

Aug. 6, 1940.

R. W. CARLISLE

2,210,706

FACSIMILE SYSTEM

Filed May 29, 1937

6 Sheets-Sheet 1

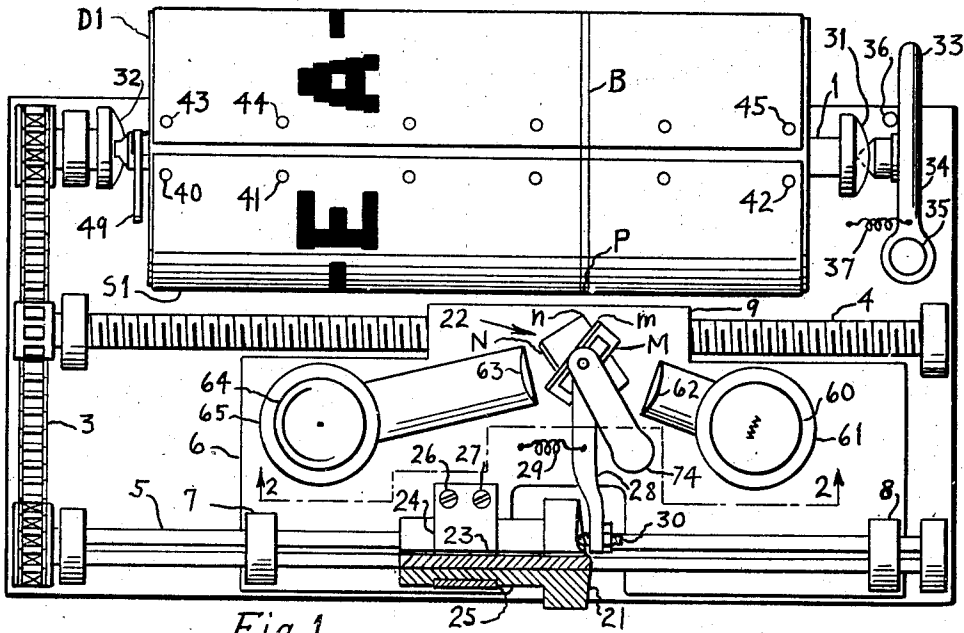


Fig. 1

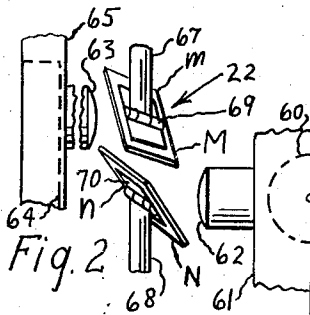


Fig. 2

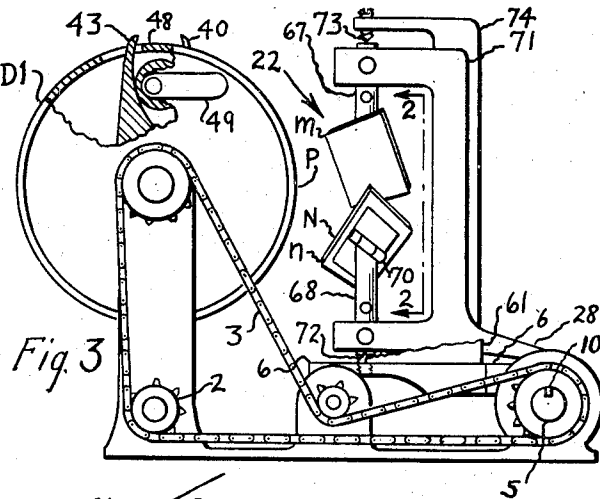


Fig. 3

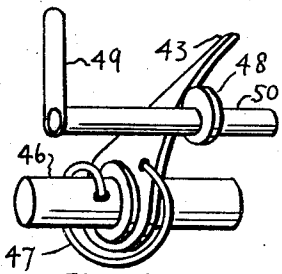


Fig. 4

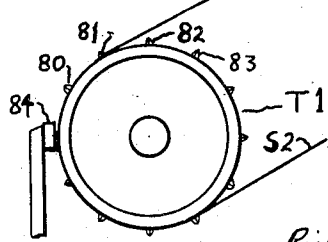


Fig. 5

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6 Sheets-Sheet 2

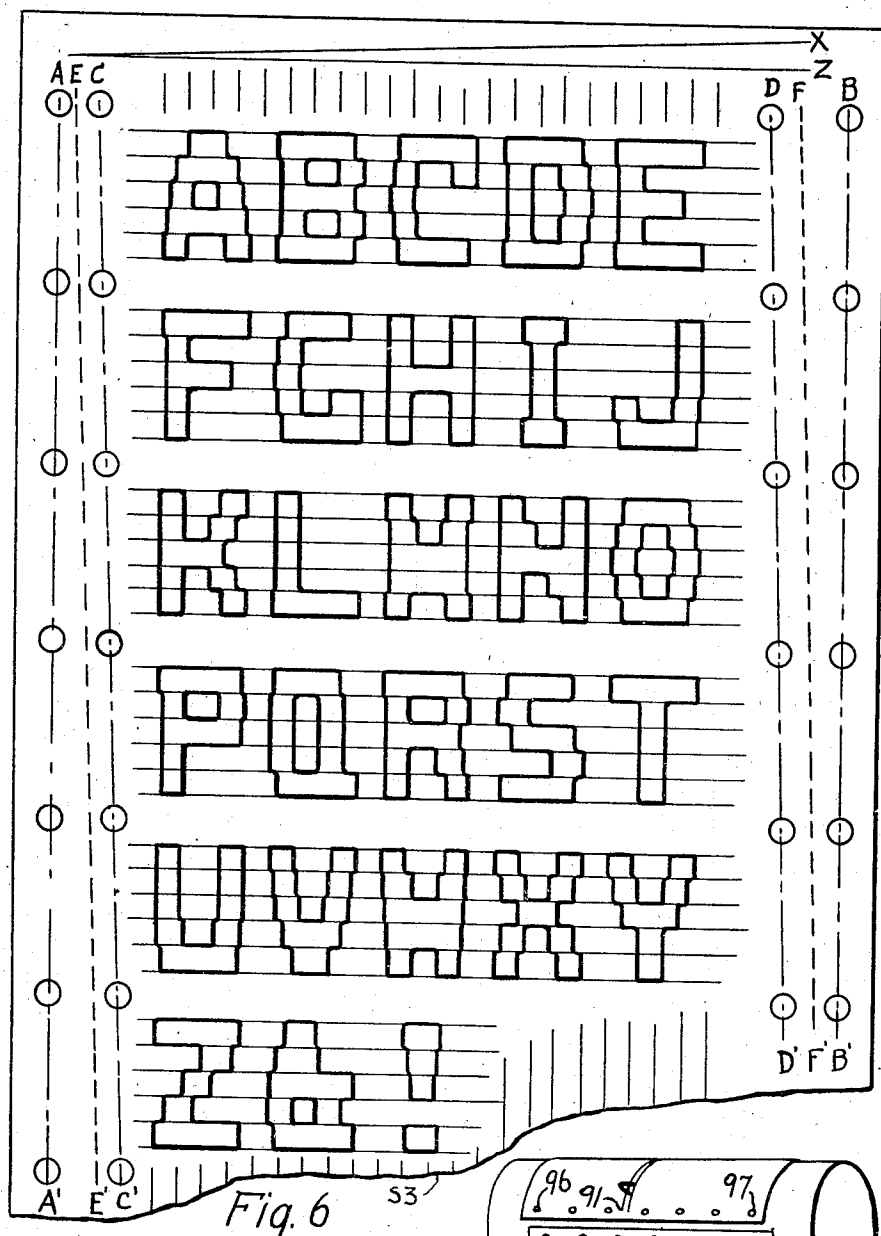


Fig. 6

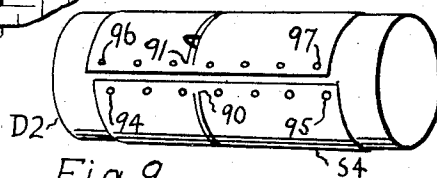


Fig. 9

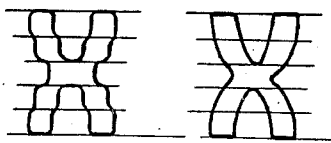


Fig. 7

Fig. 8

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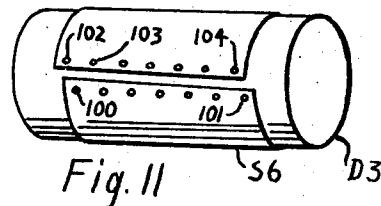
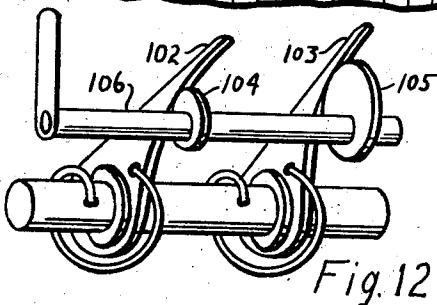
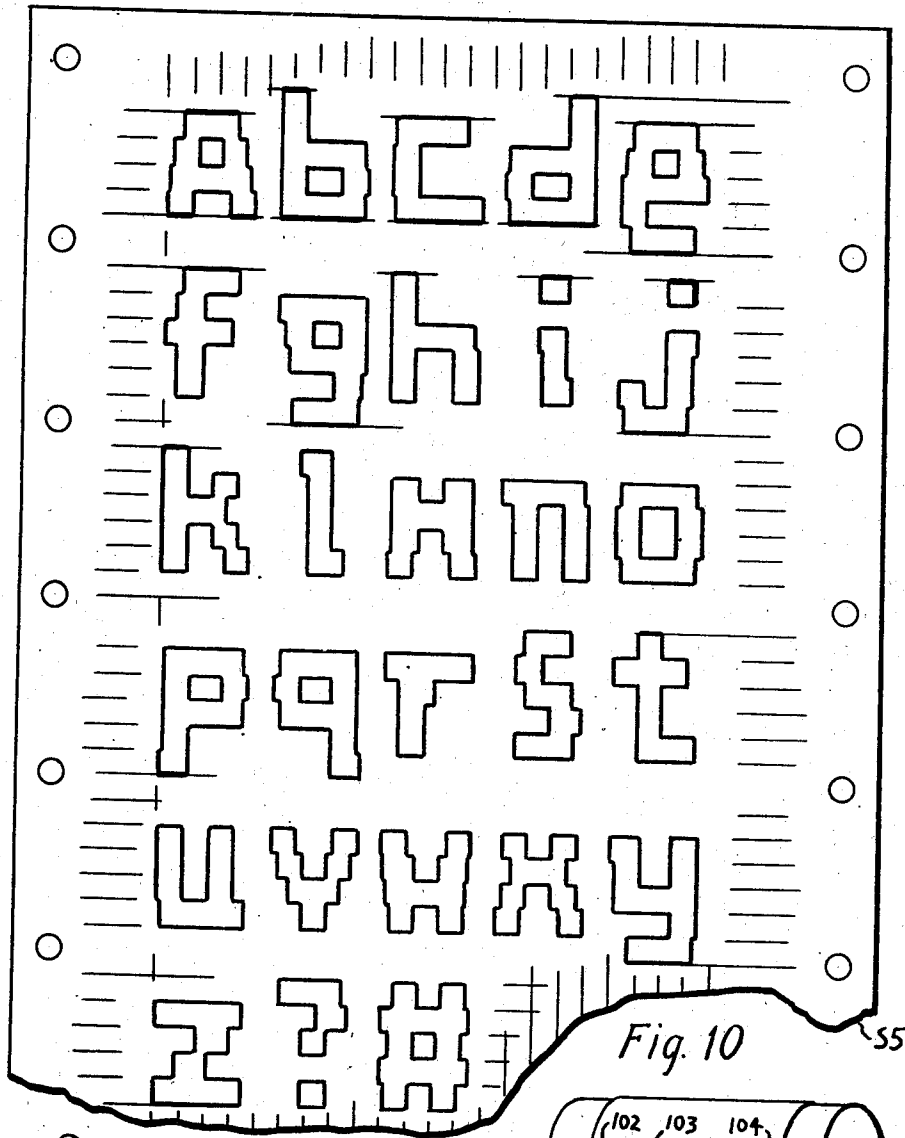
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6 Sheets-Sheet 4

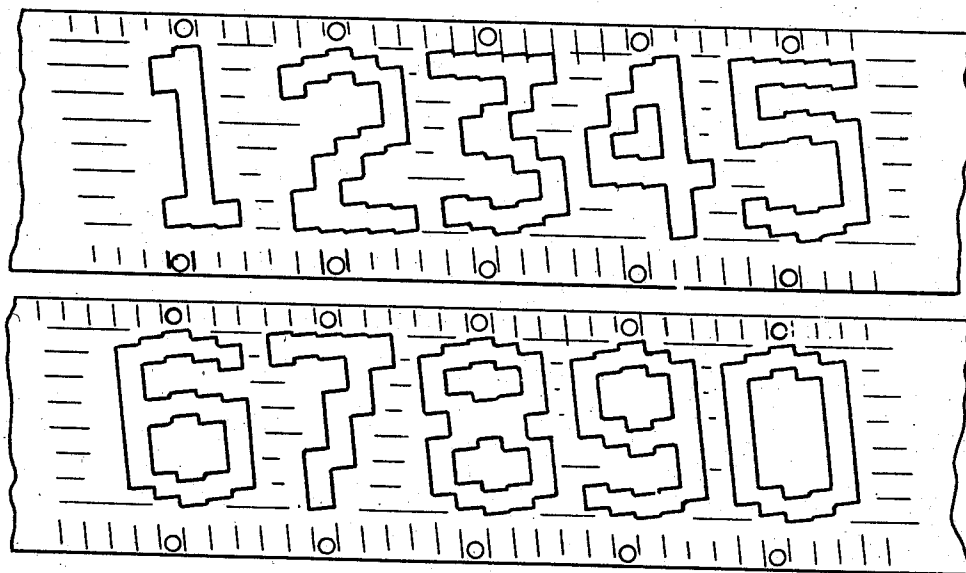
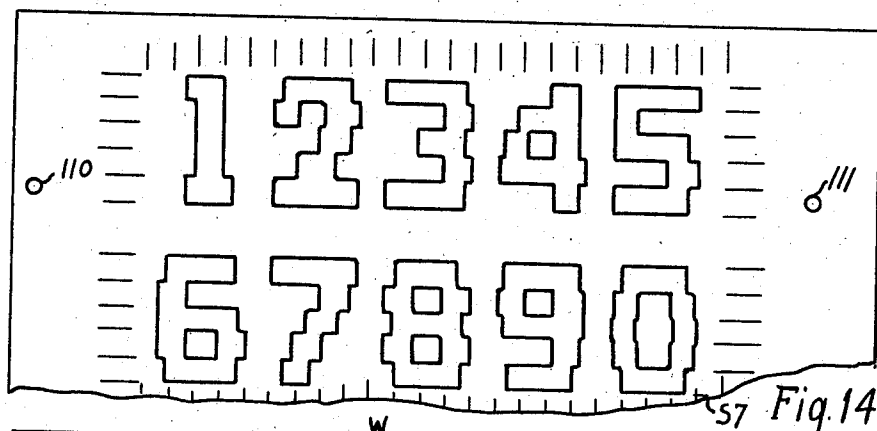


Fig. 16



57 Fig. 14

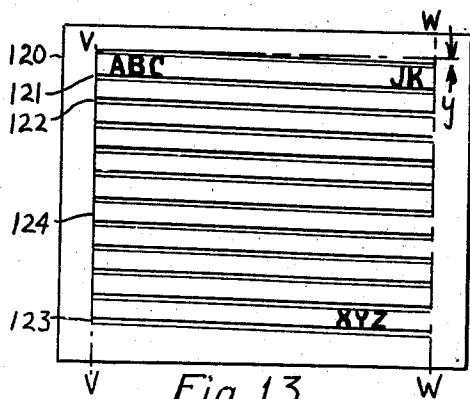


Fig. 13

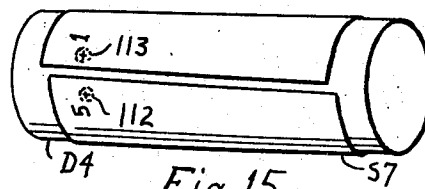


Fig. 15

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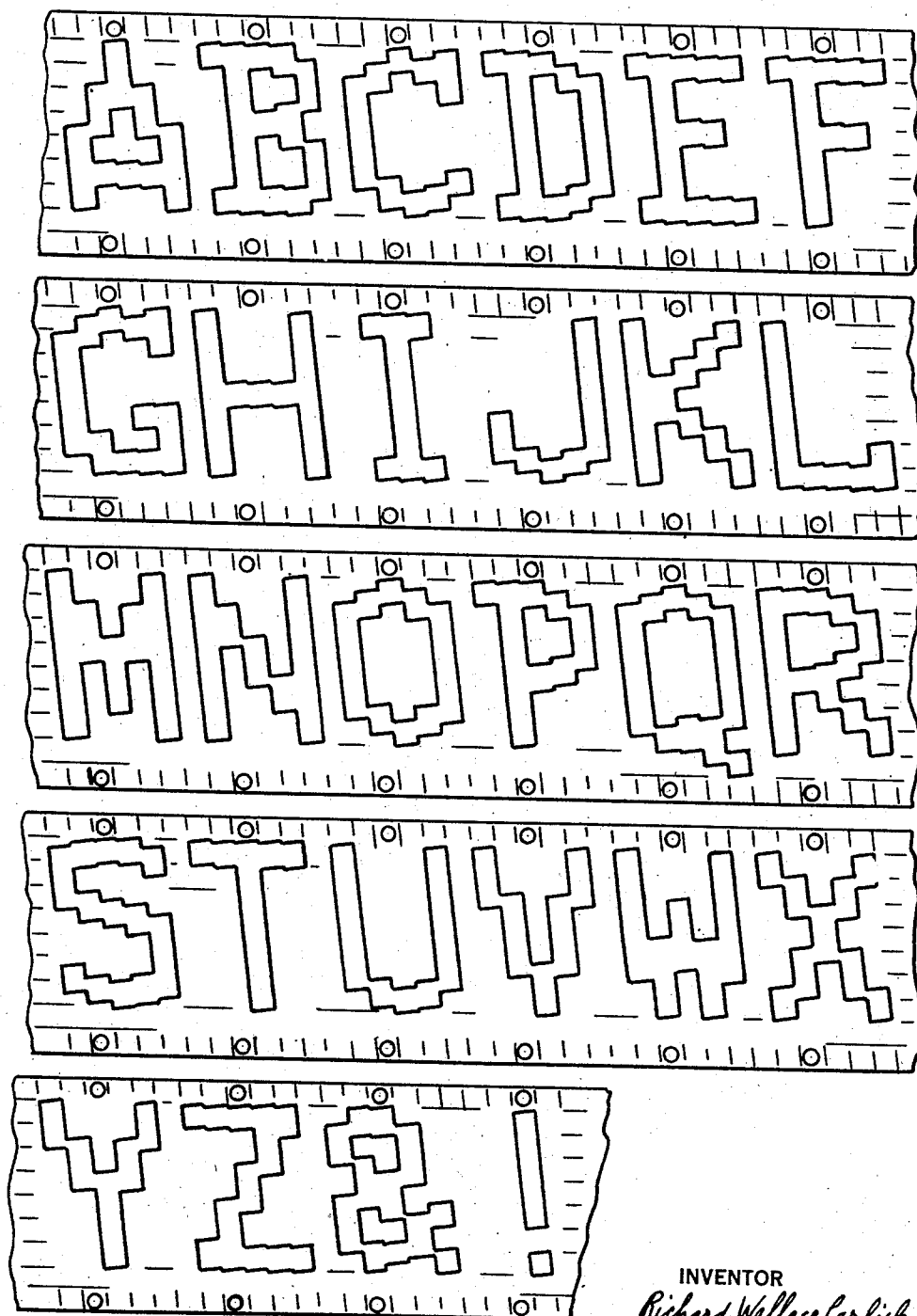
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6 Sheets-Sheet 5



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Filed May 29, 1937

6 Sheets-Sheet 6

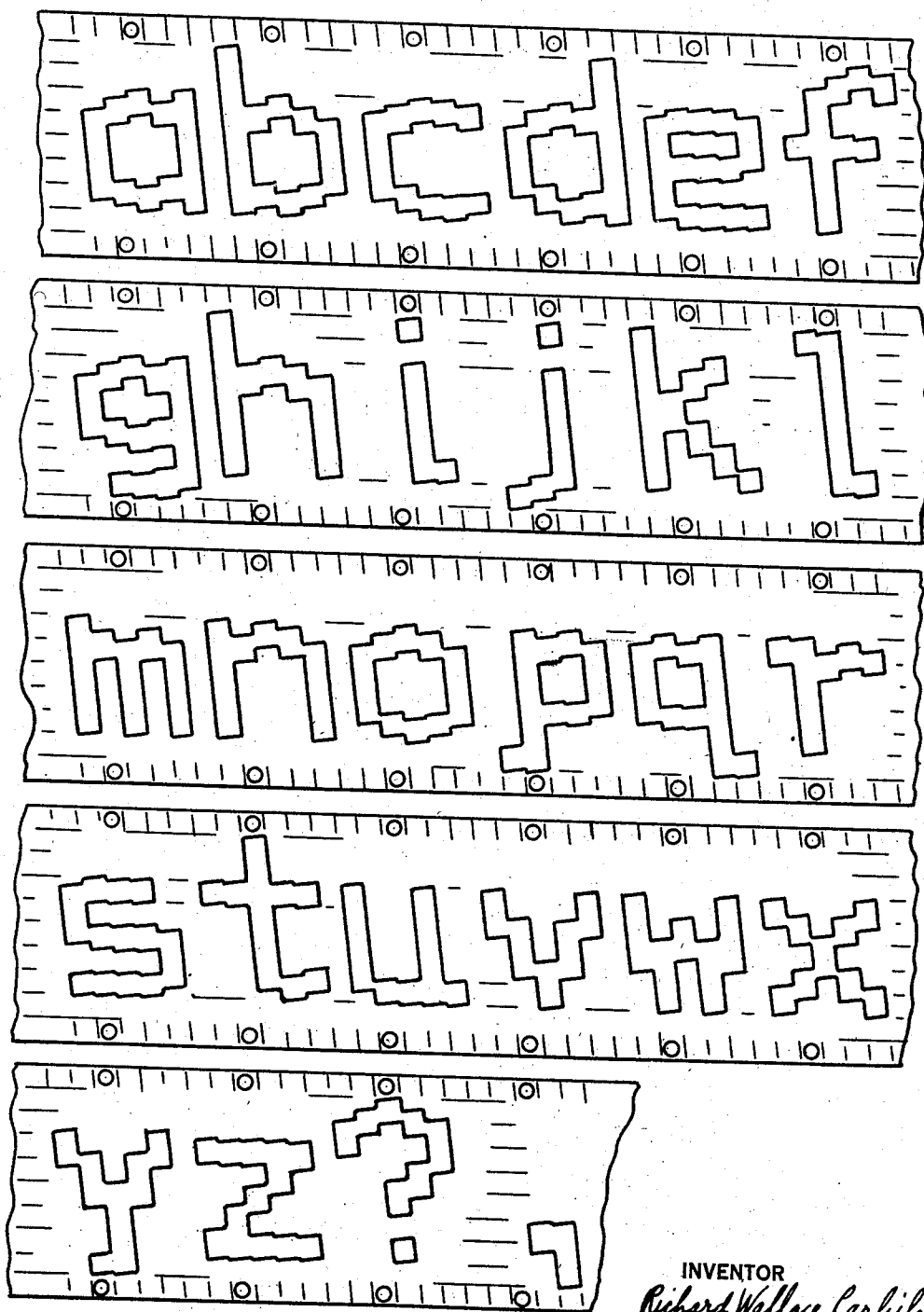


Fig. 18

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UNITED STATES PATENT OFFICE

2,210,706

FACSIMILE SYSTEM

Richard Wallace Carlisle, Elmsford, N. Y.

Application May 29, 1937, Serial No. 145,547

20 Claims. (Cl. 178—13)

This invention relates to successive-line telegraph systems, and specifically to "facsimile" and "television" systems in which very high speed of transmission of printed matter and good definition of print are desired in combination with a minimum number of scanning lines and a minimum frequency band.

It has heretofore been impractical and uneconomical to transmit matter printed on a sheet with any great speed, because the number of changes from white to black and vice versa when scanning standard type characters caused variations in electrical current which had a frequency band which was too great for transmission over standard cables, telegraph and telephone lines and radio channels designed for audio frequency signals.

It has furthermore been impossible to transmit print with high speed in a successive-line system wherein printed characters are arranged in order on a tape, for similar reasons.

It is the object of this invention to increase the print capacity of each of these systems by at least 250 percent.

It has heretofore been impossible to transmit an appreciable amount of printed material over a television system without blurring, because the number of lines or scanning bands available in each picture is very small.

It is an object of this invention to provide means for registering printed matter so as to permit scanning it with a minimum number of changes from white to black and vice versa.

It is another object of this invention to provide means whereby each line of printed matter is scanned by an integral number of scanning bands.

It is another object of this invention to provide fonts of type of such a nature that every letter is clearly delineated with a minimum number of bands of component elements.

It is another object to provide means for individually scanning each band of component elements.

Another object is to provide mechanical structures for registering sheets for printing and scanning.

Another object is to provide an optical-mechanical system for scanning a sheet in a rectangular manner.

The electrical scanning features and the recording features of apparatus utilizing my invention may be the same as those for other systems which are well-known to those skilled in the art, such as are shown in "Trans. of Pictures

over Tel. Lines" by Ives et al., Bell Sys. Tech. Jr., April 1925, Figs. 9 and 10. In these systems, type was printed on a sheet and scanned with no coordination between the formation of the type characters and their position with respect to the trace of the scanning spot. Transmitted type was blurred unless a large number of scanning lines were used per line of type.

This invention is an improvement in the method of facsimile transmission of printed type, in which special machinery is provided and special type is designed of such shape that when used in combination with this machinery, a vast improvement in speed of transmission is effected.

The various alphabets and the various methods of registering these alphabets in the track of a scanning spot which constitute the preferred embodiment of this invention may be seen from the following drawings, in which:

Fig. 1 is a plan view of a scanning drum and optical system for use with matter printed on a sheet.

Fig. 2 is an elevation of the optical system of Fig. 1 as seen from the line 2—2 in Fig. 1 and from the line 2—2 in Fig. 3.

Fig. 3 is a side elevation of the mechanism of Fig. 1, with portions of the optical system and of the drum cut away.

Fig. 4 is a perspective view of one of the clamping members used in the drum of Figs. 1 and 3.

Fig. 5 is a side elevation of a typewriter drum equipped with sprocket teeth, with a sheet mounted thereon.

Fig. 6 is a plan view of a sheet with two rows of sprocket holes along the sides, having printed thereon the enlarged outlines of the capital letters of an alphabet arranged for scanning in horizontal bands.

Fig. 7 shows a modification of a typical character of the alphabet of Fig. 6.

Fig. 8 shows another modification of a typical character of Fig. 6.

Fig. 9 shows a perspective view of a scanning drum similar to that of Figs. 1 and 3 whereon a sheet perforated as shown in Fig. 6 is mounted.

Fig. 10 shows a plan view of a sheet with one row of sprocket holes along each side, having printed thereon the enlarged outlines of the lower case letters of an alphabet arranged for horizontal scanning.

Fig. 11 shows a perspective view of a scanning drum having clamping means thereon disposed along a helical line.

Fig. 12 shows two of the clamping members used with the drum of Fig. 11.

Fig. 13 shows a plan view of a type layout for use in a scanning device.

Fig. 14 shows a plan view of a sheet having a set of numerals and a pair of registering marks printed in outline thereon.

Fig. 15 shows a perspective view of a drum having the sheet shown in Fig. 14 registered thereon.

Fig. 16 shows a plan view of lengths of tape which is provided with sprocket holes at regular intervals, and on which is printed the outlines of a set of numerals arranged in substantially vertical bands.

Fig. 17 shows a plan view of lengths of tape similar to those of Fig. 16, having capital letters printed in outline thereon.

Fig. 18 shows a plan view of lengths of tape similar to those of Fig. 16, having lower-case letters printed in outline thereon.

In the drawings, Figs. 1, 2, 3 and 4 represent a sheet scanning mechanism which exemplifies the application of my invention to methods of transmitting sheet printed matter.

I shall use the phrase "scanning width" as being the spacing between the points at which a scanning spot reaches a critical intensity value in passing from dark to light and vice versa at the edges of the lines and blocks. For example, the point at which a scanning spot reaches its critical value might be when the scanning spot is receiving only 50% of its normal light in which case the scanning width would be the same as the width of the line in the direction of scanning; but might be, for example, only 30%, in which case the scanning width would be either wider or narrower than the line width in order that the dark area and light area would cause equal half cycles for darkness and lightness when there is a series of alternate light-dark blocks of minimum width.

Sheet scanning mechanism

The sheet *S*1 on which has been printed type in specified positions as hereinafter described is mounted for scanning on the drum *D*1. This drum *D*1 is shown mounted on the shaft 1. A sprocket chain 3 causes the drum *D*1, the sprocket 2, the screw 4 and the splined shaft 5 to be driven in unison. A motor (not shown) may be connected to the sprocket 2. The carriage 6 has bearings 7 and 8 affixed thereto which slide on the splined shaft 5. It is advanced in a line parallel to the axis of the drum by means of a split nut 9 affixed to the under side of the carriage, this nut resting on the screw 4.

The cam 21 is used to control the mirror assembly 22.

The cam 21 is caused to turn with the splined shaft 5 by means of a key 23 affixed within said cam and sliding in keyway 10. The cam 21 is held from axial movement relative to the carriage 6 by means of thrust bearings, the contact surfaces of which are shown at 24 and 25. The axial position of the cam 21 is adjustable by means of the screws 26 and 27.

The arm 28 rides on the cam by means of the pressure of the spring 29. On the tip is the screw 30, by which the angle of rotation of the optical assembly 22 may be adjusted.

In normal high speed operation, several drums may be used, one being scanned while the others are being loaded. Means for changing drums quickly are therefore provided. The drum shaft 1 is removably retained in a conical bearing 31

at the right end and the slotted shaft 32 at the left end. The drum *D*1 may be removed from the mechanism of Fig. 1 by moving the handle 33 to the right. The trunnion arm 34 is pivoted at 35, and is normally held in position against the stop 36 by means of the spring 37. It is desired to register each component band of the printed characters with reference to the optical system, and in order to accomplish this the printed sheet *S*1 is supported accurately in a specific position on the drum *D*1.

In the specific embodiment illustrated in Figs. 1 and 4 and the cutaway portion of Fig. 3, there is a row of pins 40, 41 and 42 rigidly affixed to the drum *D*1, and a row of movable pins 43, 44, 45 supported within the drum on the shaft 46. These movable pins are maintained under continuous pull by springs attached to each one, as exemplified by the spring 47.

When it is desired to load or unload the sheet from the drum, the spring 47 may be extended and the pin 43 moved by the action of cam 48. Similar cam surfaces are presented to each movable pin, and all controlled by the handle 49 at the end of the common shaft 50.

In this manner the sheet is always registered (i. e., specifically disposed in predetermined relationship) with respect to the drum, and will not slide or bulge due to changes in atmospheric conditions.

Optical system

On the carriage 6 is mounted an optical system for scanning the sheet *S*1 in a predetermined manner comprised of a lamp 60 in its housing 61, lenses 62 and 63, phototube 64 in its housing 65, and mirror assembly 22.

The light from the lamp 60 is focussed upon the drum *D*1 at the point *P* by means of the objective lens 62; it is deflected to the drum from said objective 62 by means of the lower mirror *N*, and from the drum to the pickup lens 63 by means of the upper mirror *M*. Those corners of the mirrors which are nearest the drum are marked *m* and *n* respectively. These mirrors *M* and *N* are adjustably affixed to the end of shafts 67 and 68 respectively by means of the hinges 69 and 70 as shown in Fig. 2. The shafts 67 and 68 are adjustably supported in the yoke 71, as shown in Fig. 3. Shafts 67 and 68 are rigidly secured in the yoke 71 after the initial adjustment of the optical system is completed. Yoke 71 in turn is pivotally supported on the carriage 6 by means of the trunnion 72 in the carriage and the trunnion 73 in the supporting bracket 74, the latter being affixed to the carriage. The arm 28 as may be seen in Fig. 1 extends from the yoke 71 to the cam 21, so that the cam in moving said arm 28 moves said yoke 71 and thus causes both mirrors *M* and *N* to rotate back and forth. The slope of cam 21 is so proportioned that as the carriage is fed forward, the riding of arm 28 on cam 21 causes a rocking of the mirrors *M* and *N* thus imparting a movement to the light spot *P* parallel to the axis of the drum *D*1 equal and opposite to the movement of the carriage 6. Therefore, the light spot does not advance uniformly, but only in sudden steps which are caused by the movement of the arm 28 over the break in the slope of the cam 21 and are arranged to occur at the margin of the sheet *S*1 mounted upon the drum; that is, the light spot remains exactly in any given band *B* of a horizontally printed set of characters within the confines of the sheet.

Typewriter platen with sprocket teeth

It is expected that in most cases material will be printed according to an alphabet of the nature herein described in a printing mechanism which for purposes of convenience will be referred to as a typewriter.

It is one of the essential features of this invention that the printing sheet be specifically registered, i. e. accurately located, with reference to the printing means and to the scanning means.

One method of registering a sheet is to perforate it with regularly spaced apertures as shown in Fig. 10, using therewith, as shown in Fig. 5, a typewriter platen T1 equipped with sprocket teeth 80, 81, 82, 83. A sheet S2, similar in every respect to the sheet S1 shown in Figs. 1 and 10, is shown in printing position on the platen T1, with the type 84 in striking position.

After being printed with the desired impressions, the sheet S2 is removed and mounted on the drum D1 for scanning.

Sheet mounting methods

A font of type has been designed for use with the mechanism of Figs. 1 to 4. The outlines of the capital letters are shown in Fig. 6, those of the lower case letters in Fig. 10, and those of the numerals in Fig. 14, with punctuation marks shown in Figs. 6 and 10. The detailed methods of designing this font of type will hereinafter be described.

In each of these drawings each character has the common feature that it is laid out in a small integral number of component bands, each band being composed of a linear array of blocks. Each band must be specifically placed in the path of a scanning spot in order to secure the full advantages of my invention.

One method for accomplishing this, as shown in Figs. 1 to 5 inclusive, is to type characters on a sheet S2 using a platen T1 having sprocket teeth 80 to 83 which engage apertures in said sheet. The sheet is then mounted on the drum D1 with its edges parallel to an element of the drum, and scanned with a spot which by means of the rocking mirrors M and N is caused to trace exactly over each component band of the printed characters. The spot thus moves in successive planes perpendicular to the axis of the drum.

Another method of causing a scanning spot to trace exactly over each component band is indicated in Figs. 6 and 9. Here the sheet S3 is skewed and the scanning trace is moved in a helix along the drum D2.

The sheet S3, shown in Fig. 3, has two pairs of rows of sprocket holes. The outer pair AA' and BB' is perpendicular to the lines of print, and is used to register the sheet S3 on a typewriter platen as shown in Fig. 5. The inner pair CC' and DD' are inclined at an angle XYZ to the lines of print, where XZ is the width of one component band of the print and XY is the periphery of the scanning drum D2 on which the sheet S3 is to be scanned.

The cam 21 of Fig. 1 may be disconnected or eliminated altogether, and simplifications made in the mirror assembly 22 when using sheet S3. The continuous progression of the scanning trace is assured by effectively tilting the sheet S3 in front of the scanning spot, so that as the scanning spot moves continuously along the sheet S3, the end of one component band of type, such as is shown at 90 in Fig. 9 is followed co-linearly by the beginning of the next band, as shown at 91.

It is desirable to use as much as possible of the area of the scanning drum D2 for printed matter, and since the outer rows of holes AA' and BB' as shown in Fig. 6 take up space on the drum D2, it is advantageous to clip off the sheet S3 just outside of the inner row of sprocket holes before affixing the sheet on the drum. The dotted lines EE' and FF' in Fig. 6 illustrate good clipping lines. A sheet S4 printed and clipped as indicated in Fig. 6 is shown affixed to the drum D2 in Fig. 9. The sheet may be retained in position by two rows of pins, locating pins being arranged in the row 94, 95 and movable pins in the row 96, 97. Each row is parallel to an element of the drum D4, but the pins of one row are displaced longitudinally with respect to the other row by a distance equal to XZ, the width of one component band of type.

Another method of registering component bands of print with respect to a scanning mechanism is shown in Fig. 11. This system, like that of Figs. 6 and 9, requires no cam as shown at 21 in Fig. 1 and may be used with the remainder of the mechanism of Fig. 1. A sheet S5 is prepared the same as shown in Fig. 5, and is mounted directly on the drum D3. Locating pins are indicated at 100 to 101 and movable pins at 102, 103 to 104.

Each row of pins is skewed, i. e. inclined at a slight angle to an element of the cylinder in order effectively to tilt the sheet S6 with respect to the scanning spot by the same angle as described in connection with Figs. 6 and 9. A perspective view of two movable pins 102 and 103 is shown in Fig. 12.

By varying the size of the cams 104 and 105 controlling pins 102 and 103 respectively, each pin may be simultaneously controlled by a movement of the shaft 106. The mechanism is otherwise similar to that of Fig. 4.

The various cams 104, 105 are graded in size in order that the control shaft 106 may be mounted parallel to the axis of the drum D3, which facilitates assembly in manufacture.

Another method of registering a sheet with respect to a scanning drum, and one which requires no sprocket pins on the typewriter platen, is shown in Figs. 14 and 15.

At some predetermined position on the sheet S7 there is typed or otherwise imprinted a plurality of registration marks or apertures, as shown at 110, 111 in Fig. 14. The printing sheet S7 may then be removed from the typewriter and located in its correct position in a scanning device by means of the aforementioned indexing marks. This location for scanning should be such that a scanning spot will progress exactly in one component band of the print across the entire width of the sheet and then start the next component band, as described in connection with Fig. 9. In order to locate the sheet S7 on the drum D4, any one of several convenient methods may be used, such as cutting holes in the drum and affixing cross hairs therein as indicated at 112 and 113. A light may be shined through the sheet S7 from within the drum D4 in order to locate said sheet with its registration marks 110 and 111 over said crosshairs.

The improvement in scanning which is the subject of this invention cannot be secured by merely providing the equivalent of sprocket holes in a sheet, sprocket teeth on a typewriter platen and rectilinearly-disposed registration pins on a scanning drum, because all known scanners have a continuous top-to-bottom scanning movement

which causes each scanning trace to be inclined to the top edge of the sheet. Such a system would register letters only in the particular region along the line of letters where the scanning lines happened to coincide with the elemental lines of the type. For example, in a horizontally-scanned system, it might register the letters at the left end of successive lines, but not letters all the way across because some of the elemental lines comprising these letters would be displaced from the path of the scanning spot due to the continuous top-to-bottom movement thereof.

Mechanical tolerances as regards the alignment of the various component mechanical parts and sheet may be increased as the size of type is increased relative to the size of the scanning spot. There is generally no difficulty in using a scanning band width of 0.025 inch with an 0.015 diameter scanning spot.

Although great improvement can be secured in the speed of transmission of horizontally aligned characters using horizontal scanning by providing specific registration means as described above, it is often desirable to utilize vertical scanning, to which common characters are not efficiently suited. Accordingly, the principles underlying efficient character design will be set forth with reference both to horizontal and vertical scanning.

Formation of alphabet characters

Figs. 6, 10 and 14 of the drawings show one manner in which an alphabet can be concentrated with each character divided into a small integral number of component bands. In this case five component horizontal bands have been chosen for the body of each letter, and a distance equivalent to only two of these five component body bands has been chosen for the separation between lines of print. In cases where it is not required to transmit lower-case letters, since the capitals and numerals have no tails the separation between lines can be reduced to only one band.

The specific forms of characters shown in Figs. 6, 10 and 14 represent the outline form of an extremely concentrated form of alphabet, to be used when it is necessary to transmit the maximum amount of intelligence per unit of time, as in the commercial transmission of facsimile messages where an operator rather than the general public is to read the recorded letters and legibility rather than beauty of form is the primary requisite. This alphabet is also applicable in other successive-line telegraph systems where it is difficult to secure definition, as for example in television systems utilizing a small number of scanning lines when it is desired to transmit elaborate printed matter such as long subtitles or news despatches.

It has been found that to ensure a minimum number of changes from white to black and vice versa, the following rule must be followed: a standard width is established for each substantially vertical line by which each vertical line is made as thick as possible consistent with avoiding obscuring of blank spaces within a letter, and each blank space is made no narrower than the standard of width selected for said vertical lines. The standard of width selected for the vertical lines and spaces in the alphabets shown in the drawings is $\frac{1}{2}$ of the total width allotted to each letter. A space must be left between successive letters at least equal to this standard unit of width, so that the maximum space allotted to the body of any letter is $\frac{3}{4}$ of the total letter width.

The maximum width of letter body is thus $\frac{3}{4}$ or $3\frac{1}{2}$ times the unit width.

The most definite, and therefore, the clearest rendition of each letter will be accomplished in those cases where it is possible to prepare a font of type in which each character is shaped as if made from individual rectangles as here shown. If however the cost of type constructed specifically according to the outline designs of Figs. 6, 10 and 14 be excessive in any particular application, substantially the entire advantages of my invention may be derived by preparing type as shown in outline in Fig. 7, which represents the letter X of Fig. 6 with the corners of the component blocks rounded. Nearly equivalent results may be obtained by averaging the positions of the blocks, as outlined in Fig. 8, although care must be taken to avoid unduly small regions enclosed in parts of a letter. In this case an electrical wave-form equivalent to that derivable from scanning block letters of, for instance, Fig. 6, can be secured by utilizing electrical limiting devices such as that shown in Patent No. 2,005,111 to Henry Shore.

The principles of type designed set forth in my invention may be utilized either for the purpose of securing extremely high speed of transmission with fair legibility as exemplified in Figs. 6, 10 and 14 or for securing transmission much faster than with ordinary means and with perfect legibility, as exemplified by Figs. 16, 17 and 18.

The capital letters are, in general, very similar to common bold face. Some of the capitals and many of the lower case characters vary so markedly therefrom, however, that each character will be described in detail with a view towards showing the limits by which the various component parts comprising each character can be altered without losing their accuracy of definition.

In Fig. 6, "A" is comprised of two slanting lines, a bar between them and a blank space above said bar. The bar cannot be placed lower than the second line counting from the bottom; and the blank space cannot be placed next to the top line because then it would be necessary to widen out the top of the letter unduly. It is therefore necessary to place the bar in the band next to the bottom and the blank space in the band immediately above it, i. e. in the middle. The letter must be widened out at the top sufficiently to provide a width of three units in the middle, of which the center unit will comprise the open space. Laying out the letter on the basis of $3\frac{1}{2}$ units maximum width, the two lower component lines of the letter will be $3\frac{1}{4}$ and $3\frac{1}{2}$ units respectively.

"B" is comprised substantially of a vertical line on the left and an effectively curved line on the right with two blank spaces. In order to simulate the curves with rectangular blocks of color the blocks are stepped off as shown. It is optional whether the left hand vertical line should be placed at the extreme left edge of the letter, thereby allowing more space for the blank spaces or indented somewhat within the top and bottom bands in order to give the impression of serifs.

"C" has an oval shape simulated by the placement of the component rectangles. The lower right end of the loop is abbreviated as shown in order better to distinguish it from capital "G". "D", "E", "F", "G", "H", "I", "K", "L", "O", "P", "R", "S", "T", "U", "V", "X", "Y" and "Z" are designed in the same manner as "A", "B" and

"C". It may be seen that the horizontal bars of the "B", "E", "F", "H", "P", "R" and "S" are exactly in the center.

"I" has exaggerated serifs in order to distinguish it from small "i" and the numeral "1".

"Q" is shown with a serif along the base line with a special view towards utilizing it in cases where it is desired to further improve space efficiency by crowding lines of print together one above the other with only one scanning band between them.

"M" and "W" (also "m" and "w") have been simulated by special characters which have a characteristic appearance similar to that of normal letters but which lack some of the detail commonly used in standard print. These letters are properly delineated only when using at least 5 units of width, as shown in the alphabets of Figs. 17 and 18. The middle bars are suggested by a filled in region rather than delineated in detail, and the general contour of the letters accentuated by widening the top and bottom to simulate serifs where most needed. "M" has been made with vertical sides and "W" with sloping side bars in order better to distinguish one from the other.

In the lower case letters, as shown in Fig. 10, it is preferable to allocate at least five component lines for the body of the letter and at least two between lines of print, the upper one of which is utilized for the tail of letters above it.

The lower case letters shown in Fig. 10 have in many instances had to be more radically redesigned than most of the capital letters in order to fit into the small number of horizontal bands herein utilized.

For "a", it was found that a miniature reproduction of a capital "A" shape could be made with greater apparent definition than any similar sized attempt to reproduce the common lower case printed "a".

All of the lower case letters except "b", "d", "h" and "j" have been designed with bodies four bands high, i. e. extending within one band of the top; this was done either to provide more space for horizontal bars or for tails. The letters were made low, however, in the case of letters having tails on top, such as "b", "d" and "h" in order that said tails would appear more distinct.

In the cases of "i" and "j" the dots were placed on the top band. The band below said dots had to be left blank and the space below that was utilized for the remainder of the letters.

Small "e" was spread out vertically in order to make it possible to differentiate it from small "c". This is necessary in order clearly to show the central bar. The most normal appearing location of this redesigned letter is with its bottom stroke in the line below the base line, as shown.

Small "m" is indicated by a pair of inclined lines and a block in the middle which simulates the inclined lines generally used in the middle of the capital "M" but for which there is here no room available. The side walls are slanted in order to differentiate it from capital "M"; this however is not essential.

Small "s" as shown is similar to but considerably narrower than capital "S".

Small "w" is similar to small "m" but inverted relative thereto.

Small "x" is similar to capital "X" but with the top band deleted.

The design of "b", "d", "h", "i", "j", "l", "m", "n", "o", "p", "q", "r", "t", "u", "v", "y" and

"z" may be seen by inspection. Curves normally round surrounding a blank space are here shown as practically rectangular blocks.

In any case where great speed is desired and where it is desired to differentiate lower case letters from capital letters without necessarily presenting them with normal appearance, a decrease in the number of component scanning bands required per line of print can be secured by moving all letters having tails one band higher. There will then be no tails protruding below the 5-band body of print; only one band need be left between lines of print and by the elimination of one band between each line of print the effective speed will be raised one-seventh or 14%.

The numerals are designed in a manner similar to the other letters, as shown in Fig. 14.

The rules for the formation of an alphabet for vertical scanning are similar to those for horizontal scanning. A type font designed for optimum legibility is shown in outline in Figs. 16, 17 and 18. 5 component vertical bands have been chosen to represent each letter in the lateral direction, as compared to $3\frac{1}{2}$ horizontal elements used in the case of Figs. 6, 10 and 14, in order to permit symmetrical figures such as "A", "M", "m", "W" and "w" to be clearly portrayed. The width of each element in the vertical dimension is approximately $\frac{1}{4}$ of the height of the body of the characters. By sacrificing some of the delicacy of the letters, this dimension can be increased to $\frac{1}{6}$ of the body height.

Each component band of these characters has been sloped in order to avoid the necessity of using any specific means for making a scanning spot follow any given band over its entire length. To illustrate the simplicity of scanning a tape imprinted as shown, it may be mentioned that a drum similar to D1 in Fig. 1 but much smaller may be loaded with a piece of this tape and without taking any further precautions, the cam 21 may be eliminated.

Application to television

One method by which type can be set up for scanning according to the principles of this invention is to arrange a frame as shown in Fig. 13. This frame 120 is provided with parallel slots 121, 122, to 123 for holding type such as is shown in Figs. 6, 10 and 14. The frame 120 is set with said slots at the same angle γ to the horizontal as the actual scanning trace. This angle γ has such a value that its tangent is the ratio of the width of the scanning band to the total width of sheet traversed by the scanning spot. For instance, in a 441 line television system in which the width of each frame is x inches and the height $\frac{3}{4}x$ inches, the width of each scanning band is

$$\frac{3}{4} \times \frac{x}{441} \text{ inches, tangent } \gamma = \frac{3}{4 \times 441} \text{ whence } \gamma = \frac{1}{588}$$

radians or 0.098 degree. With the slots set at the above mentioned angle, the type is then set up in the frame 120 with the left edge 124 vertical, as for instance along the line VV. Further neatness of type setup may be attained by making the right hand edge vertical, as along the line WW. The angle γ has been exaggerated in Fig. 13 for the sake of illustration.

Type set up in this manner may be set directly in front of a television camera and scanned, provided care is taken to so locate it that an integral multiple of scanning traces is registered upon each component band of the characters.

In all of the drawings illustrating the various alphabet characters, said characters have been greatly enlarged in size and since the drawing is limited in size the angles of tilt such as XYZ in Fig. 6 have accordingly been much greater than is necessary in practice.

The adjustment of the vertical line of the left hand letters described in connection with Fig. 13 would also be of advantage in connection with the sheets Figs. 6, 10 and 14 when used in connection with the drums of Figs. 9, 11 and 15. Since however many more letters per line are generally used than the number shown, neglect of correcting for this angle does not generally cause appreciable distortion of the shape of the printed section.

Larger alphabets

In any case where larger letters are desired, as for artistic effects or purposes of emphasis, it will improve the definition of the print if an integral multiple of scanning bands is registered upon each component band of print.

Elaborations on the alphabet will suggest themselves to any artistic designer or designer of business forms, or the like. In the former case it may be desired to achieve artistic effect without the blurring of lines so common to ordinary artistic types; the commonest fault of artistic types is to use a crowded lower case "e" with a thin cross bar, which even in larger sizes of type is difficult for a scanning spot to delineate. Business forms may be arranged with lined squares and the like by simply causing horizontal lines to fall exactly on a scanning band. Larger sizes of type and italicized letters may be used for headlines and places where special emphasis is desired.

Comparison of maximum attainable speeds

The maximum speed with which a given type may be scanned may be calculated in the following manner, taking typewriter print as an example. The assumption will be made that means are provided according to the principles of this invention to register print in predetermined alignment with the scanning spot.

Average typewriter print is 8 units wide and 14 units high, including spaces between successive letters and successive lines. The product of the number of units of width times the number of units of height yields 112 rectangular elements per letter. An average word is generally taken as 5 letters, to which must be added the space of one letter to take account of the separation between words. The number of elements per word is therefore $112 \times 6 = 672$. Suppose it were desired to scan 60 words per minute; this would be equivalent to one word per second, or in the case of typewriter print, 672 elements per second.

According to the analysis made and described in "The Production and Utilization of Television Signals" by Gray, Horton and Mathes, Bell Sys. Tech. Jr. Oct. 1927, as summarized at the end of Section II (a), "the highest frequency required is approximately one-half the number of picture elements scanned per second," hence this requires $672 \div 2$ or 336 cycles per second. The number of words per minute which could be transmitted using a band width of say 1000 cycles is then $60 \times 1000 \text{ cycles} \div 336 \text{ cycles} = 179 \text{ words per minute}$.

Combining the above factors, it may be seen that the number of words per minute which can

be scanned using type which has been specifically registered, equals

$$60 \text{ (seconds per minute)} \times (\text{cycles band width}) \times \frac{2 \text{ (words per cycle)}}{(\text{width units}) \times (\text{height units}) \times 6 \text{ (letters per word)}}$$

If the printed matter is not specifically registered it must be scanned so closely that each critical part of the characters such as the bar of "e" is traversed by more than two scanning traces. If only two traces were used, each might lie exactly half-on and half-off the bar and thus give a very indistinct signal. In order to be conservative, it has been assumed that inexact reproduction of "e" is customarily tolerated in occasional instances, and it is accordingly assumed that the number of words per minute which can be scanned with registered print is just twice the number for unregistered print.

Various classes of type are compared in the following table, in which calculations of speed presume specific registration:

Class of type	No. of units of width req'd.	No. of scanning bands req'd.	Words per minute		
			200 cycle band	1000 cycle band	5000 cycle band
Standard typewriter (single spaced)	8	14	36	179	895
Bold face print, lower case and capitals	7	11	52	260	1300
Type shown in Figs. 16, 17, 18	6	9	74	370	1850
Type shown in Figs. 6, 10, 14	4½	7	127	635	3175
Type shown in Figs. 6 and 14 single space between lines	4½	6	148	740	3700

For the sake of comparison, it may be noted that printing telegraphs of the types well known in the art have a maximum speed of approximately 60 words per minute and utilize a frequency band of substantially 200 cycles. Long telegraph lines and poor radio channels are often limited to 200 cycles; common telephone lines and good radio channels have a band width over 1000 cycles; high quality telephone lines and ultra-high frequency radio channels have a band width over 5000 cycles.

Printed matter may be recorded at frequencies up to 5000 cycles using recording apparatus similar to that described in my co-pending application Serial No. 6,993, filed Feb. 18, 1935.

The appearance of print designed according to the principles described herein may be improved during the recording process by the use of the principles described in Patent No. 1,953,307 to Robert E. Naumberg. By these means the heaviness common to bold face type and to my own high speed designs may be relieved, and the outline of the characters accentuated.

I claim:

1. In a system for transmitting printed images, the combination of a font of type each character of which is divided into a small integral number of linearly component blocks of substantially uniform width in a scanning direction, means for printing said type on a sheet with said component blocks in register with scanning bands, a scanning mechanism, means for registering said sheet thereon and means for scanning individually said component bands.

2. A device for facsimile reproduction which comprises a typewriting machine having means thereon for accurately positioning a sheet to be printed with respect to the line of printing and having its type composed of a definite num-

ber of blocks, each lying within one of a small integral number of bands, and the letters of which have their said component blocks aligned in the same bands, a printing sheet adapted to be positioned by said positioning means in the typewriting means and a scanning mechanism having means thereon for accurately positioning a printed sheet with respect to the component bands of the print whereby to bring said bands into accurate register with the scanning spot.

3. In a scanning system, in combination, a continuous feed mechanism, an optical system comprising means for moving the point of scanning, and an intermittent mechanical action linked to said optical system and the continuous feed mechanism for simultaneously moving the scanning point transversely to the movement produced by the continuous feed mechanism and simultaneously moving the scanning point longitudinally with the movement produced by the continuous feed mechanism an amount sufficient to cause it to move backwards during each scanning line a distance equal to the forward travel of the continuous feed mechanism.

4. That improvement in the art of transmitting images of printed matter telegraphically where a scanning spot is utilized to effect analysis of the printed matter into a series of telegraphic impulses which comprises printing upon a sheet to be scanned a message to be transmitted, said print being in type, each letter of which is composed of a number of blocks, each lying approximately within one of a small integral number of bands, and the letters of which have their said component blocks aligned in the same bands, orienting the printed sheet in a scanning device, and separately scanning each of the component bands with the spot, whereby to produce telegraphic impulses in which each change of current is significant with respect to the letter being scanned and operating a device for visibly reproducing the image synchronously with the scanning spot and controlling said operation by said telegraphic impulses to reproduce the image of the message transmitted.

5. That improvement in the art of transmitting images of printed matter telegraphically as described in claim 4, in which the scanning is horizontal and a spacer line is left between adjacent lines of print.

6. That improvement in the art of transmitting images of printed matter telegraphically where a scanning spot is utilized to effect analysis of the printed matter into a series of telegraphic impulses, which comprises printing upon a sheet to be scanned a message to be transmitted, said printing being in type each letter of which is composed of a number of blocks, each lying approximately within one of a small integral number of bands, and the letters of which have their said component blocks aligned in the same bands, mounting the printed sheet on a drum, orienting the constituent bands of type parallel to the path of a scanning device, and rotating the drum and advancing the drum axially with respect to the scanning spot so that the scanning spot follows each component band whereby to produce telegraphic impulses in which each change of current is significant with respect to the letter being scanned, and operating a printer synchronously with the scanning spot, and controlling said operation by said telegraphic impulses to reproduce the image of the message transmitted.

7. That improvement in the art of transmitting printing as described in claim 6, in which the scanning spot advances into alignment with another component band at the end of each line of print.

8. That improvement in the art of transmitting printing as described in claim 6, in which the paper is skewed on the cylinder so that in one revolution of the cylinder each of the component bands has moved along the cylinder its own width, and the scanning spot advances into alignment with another component band, whereby the scanning spot follows around each component band consecutively.

9. A cylindrical drum adapted to hold a perforated edge sheet for a facsimile scanner, the drum having a row of locating devices set at a predetermined angle with an element of the cylinder for engaging the perforations of one edge of the sheet, whereby to hold the sheet at the predetermined angle.

10. A cylindrical drum as described in claim 9, in which there is a second row of locating devices arranged at the predetermined angle and movable with respect to the cylinder, and means adapted to move them as a group out of engagement with the perforations of the other edge of the sheet.

11. In a facsimile scanner the combination which comprises a scanning device for determining a scanning spot, means for holding and continuously moving matter to be scanned relative to the scanning device, and means synchronized with said relative movement to continuously advance the scanning spot with respect to the matter to be scanned and in a direction transverse to said relative movement, and means synchronized with the relative movement of the matter to be scanned, for repeatedly retrograding the scanning device with respect to the matter to be scanned equally with the advance of the advancing means, said retrograding means restoring to its initial position at the end of each line scanned, whereby to allow the advance of the advancing means to become effective all at once.

12. A combination as defined in claim 11 in which the retrograding means comprises optical means for changing the direction of motion of the scanning spot.

13. A lower case alphabet for use with a scanning system in which the letters are composed of block-like printed areas and unprinted spaces falling integrally into at least five corresponding vertically adjacent bands of width suitable for scanning, whereby when the letters are printed in words and lines said blocks and spaces fall into alignment to form scanning bands with sharply defined dark and light areas.

14. A code device for controlling a facsimile device to determine the transmission of signals which comprises a supporting surface having block-like printed areas and unprinted spaces falling integrally into at least five parallel bands of width suitable for scanning, said blocks and spaces forming letters of an alphabet.

15. A code device for controlling a facsimile device to determine the transmission of signals which comprises a supporting surface having block-like printed areas and unprinted spaces falling integrally into at least five vertically disposed bands of width suitable for scanning, said blocks and spaces forming letters of a lower case alphabet, the loops of the letters being formed in at least three of said bands, the upper exten-

sions being formed in at least one band, and the lower extensions in at least two bands below the loops.

16. A code device as defined in claim 15, in which the lower horizontal bar of the letter "e" is in one of the bands provided for lower extensions and tails whereby to leave more space in a small number of bands above the bands provided for lower extensions and tails for the remainder of said letter.
17. A font of type for use in facsimile transmission by scanning along parallel lines in which each of the letters is composed of elements conforming substantially to the outline of blocks arranged in lines aligned with the scanning lines, the width of the lines being substantially equal to a scanning line and the total height of each letter being an integral multiple of the width of a scanning line.
18. That improvement in the art of transmitting images of printed matter telegraphically where a scanning spot is utilized to effect analysis of the printed matter into a series of telegraphic impulses which comprises printing upon a sheet to be scanned a message to be transmitted, said print being in type, each letter of which is composed of a small number of blocks, each lying within one of a small integral number of bands, and the letters of which have their

said component blocks aligned in the same bands, the scanning width of the smallest spaces between blocks being approximately equal to the scanning width of the smallest blocks, orienting the printed sheet in a scanning device, and separately scanning each of the component bands with the spot, the speed of scanning being regulated so that the frequency of the telegraphic impulses approximates but is less than a maximum frequency channel available for transmission of the telegraphic impulses, and transmitting the impulses over the transmission channel to a device for visibly reproducing the image, and operating said viewing device synchronously with the scanning spot, and controlling said operation by said telegraphic impulses to reproduce the image of the message transmitted.

19. A code device as described in claim 14, characterized by having the outlines of the block-like printed areas averaged into simple shapes of characters on said supporting surface, whereby the printing of said characters is simplified without materially affecting the number of bands required for their transmission.

20. A code device as described in claim 14, characterized by having lines between groups of printed areas falling integrally into one or more bands of width suitable for scanning.

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