of written language. A written language that is based on an alphabet, permitting the in-line combination from a relatively small number of different letters into a vastly greater number of words, provides a system most convenient for printing reproduction.

For printing, the characters of written language—letters, figures, punctuation marks—must be rendered into standardized forms called *type*. While the rendering of each character must have a recognizable basic shape, each particular set of characters (called a font) may differ from another set in style, size, or both.

The particular style of a font is called its *face or typeface*, named from the flat printing surface on the three-dimensional type of letterpress. The design of a face affects the ease with which it can be read, the mood it establishes, and certain special functions that may be desired in special situations: attracting attention or providing emphasis. The design takes into account both the appearance of the individual char-

acters and how they fit together into an overall effect.

A font has not only a particular style but a particular size. The principal identifying size is a vertical dimension that determines the distance from the base line of one line of type to the base line of an adjacent line of type when the two are at the designed distance apart—"set solid," with no additional line spacing between them. This dimension is called "*point size*" from the name of the unit (the point) used in type measure, as discussed subsequently.

The design and selection of the faces and sizes of types and their arrangement and spacing is called *typography*. The actual operation of assembling types into words and lines in accordance with the manuscript and typographic specifications is a part of typography called *typesetting*.

## Development of Typefaces

Type designed by the early printers copied the styles of the local scribes. In the northern part of Europe, the boldfaced Gothic letter forms, sometimes called black letter, were predominantly used. Thus, the letter form designed by Gutenberg in Germany for his 42-line Bible, which is said to be the first printing from movable type, is characterized by the heavy Gothic letter form. In Southern Europe, the

influence of the early Venetian letter forms is responsible for what is known as the Roman letter. Nicholas Jenson, a Frenchman from Venice, designed a Roman letter form that still influences type designers. The Venetian Roman letter had minimal contrast between the thin upstrokes and the heavier downstrokes and is characterized by thick, rounded, uneven serifs (short cross-lines at the ends of main strokes) that were similar to those serifs formed by pen strokes or chiseled into stone. Shortly after Jenson, another Venetian, named Aldus Manutius, designed two more Roman faces and also the sloped letter known as italic. The influence of the Roman letter spread northward into France and England where designers such as Claude Garamond and William Caslon refined the Venetian Roman by increasing the contrast between the thin upstrokes and heavier downstrokes and forming serifs that angled out sharply from a rounded bracket where the serif joins the stem.

The first significant change from the Oldstyle Roman to what is termed a modern face was brought about by John Baskerville, who used wove paper for the first time in printing. The smoother paper surface made possible the use of finer typefaces. Baskerville's type, a tran-

Instead, he designed with maximum contrast of thick and thin

sitional design, refined the thin strokes. Bracketed serifs trailed to a point, and the swells of the round letters, unlike those of Oldstyle Roman, were vertical except in the “e.”

Transitional designs continued until the eighteenth century, when Giambattista Bodoni designed the first truly modern typeface. He made the first complete thrust away from the graceful, easy-flowing lines of oldstyle and transitional types.

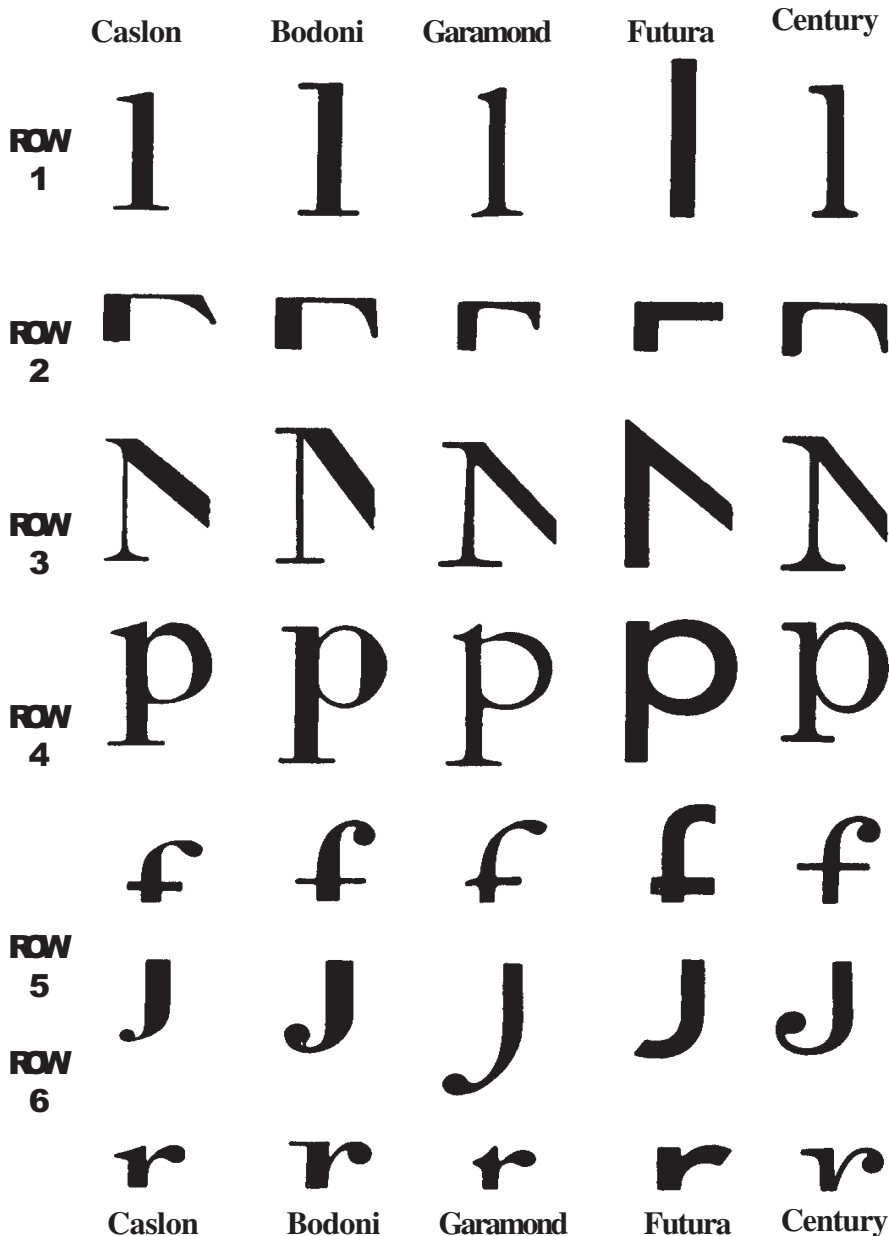
strokes, terminating the main strokes with straight, thin, and unbracketed serifs. Although he designed in the eighteenth century, the term “modern” still applies to type designs based on Bodoni’s principles.

## Elements of Type Design

The basic unit of type matter is the character, and everything discussed in the preced-

ing segment concerns features of the character: weight of the strokes—thin, thick, or varying; kind of serif and how it is joined to the end of the stroke; slope of the character; shapes of the curved elements; and special features, such as the kind of ear on the small “r.” Such design elements affect the suitability of a typeface for specific purposes, as discussed in Section Three.

But type designers also have to be concerned with the overall appearance of the type as the characters are fitted together into words and lines. The first requirement for this, of course, is consistency of style, with respect to the features mentioned above, from character to character. Another consideration is how far one character is from the next. For metal or other three-dimensional types set side by side, this space between letters is the difference between the overall width of the character and the width of the type body on which the character is carried. Thus basic letterspacing is part of the type design.



*The distinguishing characteristics of a typeface. This composite shows characteristic elements of letter forms. The first row shows serifs; second row, termination of top strokes; third row, weight of strokes; fourth row, shape of rounded character elements; fifth and sixth rows, terminals on j and f; seventh row, formation of ears in letter r. The faces represented: (1) Caslon Oldstyle; (2) Bodoni; (3) Garamond; (4) Futura; (5) Century Expanded.*

One problem is that the visual space between characters is affected by the varying shapes of the adjacent sides of characters. Some combinations of side-by-side letters with normal spacing mesh better than others. Early designers improved many of these problem letter combinations by designing two or more characters together on one type body, a combination called a *ligature*. A few of these, such as “ff,” “fi,” “fl,” “ffi,” and “ffl,” persist to the present in some fonts.

Sometimes portions of such characters as an italic “f” were made to project beyond the type body to permit overlapping an adjacent letter. A projecting part of this kind was called a *kern*. With the advent of phototypesetting, the term *kerning* was extended to the practice of achieving similar results electronically by reducing the normal letterspacing.

**Folio Extra Bold**

**Bodoni Extra Bold**

**Futura Medium Condensed**

**Stymie Black**

**Whitin Black**

*Several popular display faces. Folio and Futura are sans serif designs; the Bodoni is modern; Stymie, square serif; Whitin, a “bracketed” oldstyle face*

**SIZE**

SIZE

**WEIGHT** WEIGHT

**FORM** FORM

**COLOR** COLOR

*The basic considerations in type design. Note the force and character of letters as they change in size, weight, form and even color.*

# The Evolution of Typesetting

The operation of setting type by hand remained essentially unchanged from the days of Johannes Gutenberg (about 1450) to the invention of the Linotype in 1886, and is still in limited use today. Even the alloy used in casting the individual metal types had the same basic constituents as modern foundry type: lead, antimony, and tin. In the typesetting operation, individual types residing in a compartmented case are hand-assembled into words and lines in a hand-held device called a composing stick. From there the lines are transferred to a tray called a galley

Although machine-setting has largely replaced handset and two-dimensional type has largely replaced three-dimensional, the traditions, terminology, and principles of typography have their roots in the centuries-old system. For example, the terms “uppercase” and “lowercase” that are still applied to letters originated from the respective positions occupied by the capitals and small letters in the type case. The practice of increasing the spacing between type lines by inserting thin strips of lead is called “leading”; the same term is often applied to the control of interline spacing by paper advance in phototypesetting. And many other standard typographical terms originated in reference to the individual handset types.

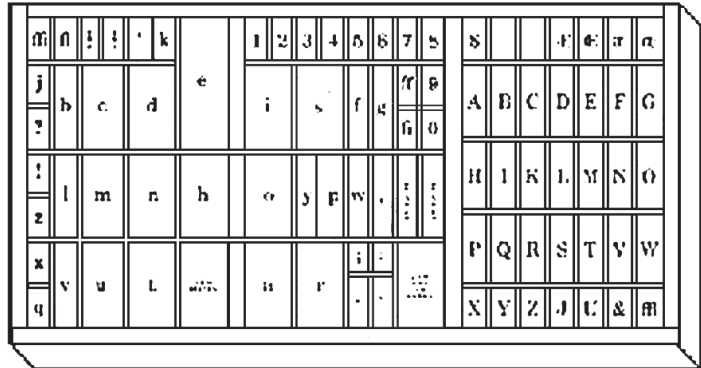
# Nomenclature of Type

Type is available for every letter, numeral, or other symbol that is used in graphic communications, and these letters and symbols appear in a great number of designs and sizes. To describe the characteristic appearance of types, a unique terminology for typography has been developed over several centuries, and since these terms are still used extensively, a student of typography must be thoroughly acquainted with them.

**Type Font.**

A complete assortment of characters of one size of typeface that includes capitals, small capitals, lowercase letters, numerals, ligatures, and punctuation marks is called a font of type.

A font of type usually contains a sufficient assortment of characters for setting ordinary composition such as newspapers, magazines, and other non-technical material. In some cases, a “pi” font must be used in conjunction with a main font to permit the setting of superior and inferior characters, mathematical symbols, and accented



*Type arrangement of the California Job Case. Note that the most frequently used letters, "e", "t", "a", "o", "i", and "n" have larger boxes to accommodate the larger of letters required by each*

characters for certain languages.

## Type Series.

Most typefaces used in metal composition are made in a wide range of sizes known as a series. Generally, a type series in metal composition be-

gins at a 6-point size and goes up to 36-point or in some cases as large as 96-point type.

## The Point System.

The term point is derived from the American Point System. This system of measurement is used in most English-speaking countries. The point system has two units of measurement: points and picas. There are 12 points in 1 pica and 6 picas in 1 in., or 72 points in 1 in. (Actually, 6 picas are not exactly equal to 1 in.; they measure 0.99576 in.) Type body size is specified in points, such as 10-point Bodoni. A pica type is 12 points, and agate type used in newspaper ads is 5 1/2 points. There are 14 agate lines to a column inch. This is the measurement used to calculate

the space occupied by advertisements in newspapers. Large wood type used for posters is expressed in pica lines. For example, lo-line type would be 10 picas in height.

abcdefghijklmnopqrstuv

wxyz .-,:;’?!& “” fffiffiffi

**Line length.**

The length of a typeset line is also specified in picas such as an 18-pica line length.

ABCDEFGHIJKLMNOP

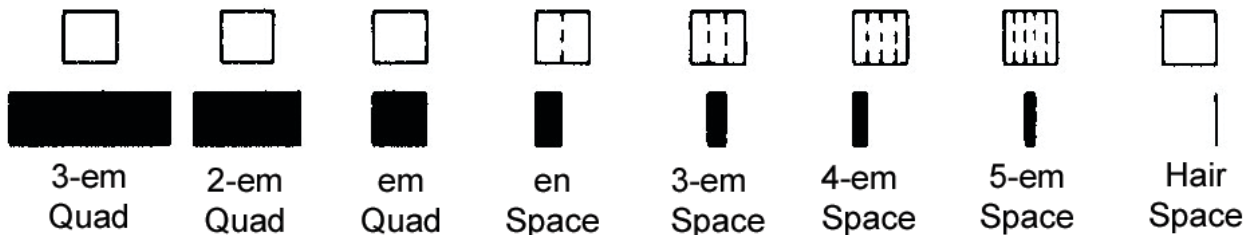
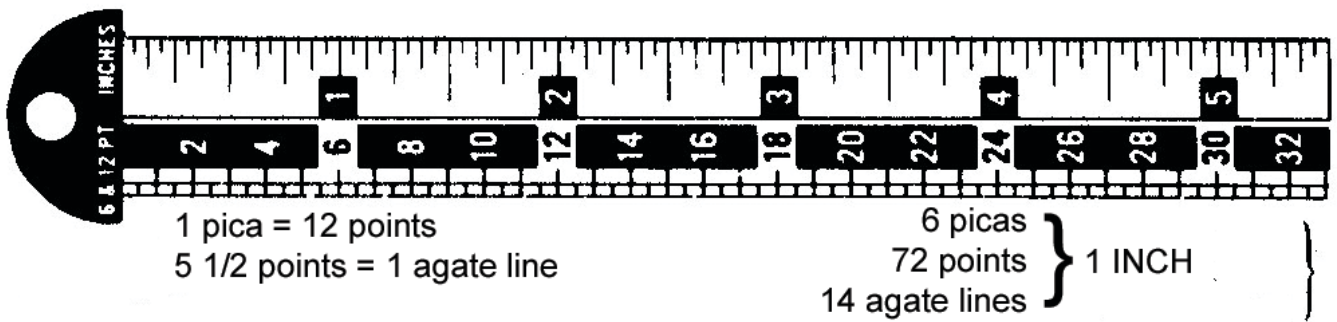
QRSTUVWXYZ

\$1234567890

*The characters found in a typical type font. Note the ligatures.*

**Point Size or Body Size.**

The height of a font of characters is always referred to as the body size or point size and is expressed in typographic points. The measure of the height is slightly more than the distance from the highest ascender to the lowest descender of the characters in the font.



*The point system. Note that 30 picas comes to slightly less than 5 in. The em is a square of the type's point (body) size. NOTE: Spaces are exact fractions of the em; quads are exact multiples.*

It must be emphasized that, although different type designs may have the same body size, the size of the faces will appear different due to the difference in the lengths of the ascenders and descenders.

To determine the type size of a printed sample, measure the depth in picas of twelve lines. If the material is set "solid," the measurement will be the point size of the type. If "leaded," the measurement (in picas) will be the point size plus the leading, such as "10 on 12" point, twelve lines of which will measure 10 picas.

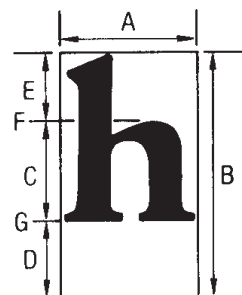
**Set Size or Set Width.**

All alphabets have characters of different widths; the letter "i," for example, is narrower than the letter "m." The type designer, or calligrapher, considers this when designing a new typeface so that any combination of letters in a word will appear to be consistently spaced. This characteristic is called the set-size or set-width of a typeface.

- Century Expanded
- Century Expanded Italic*
- Century Bold
- Century Bold Italic*
- Century Bold Condensed
- Century Bold Condensed Italic*
- Century Oldstyle
- Century Oldstyle Italic*
- Century Schoolbook
- Century Schoolbook Italic*
- Century Schoolbook Bold

*A typical type family set in 12 pt. Some large type designs are available in large families, some in small families.*

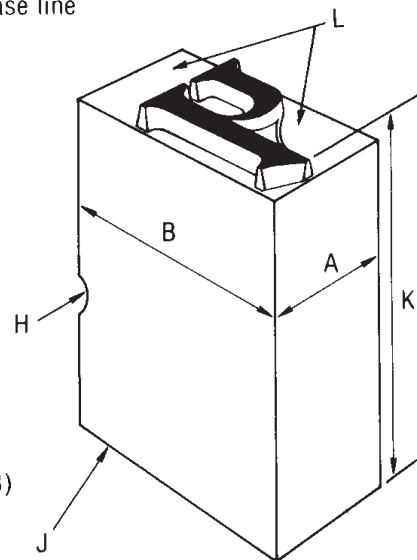
**Decorative type designs seldom are available as a family.**



- A Set-width of character
- B Point size of character
- C "x" height
- D Descender space
- E Ascender space (note ascender)
- F Waist line
- G Base line

*Type nomenclature. Left; terms related to the typeface; right: terms related to a piece of metal type.*

- A Set-width of body
- B Point-size of body
- H Nick
- J Foot
- K Height of type piece (.918)
- L Shoulder



## The Invention of Linecasting

Many efforts were made in the nineteenth century to mechanize typesetting to meet the demands of the rapidly increasing volume of typesetting required daily by newspapers. These efforts had very little success as long as they attempted to accomplish mechanically the as-

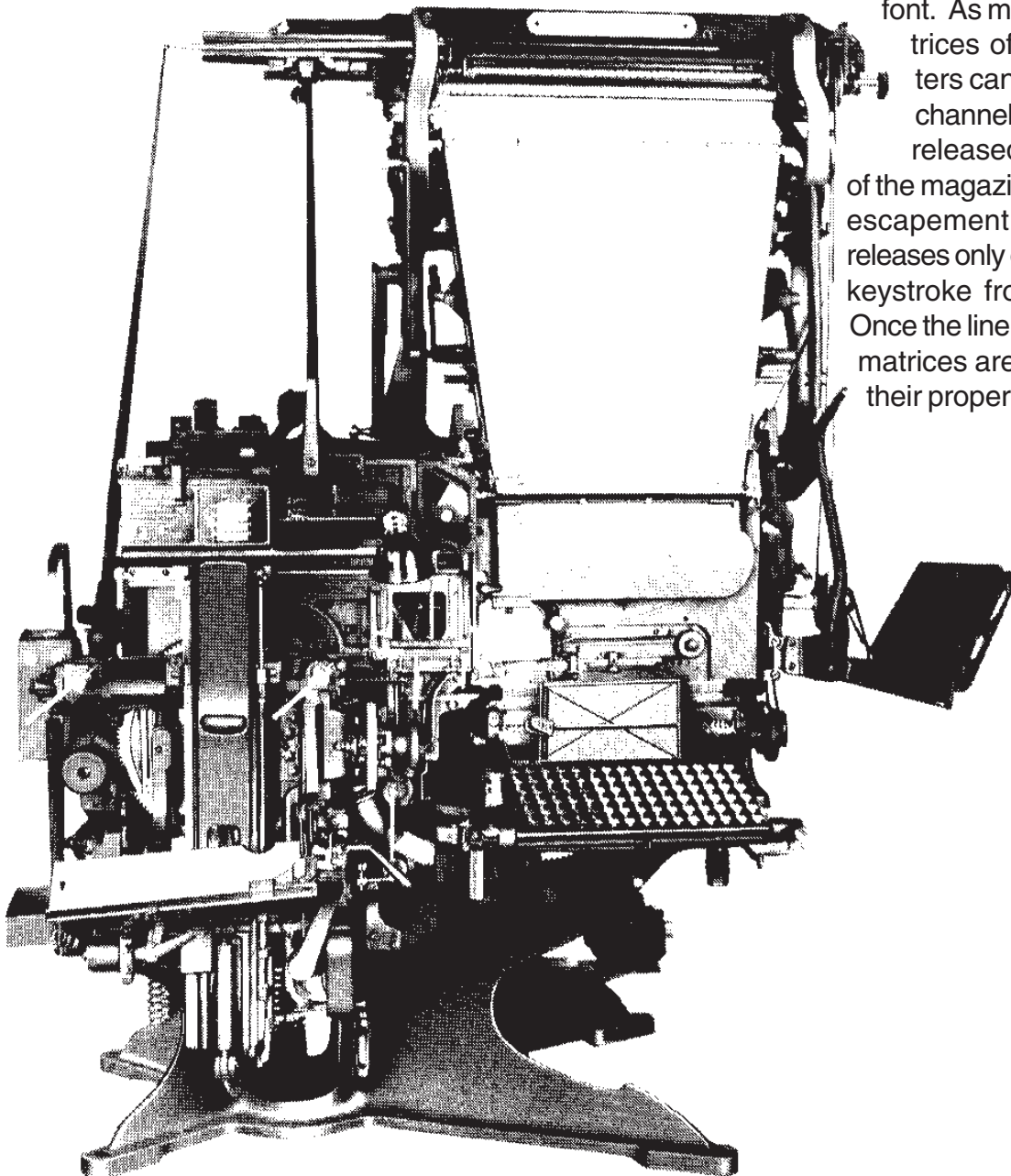
sembly of individual types.

Ottmar Mergenthaler set off the first revolution in typesetting by conceiving and bringing to fruition a completely new approach. His Linotype, which quickly evolved into a form basically similar to that still in limited use today, has a system in which *matrices* (individual character molds) rather than the type themselves are assembled a

line at a time, after which the entire line of type is cast as a single piece of lead and the matrices are recirculated.

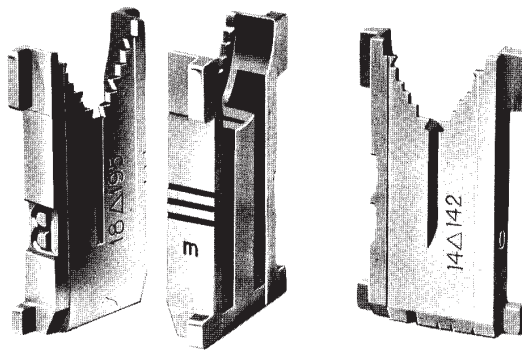
### Keyboard-operated (manual) linecasting machine.

Fonts of matrices are stored separately in special containers called magazines. From one to eight magazines can be held on a machine at essentially a flat metal box with channels for each different character of the font. As many as twenty matrices of identical characters can be stored in each channel. The matrices are released from the bottom of the magazine by means of an escapement mechanism that releases only one matrix for each keystroke from the keyboard. Once the line has been cast, the matrices are redistributed into their proper channels.



The keyboard is unlike a typewriter keyboard in that it is composed of ninety keys arranged in three sections—lowercase on the left; figures, points, spaces in the center; and capital letters on the right. Through a series of cams and mechanical linkage, each key is connected to a magazine escapement. A touch by the operator’s finger releases a matrix with instant response. A magazine has ninety channels, corresponding to the ninety keys on the keyboard. A full magazine will hold twenty matrices in each channel; a three-quarter, sixteen; and a half, ten. Each mat has seven teeth on either side of the V-shaped top edge. The teeth correspond to matching grooves on a distributor bar. Mating of the teeth with the grooves releases each mat into its proper channel when the matrices are being distributed back into a magazine.

A reference also appears on each mat enabling the operator at a glance to distinguish each letter as it is being assembled. The mold side of a mat contains two characters, which are generally a roman and an italic or a light and a bold face. The two faces are in a vertical alignment on the side of the matrix, and the face to be cast is determined when the matrices are being assembled. In the assembly process, matrices are mechanically aligned on one of two horizontal levels, called rail positions. The lower rail would be roman, the upper rail would be italic or, with a different set



*Matrices used for casting lines of metal type. Left: casting edge of a single-character mat; center: reference side; right: side view of a duplex (two-letter) mat showing point size and font number. The left edge shows the intaglio images.*

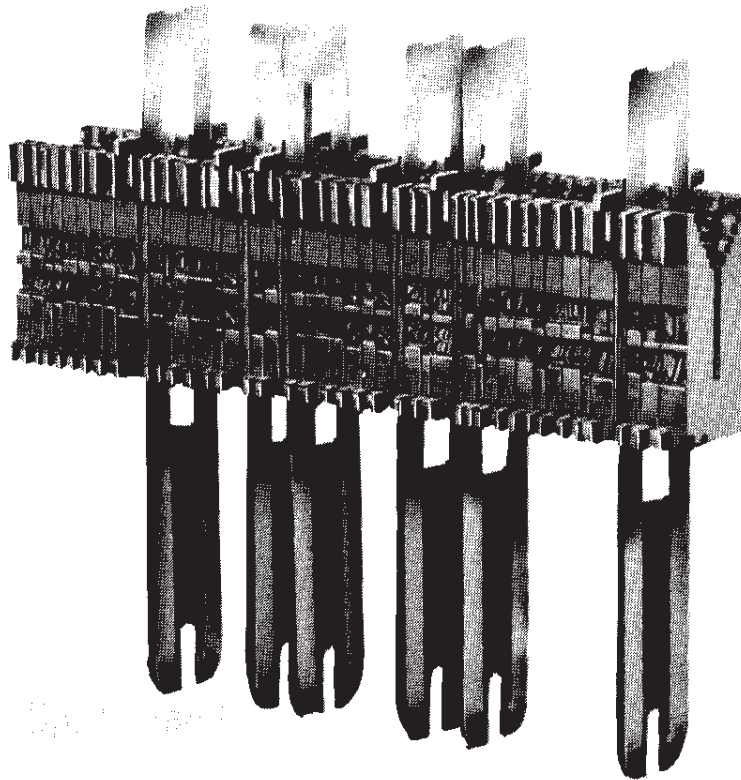
*Courtesy Mergenthaler Linotype Co.*

of matrices, the lower rail could be light with the upper rail bold-face.

When a key is depressed, a mat is released from the magazine and travels down a conveyor belt into an assembler, where mats and space bands are assembled into a complete line. The line is then transferred to the casting position, where a

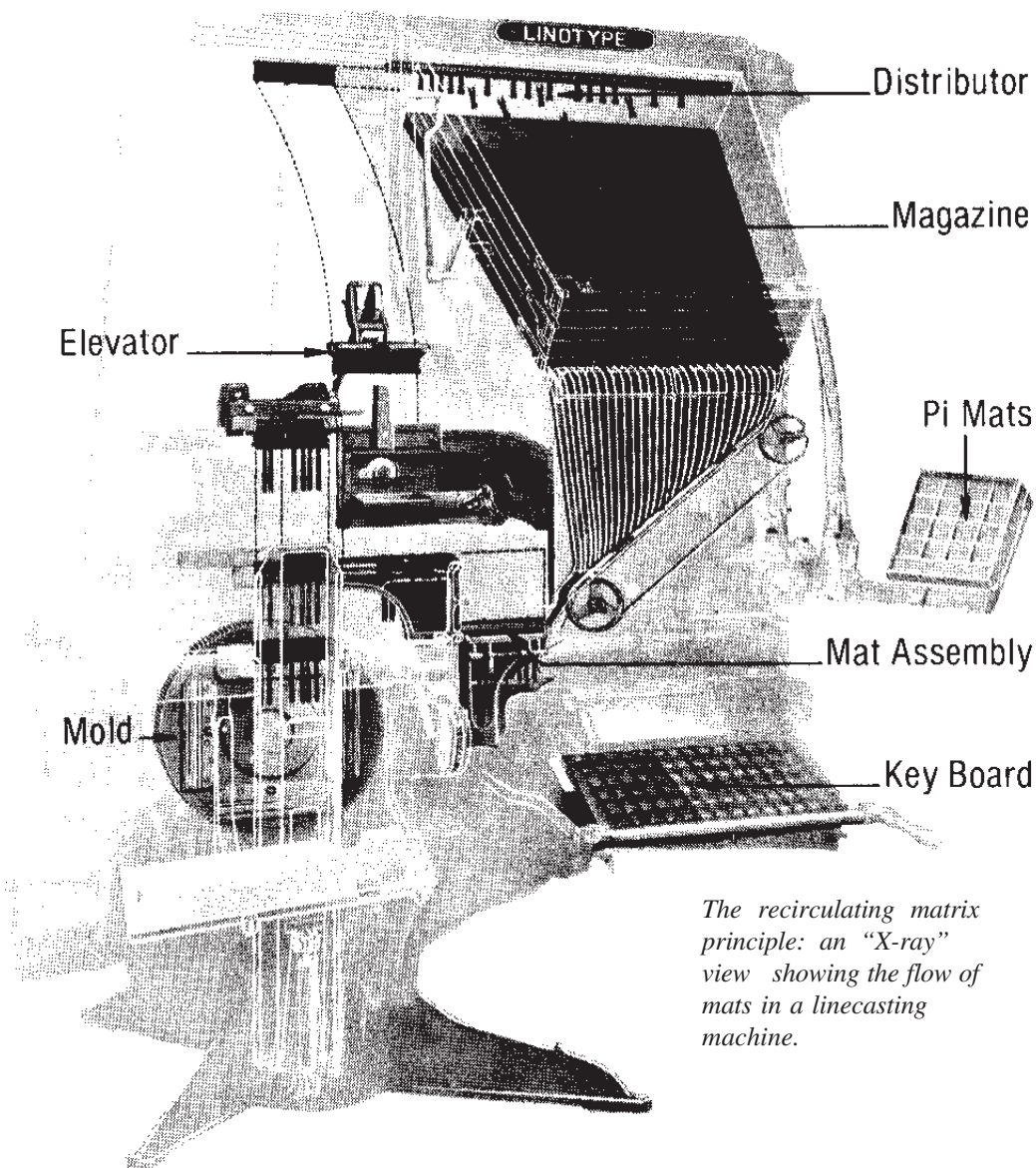
justification bar forces the wedge-shaped bands up, expanding and justifying the line between vise jaws that are set for the line measure and which hold the mats during casting.

Once a line is justified, molten metal is forced into a mold and against the mats, forming a “slug” of type. The bottom and sides are then automatically



*Courtesy Mergenthaler Linotype Co.*

**A complete line of Linotype mats (duplex mats in this case) and spacebands.**



*The recirculating matrix principle: an "X-ray" view showing the flow of mats in a linecasting machine.*

*Courtesy Mergenthaler Linotype Co.*

trimmed, and the slug is ejected into a galley.

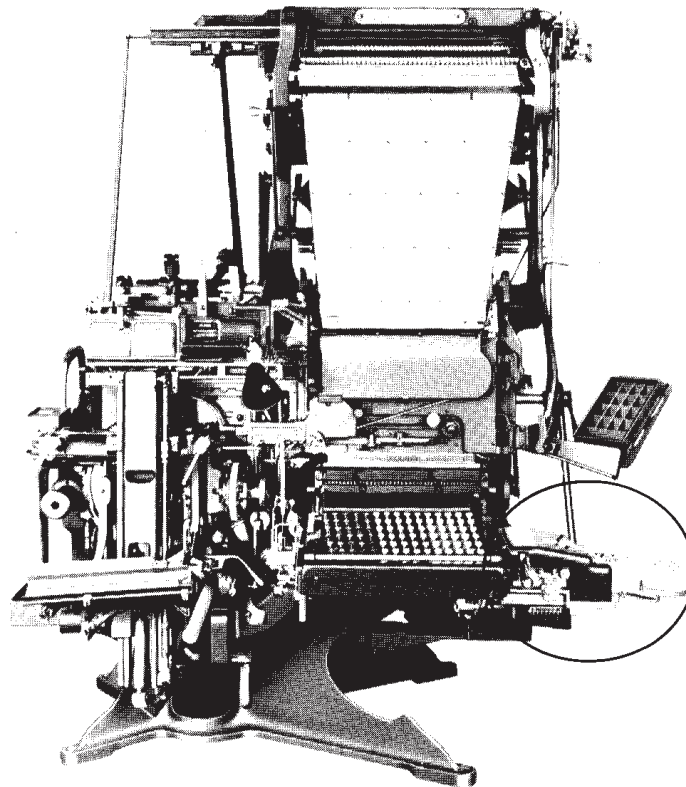
While trimming and ejecting of the slug is taking place, the mats and space bands are mechanically separated by a series of arms and elevators. A distributor elevator carries the used mats to a distributor box that transfers them, one at a time, to a series of distributor screws and distributor bar. The revolving distributor screws transport the mat across the distributor bar until a combination of the

mat's teeth and the distributor bar teeth release the mat, dropping it into its respective channel for further use.

Most keyboard-driven linecasting machines are limited to a 30-pica line length. However, some machines have a 42-pica capability. Type sizes range from 4-point to 14-point for text composition. For special applications, these machines can set up to 60-point.

Linecasting machines can

carry multiple magazines, as well as auxiliary magazines if equipped with auxiliary keyboards. However, such machines are made for specific applications. A machine with a single distributor and single magazine is generally used only for text composition. When equipped with multiple magazines and keyboards, it has the type-mixing capabilities required for advertising and complex typography.



Courtesy Mergenthaler Linotype Co.

*A tape-driven linecasting machine. The tape drive mechanism is circled; the machine can also be operated manually. Operating from the tape, machines of this type can set up to 15 newspaper lines per minute.*

The six-level tape is read by the linecasting machine tape reader that mechanically activates the cams just as if an operator struck keys. The tape-driven machine is faster than a keyboard model. Manual machine speed rarely exceeded eight newspaper lines per minute as compared to fifteen lines per minute on tape-operated machines.

Various input methods are available for tape-operated machines. The original TTS machine of Teletypesetter Corporation was the first keyboard tape system developed for input to tape-operated machines for *local production* of news or commercial composition. The TTS system was also used for *wire transmission* of composed matter from one sending station

to any number of distant cities to operate linecasting machines.

On a manually operated machine, the operator encodes the assembly of mats and space bands and determines line-ending hyphenation and justification range. Since there is no assembly of mats when keyboarding for tape-operated linecasters, a numerical width control must be used. The system uses eighteen units to the em.

Most keyboards are "blind"—do not produce a printed output. During operation, the operator, working on a typewriter keyboard configuration, watches a semicircular scale, having a series of pointers. The keyboard counts the unit value of each character, subtracts it from the total number of units in the line,

and indicates to the operator when he is within justification range—that is, the range where there will be sufficient room for expansion of space bands. A prime function of the operator, while visually monitoring the justification scale, is to decide if a word, an additional syllable, or a better word division can fit on the line. This is a decision the operator must make. If the line is too loose and an additional word or syllable will not fit, he must erase the tape up to the last line, re-perforate or re-keyboard the line and letterspace it to permit justification, or hyphenate the last word.

A multiface perforator has the ability to count non-unit width typefaces since such matrices can be divided into thirty-two units to the em. In this system,

the narrowest character can be five units, or 5/32 of an em. Universal and multiface perforators utilize interchangeable counting magazines, which are simply hard-wired panels containing the unit-width information for various typefaces. Some perforators can carry four counting magazines for four duplexed typefaces.

The first typesetting system that used a numerical control for spacing and justification was not the tape-operated *linecasting* machine, but one that casts *single* characters, the Monotype.

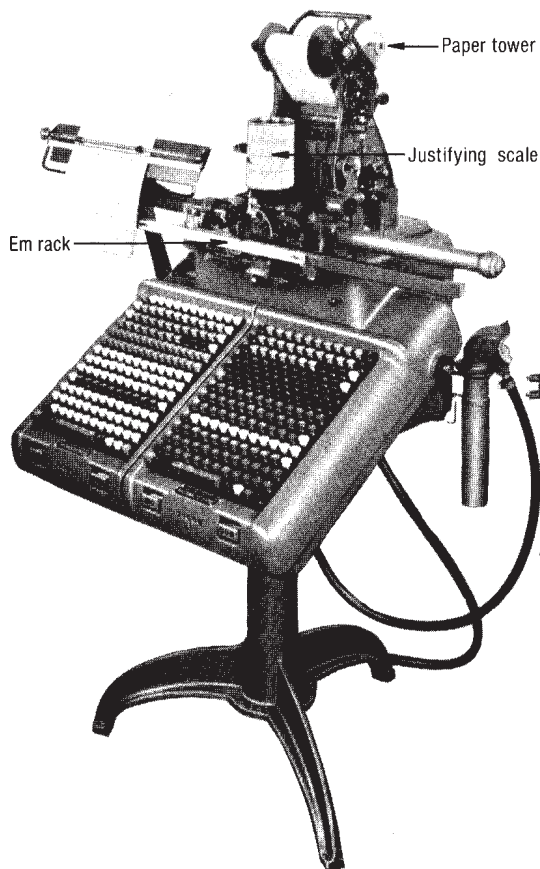
This system uses a single matrix for each character. These are stored in a matrix case and are not removed for

casting as in a circulating-matrix system, but rather the matrix case is shifted and positioned above a mold for each character that is cast. The positioning of the matrix case is pneumatically controlled through the encoded holes on the perforated ribbon. This control of the caster is, in principle, similar to the much older jacquard loom on which elaborately woven patterns were produced utilizing a punched paper master card.

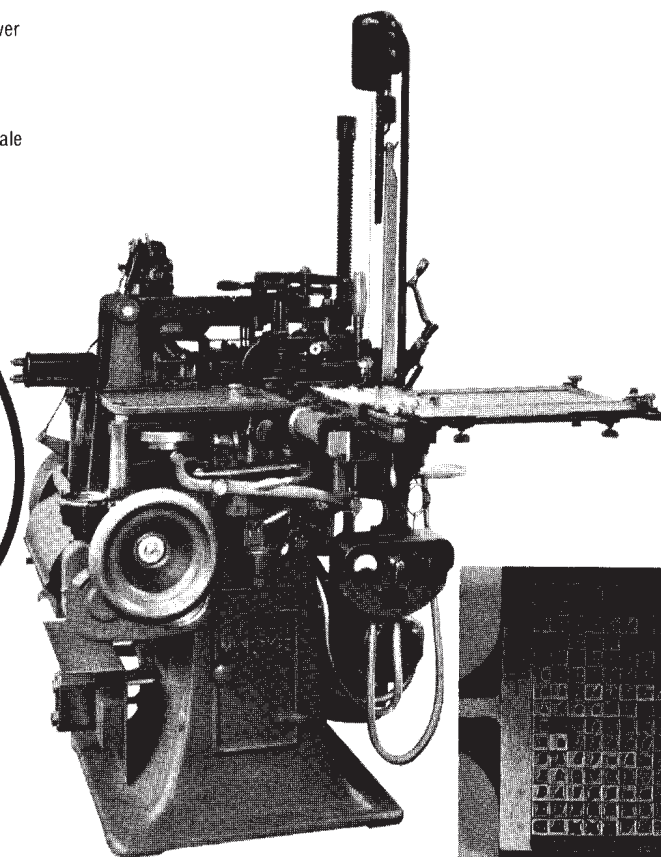
## Typesetting by Monotype

The Monotype System is the original tape-operated metal typesetting system. This system casts single characters one at a time and places them in a line,

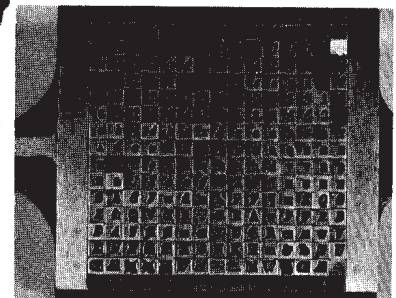
rather than a solid slug as produced on the previously described linecasting systems. Two machines are used in the Monotype system: a keyboard and a caster. The arrangement of keys on the keyboard is similar to that of a standard typewriter. The operator actuates it to produce a punched paper ribbon, thus encoding the copy. The encoded ribbon, which is about five inches wide, includes all necessary information to direct the caster in selecting and casting the proper character matrix and such spaces as are needed to produce justified lines of individual type characters.



The Monotype keyboard.



The Monotype caster.



Courtesy Monotype Corporation

The Monotype mat case.

## Conversion for Lithography

With the rise of lithography and other printing methods having an image carrier produced by photomechanical means, metal type composition had to be converted into two-dimensional type images suitable for photomechanical use.

Several conversion procedures were developed. One was direct photography of the letterpress form. Another was a mechanical/chemical method employing a translucent conversion film with pressure-sensitive cellular coatings. The film was placed in contact with the relief image surface and pressure was applied by a large number of tiny metal balls vibrating against the back of the film. This action collapsed the coating cells in the areas of the type-faces. A dye applied to the film darkened it except in the collapsed-cell type areas, which were transparent. These conversion procedures are now obsolete.

### Reproduction Proofing.

A procedure that was common and that is still occasionally used—although conversion from metal composition by any method has become quite rare—is a carefully printed *reproduction proof* (“repro”) of the type.

Quality in proofing requires standards of press settings, ink, paper, bearers, use of a tint bar, etc. Only stiff inks that dry readily should be used for reproduction proofing. To accept ink properly,

the printing face must be free of dirt and oil. Just before proofing, the form should be wiped with an oil-free solvent applied with a lint free cloth or clean type brush. The press rollers must be smooth and true and not too hard. The inking system, as well as the ink, must be free of lint, dust, dried ink particles, and other foreign matter.

The cylinder packing should be as hard as practical. The harder the packing, the less embossing, and the sharper the print. This requires great care in the leveling of the form, as well as good type and plates. It is desirable to use bearers on each side of the form, running in the direction of cylinder travel. This will minimize the wiping action of rollers over the face of the form. These type-high bars also help bear-off excessive roller pressure.

Reproduction proofs can be made on opaque, translucent, or transparent material. The opaque material is generally a stock made especially for letterpress proofing. A high-gloss cast-coated stock also may be used.

The importance of judging the proof under magnification cannot be overemphasized. Weak areas in the ink that appear black or solid to the unaided eye may be penetrated by the camera lights and ultimately result in ragged or broken letters.

## Direct Setting of Type Images

The makeshift nature of metal type conversion emphasized the desirability of typesetting systems that produced two-dimensional type images directly. Some of these already existed in forms that had been developed for other purposes. The typewriter, invented in 1868 for correspondence, was modified in special ways to make it more acceptable as a typesetter for printing. Such typewriter-like typesetting is called strike-on.

**Strike-On.** Strike-on typesetting systems generally require retyping to perform justification of lines. In the VariTyper system, the operator sets the carriage for a particular line length. He or she types the line until the internal counting mechanism signals that a line is within justification range. The operator tabs over and retypes the line at this time. The variable word space mechanism automatically adds space or subtracts space from between words to permit justification.

The IBM Selectric composer operated in a similar manner, that is, retyping each line. Both IBM and the VariTyper had interchangeable fonts. The IBM had golf ball-shaped type elements for various fonts while the VariTyper had a semi-circular-shaped font. All strike-on typesetting devices utilized a nonreusable carbon ribbon to produce a sharp black image onto a reproduction grade pa-



is placed in position and bur-nished onto the mechanical. The succeeding letters are posi-tioned in proper order until a completed word or line is set.

Cut-out acetate type con-sists of a preprinted sheet with an adhesive base under the characters. The characters are cut apart and positioned on a

other methods as it has in other areas.

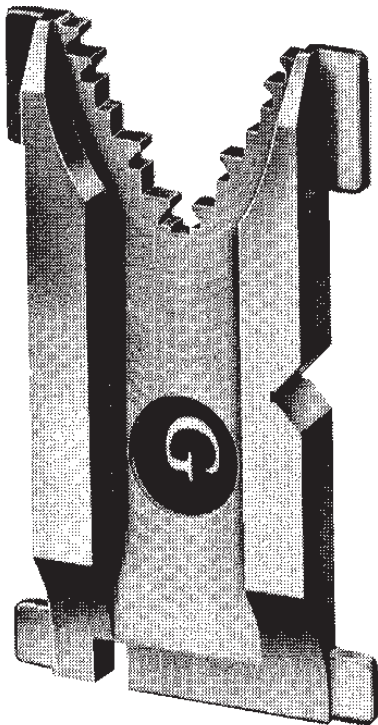
## Phototypesetting

The handsetting of indi-vidual types and the machine-casting of individual characters and of lines of type are all still performed to a small extent. But phototypesetting, the second revolution in typesetting meth-ods, has become so predomi-

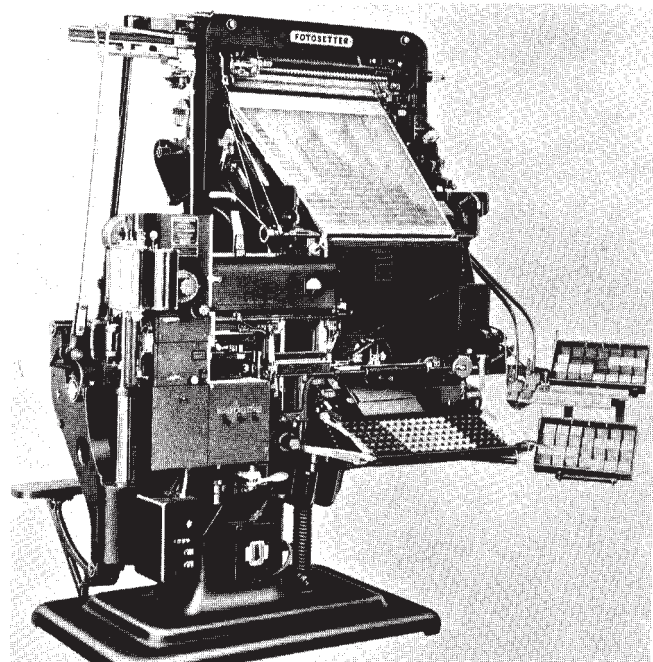
extent of mechanical and elec-tronic sophistication utilized in the system.

## First Generation Typesetters

The matrice phototypeset-ting machines, generally re-ferred to as first-generation photo- typesetting devices, evolved from two of the metal



*Font matrix used on the Intertype Photosetter introduced in 1950.*



*Courtesy Harris Corporation*

*The Intertype Photosetter recirculating matrix machine.*

mechanical.

Another form of art type consists of characters printed on strips of paper. Each character is selected by hand and placed into a long wooden composing stick. After the type is set, a strip of tape is applied across the characters to hold them together, enabling them to be transferred onto the mechanical.

But even for the preparation of artwork, phototypesetting is now widely used, superseding

rat

as to have practically super-seded all previous methods for most purposes.

Phototypesetting systems have undergone four major evolu-tionary changes from the devel-opment of the first phototype-setting- device patterned after metal typesetting machines, to the present laser imaging sys-tems. These are classified as first, second, third or fourth-gen-eration devices according to the

typesetting machines and one impact typesetting device. The Intertype Fotosetter, first mar-keted in 1950, incorporated the same mechanical features of the recirculating matrix system as the Intertype metal linecasting machine (a machine basically similar to the Lino-type). One difference is that the Fotosetter matrix, called the Fotomat, contains a single pho-tographic image in the center of

the metal matrix rather than a duplex die image on its back edge. Once a line of Fotomats and word spaces are assembled, each Fotomat is positioned, one at a time between a lens and a light source to expose the type character onto film or paper. The amount of space each character occupies in a line is determined by the width of the brass Fotomat which, by means of a rack and pinion, moves the film cassette the required distance. This is known as the letter escapement. Justification is automatic, but instead of spacebands there are fixed spaces used between words. Prior to exposure, the camera measures the entire line length including the fixed spaces, and the deficit needed for justification is automatically distributed between words and, in earlier models, between letters.

The Fotosetter magazines contain 117 channels; a double distributor permits mixing 228 characters. In addition, a manually operated revolving lens turret with fourteen different lenses makes possible reproduction sizes from 3 to 72 points, from matrices of 6, 8, 12, and 18 points.

The Monophoto Typesetter was developed to set type photographically rather than by "hot metal" as produced on the Monotype caster. A similar Monotype keyboard for punching the paper ribbon is used. Justification is much the same as with metal, and manual adjustment of a single lens repro-

duces different image sizes. In place of the matrix case with metal matrices, the matrix case is a film assembly of the font. The Justowriter impact typesetting machine, a typewriter-like device, was forerunner of a first-generation phototypesetting device, the ATF Typesetter. This phototypesetter is tape-operated and similar to the Justowriter except that instead of strike-on characters, it utilizes a revolving disk containing 168 letter images. The images on the disk are flashed on a photographic film or paper that is carried in a cassette. Escapement, or space required for each image, is determined by a gear mechanism that moves the carriage containing the cassette; the disk does not escape. Size changes can only be accomplished by changing the font disk. For each new font disk, a carriage gear ratio must be changed manually for the new "unit" of width.

## Second Generation Phototypesetters

Second generation is the classification for the earliest systems that were designed specifically for setting type photographically; they were not adaptations of earlier typesetting systems.

Second-generation phototypesetters can be operated directly from a keyboard in which both the keyboard and the photocomposition device are one unit, or from an encoded paper or magnetic tape prepared on

a separate keyboard. Prior to keyboarding a manuscript, format data such as typeface, point size, set width, line length, and leading between lines must be entered into the keyboard mechanism. This is done by function switches or operator key commands. Once completed, the operator can then proceed to set the type. A line counter accumulates the width value of each character and space, and when a justification range is reached, the operator makes an end-of-line decision that may come at the end of a complete word or, if necessary to fill the line, at a discretionary hyphenation. Each line that is set is held in a buffer until an end-of-line decision is made, then it is released for automatic justification on tape or directly into the phototypesetting machine. On some phototypesetting machines, the character width value or escapement is carried on the tape, but others require prewired plug boards that are inserted into the phototypesetter for each font used.

*Computerized Typesetting.* Since perforated tape used for driving typesetting devices is encoded in digitized form, computerized typesetting devices were practical to develop. These devices were made primarily to relieve the keyboard operator of end-of-line decisions, thus increasing machine output. Early models had a controller that contained a hard-wired logic to perform hyphenless justification or, in more sophisticated models, hyphen-

ation and justification. Hyphenation in these systems was performed by pure logic only; dictionary and exceptions-to-the-rule hyphenation was not possible.

An input tape—sometimes referred to as “idiot tape”—as prepared with an encoding scheme that preceded the encoded manuscript. This tape, paper or magnetic, was placed into the controller that produced a second tape containing hyphenation and justification codes. This revised tape was then used to drive the phototypesetter.

In cases where hyphenation was not done logically by the controller, an operator would insert special hyphen codes between syllables in large words that might appear at the end of a line. If hyphenation was possible, the controller would select one of the hyphen codes for the end of the line. All other hyphen codes that were not used were automatically rejected.

The next development was the use of a stored-program computer. A format program (written specifications of typesetting requirements in a language acceptable to the computer) sets up the basic criteria from which the computer can arrange or compose the input data. The data is preceded by an encoded format code such as /F1. This code, when translated in the stored program codes, compiles and executes magnetic tape output that is hyphenated, justified, and paginated.

Hyphenation by computer is done by logic and by an ex-  
R08/02

ception dictionary. (An exception dictionary is a list available to the computer of all words not logically hyphenated.) A line is set until a word oversets the line. The overset word is passed through a hyphenation routine that first checks to see if the word is in the exception dictionary. Failing to find the word in the exception dictionary, the computer then subjects the word to a routine of hyphenation logic. The first breakdown is by prefix and suffix; then the root of the word is broken down according to logic criteria.

Once the hyphenation point is determined, the portion of the word that is to be retained is sent back to the line with a hyphen ending, and justification begins. The total number of spaces has been counted, and the additional space required to justify is equally divided among all the total word spaces. The original space between words is the minimum space allowable—approximately one-third of an “M.” If the “M” is divided into 18 units, such as in Monotype composition, the minimum word space allowed would be six units.

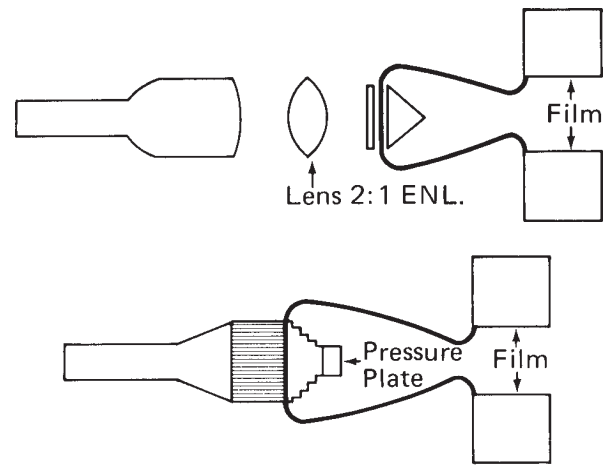
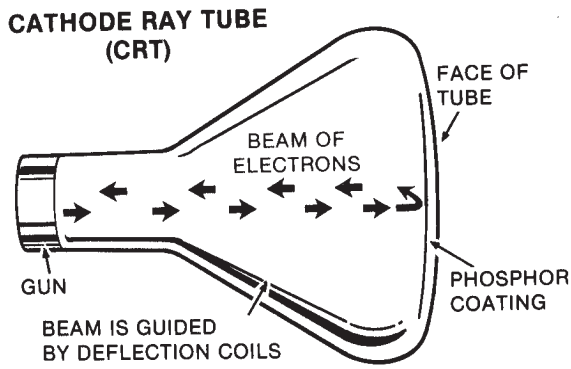
The computer has since been replaced with a minicomputer that is combined with a phototypesetter. This permits hyphenation, justification, and other newer capabilities such as pagination on the single system. Or an off-line minicomputer—commonly called a host computer—can also be used for hyphenation and justification. A second minicomputer is still

used on the phototypesetter as a control logic.

With this latter system, an unjustified and unhyphenated tape, or typed document that is scanned on an OCR (optical character recognition) device, can be put into the mini host computer that has several capabilities. It will character-translate, hyphenate, justify, and then send the information into the phototypesetter. The advantages of this system are the ease of operation and the versatility of the computer. All lines are read into the machine and stored in memory, from which there are many capabilities such as translation, hyphenation, justification, pagination, or deciphering by scanning the information for control codes and converting them into format statements that were previously stored.

Second-generation machines may use a grid, spinning disk, or drum to carry negative image matrices that are projected onto photographic film or paper. If a grid is used, the entire grid is illuminated and the desired character is selected by a series of optical wedges that allows only the character image to pass through a series of prisms, enlarging lenses, and mirrors until it is finally positioned and exposed on the photographic film or paper.

A stroboscopic light illuminates the negative images carried on spinning disks or drums. Photocomposing machines that use a spinning disk or spinning drum generate characters at a greater speed, since they do not



LEFT: Cathode Ray Tube (CRT). Similar to a TV picture tube in design, but with up to 6 times the resolution. The phosphors on the face glow when struck by the electron beam. RIGHT: The light is transmitted by lens or fiber optics onto the photographic film or paper.

depend upon the mechanical movement of optical wedges. Instead, as each encoded character is spun into position in front of an aperture or shield, a stroboscopic light illuminates and projects it on through the optic system to the film or paper.

Horizontal position of each character image is controlled by a traveling lens that escapes the required character width or by a moving carriage that holds the film or paper cassette. The film advance mechanism determines the vertical spacing between each line.

completed, the film cassette is removed and the film or paper is passed through a processor that develops and fixes the photographic images.

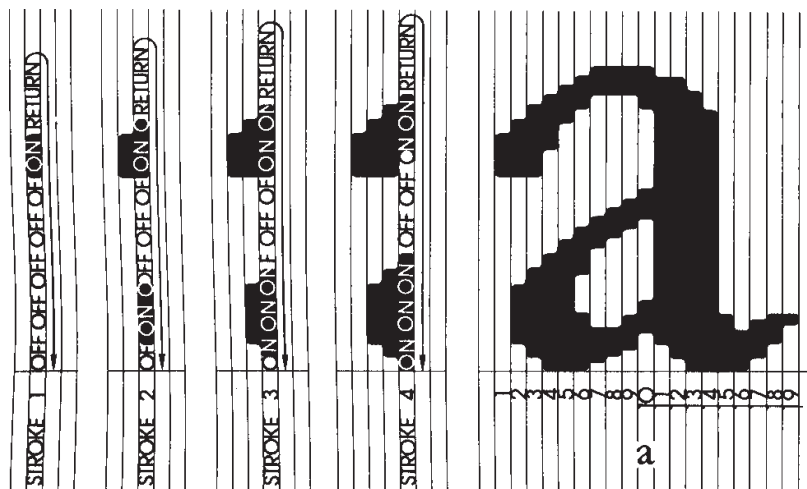
### Third Generation Phototypesetting

Computerized photocomposition systems that utilize a cathode ray tube as part of an image-forming system are termed third-generation phototypesetting devices. These machines are pure electronic devices. The characters are cre-

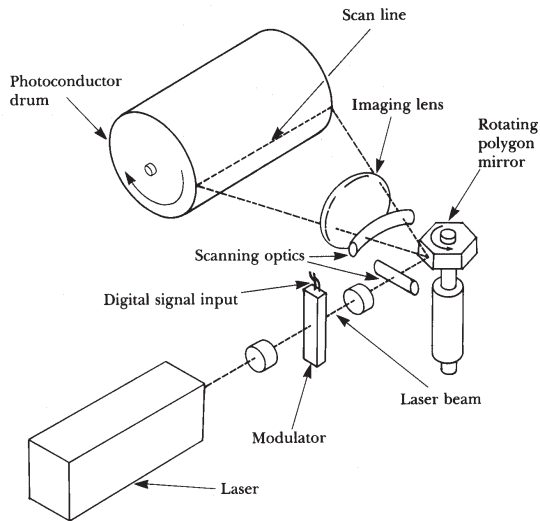
ated through the stroking of an electron beam on the face of a cathode ray tube.

Some machines have stored negative character images similar to second-generation machines. But, instead of strobe lights for illumination, light from an index or blank CRT passes through the matrix to photomultipliers or photoelectric cells, where they are converted to a digital format for stroking on a CRT tube. The strokes on the CRT tube are in vertical patterns, formed by a series of signals.

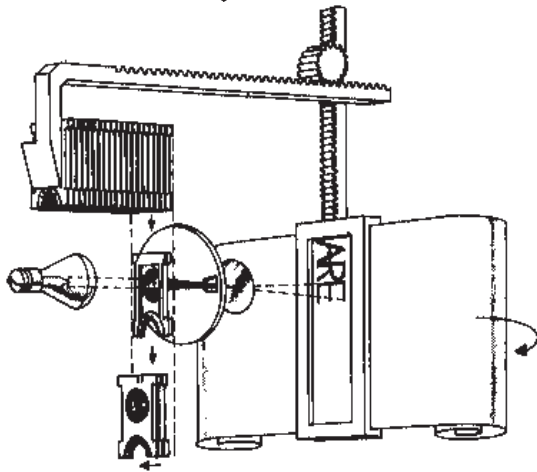
Each series of signals corresponds to a vertical scan of a narrow portion of the character. As the scan is made, on-off signals indicate the presence or absence of character portions within the vertical scan. For instance, a narrow vertical scan through the center of a capital Character generation on a CRT typesetter. The character is generated on a common base line, from left to right. The raggedness is not apparent to the unaided eye, but is readily apparent under magnification.



3-2  
Laser scanning system

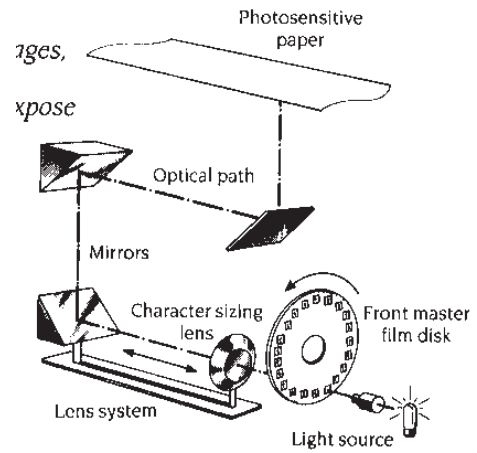


*Simplified view of a typical laser scanning imager. Much similarity exists between a desktop laser printer and a sophisticated photoimager. In the latter, the photoconductor drum is replaced with photographic film or paper.*



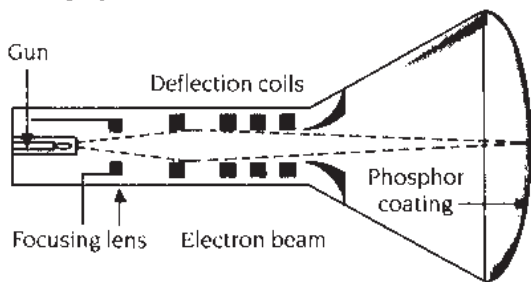
1st Generation:  
Photomechanical

- Type matrix photographed, one assembled line at a time.
- Positive images.
- Lens vary character size.



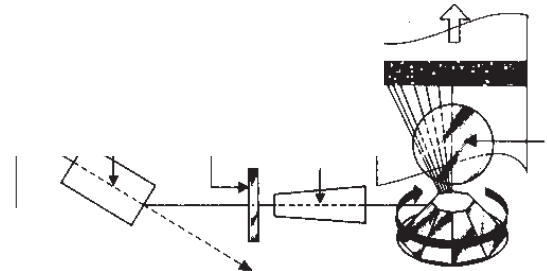
2nd Generation: Xenon Flash

- Rotating drum or disk held type images, one for each type face.
- Flashing through negative font to expose high speed film or paper.
- Lens vary character size.



3rd Generation: CRT Technology

- Digitized CRT image projected to film and paper.
- Positive images.
- Lens vary character size.



4th Generation: NeHe Laser Scanned Output

- Exposure to continuously moving film or paper.
- Imaged right or wrong reading, positive or negative.
- Originally somewhat slower but now highly competitive in speed.

“B” would have six on-off signals. These signals are then transmitted electronically to the face of a CRT. The speed of the scans and the generated signals that appear on the cathode ray tube is so rapid that the image appears as a whole character rather than just vertical signals. The image is picked up from the tube by a traveling lens that projects it onto the film or paper.

Most CRT photocomposition machines use image patterns that are in a digital format and stored on either a magnetic tape or disk. When the first character of a font is called for, the entire font is brought over into the machine’s electronic memory. Digitization of characters in a binary format is the recording of the starting and stopping points of each vertical stroke of an image. Other systems use a matrix of tiny dots for image formation. Many digitized fonts can be stored to be accessed on command at a very high rate of speed.

There are two systems for creating the image on photographic film or paper using a CRT. In the first system a line or character is generated on the face of the CRT and goes through a lens system-stationary lens or moving mirror-to the film. The second system uses fiber optics instead of a lens in which one end of the fiber optics is permanently fused against the face of the CRT and the other end is in intimate contact with the film. The systems that use a lens or moving mirror have a 5-in. CRT with a 2:1 ratio. This means that

a 5-point image that is created on the face of the tube is blown up to 10-point on the film or paper. The systems using fiber optics have a 10-in. CRT and produce at a ratio of 1:1.

Speed of CRT machines varies from as much as 250 characters per second to 3,000 characters per second, depending upon point size, graphic arts quality of the images, and scan line density. Compared to a second-generation machine, which has a speed of from twenty to sixty lines per minute, CRT is much faster in terms of characters or lines produced. However, the CRT phototypesetting machine acts as a computer slave and must be driven by a computer-generated tape. Raw data is hyphenated, justified, and paginated on the host computer and encoded for proper operation on the CRT device.

### **Phototypesetting Systems.**

The cathode ray tube was also put to use in another device: the video display terminal. Such a device, with its keyboard and TV-like screen, permits typographic material to be input (by keyboard or from a storage medium), displayed, and manipulated by deletion, insertion, and rearrangement; specifications of type size and style as well as line length and spacing to be applied; perhaps a hyphenation- and-justification routine to be performed; and the modified material to be output to a phototypesetter or other device. The VDT input/editor became an integral part of phototypesetting systems.

The equipment system that prepares input for the phototypesetter is sometimes called the “front end.” The term “direct input” was originally applied to a system that combined the input keyboard and the phototypesetter in the same piece of equipment; the keyboarding and typesetting commonly operated simultaneously. Later the “direct input” term was extended to any small setup in which the same person keyboarded and operated the typesetter; but the keyboard would commonly record on a small, flexible disk (“floppy disk”) for later rather than simultaneous typesetting; and there might be an additional input/editor keyboard without typesetter. This began to be called a “small integrated system” in contrast to the “large integrated system” consisting of several independent VDT keyboards all feeding the typesetting operation. It was to the VDT keyboards of the large integrated system that the term “front end” was most usually applied.

## **Fourth Generation Imagesetting**

The fourth generation of typesetting ushered in a whole new era in speed, sophistication and ease of use for the typographer. Even the name “typesetter” was generally replaced by “imager”. It also made it possible to obviate some of the customary (and often typographically important) limitations of traditional typesetting.

The traditional point mea-

suring system was computerized and can now be broken down into hundredths. Type sizes are custom fit to the area. Traditional line spacing "leading" measurements are meaningless as the computer creates a fractional spacing amount for both the type size and the interline spacing. And it can all be done by, generally, less highly skilled operators who only need to know how the application software will treat a particular type or art element.

Fully digitized, the system now "paints" both type and art (both halftone and line) in position directly onto a photosensitive strata. The film or paper is processed and the traditional pasteup operation is eliminated.

The speed of fourth generation systems is much greater than any of the previous innovations. The manufacturers like to quote newspaper pages per minute vs. the older systems lines per minute. Speeds in excess of 10 full newspaper pages per minute are possible.

Basic to the system is the introduction of (commonly) a modulated Helium-Neon (HeNe) Laser. The data generated by the operator through software program drives the laser which provides exposure to continuously moving film or paper. The image, through data manipulation, can be right reading or wrong reading, positive or negative.

It is valuable to study the fundamental differences—and

similarities—between the four generations of typesetting equipment. The systems have evolved more in the past 100 years than since the invention of movable type. New advances and applications of technology are causing an ever accelerating rate of change. The fifth generation of non-impact imagers eliminate more steps in the traditional process. Only time will tell which of the new systems will survive or become major players in the process.