Dec. 18, 1962 G. C. NEWTON 3,068,767

APPARATUS FOR JUSTIFYING A LINE OF CHARACTERS

Filed Jan. 20, 1959 2 Sheets-Sheet 1

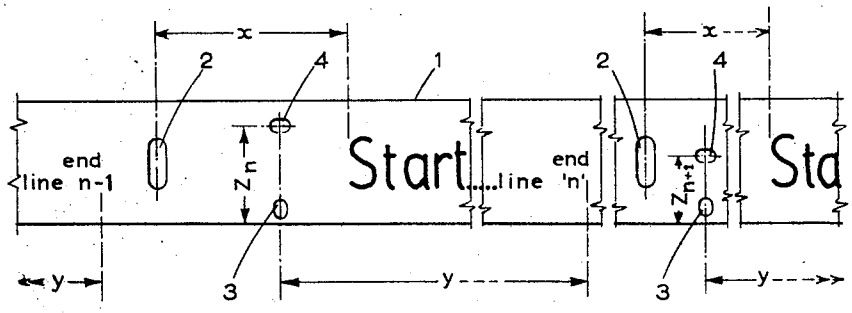


FIG. 1.

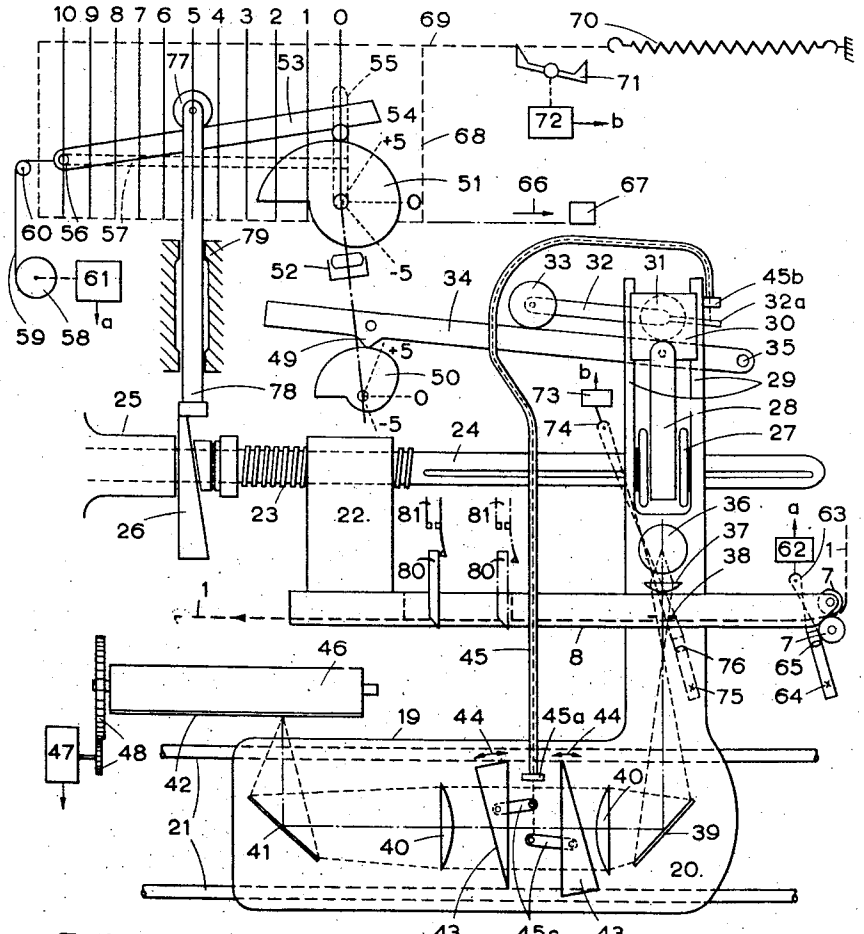


FIG. 3.

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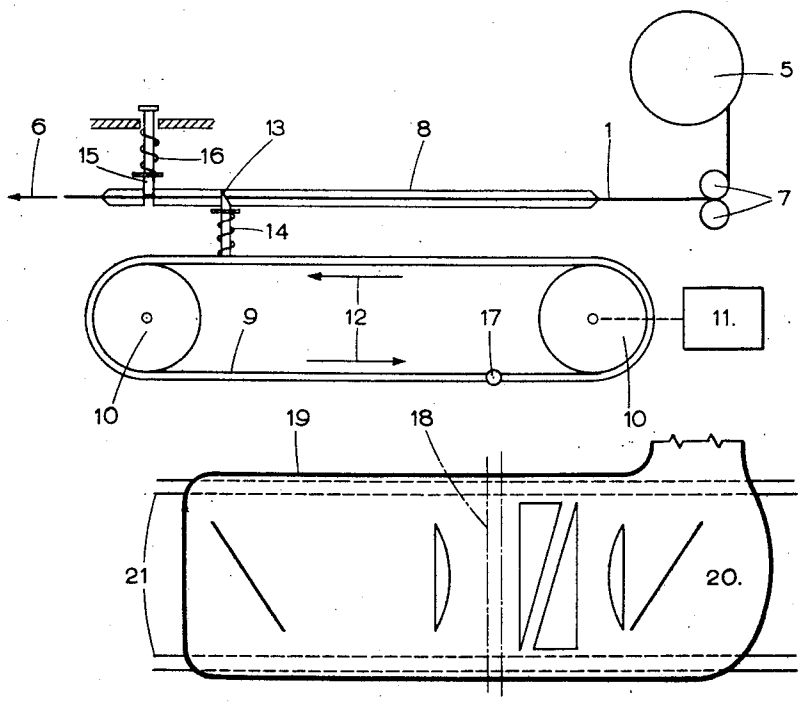


FIG. 2.

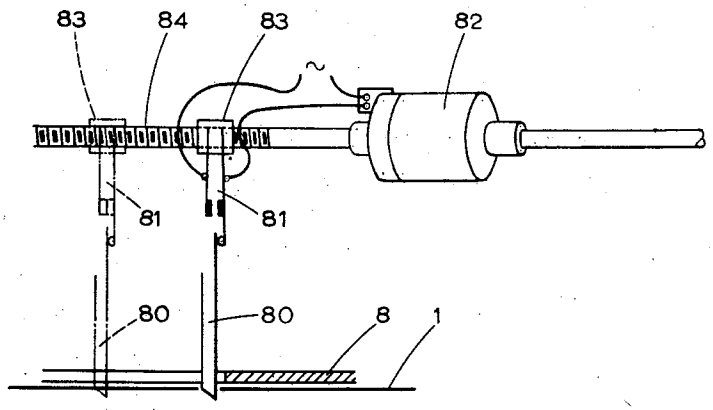


FIG. 4.

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APPARATUS FOR JUSTIFYING A LINE OF CHARACTERS

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4 Claims. (Cl. 95—4.5)

This invention relates to methods of and apparatus for justifying a line of characters.

Many different methods of justifying lines of characters have been proposed. In one such method justification is achieved by varying the lengths of the interword spaces. Another known method involves the variation of intercharacter spacing together with, if desired or necessary, variation of the interword spacing. Yet another method makes use of an optical system to produce anamorphic magnification (which may have a ratio less than, equal to, or greater than unity), whereby each complete line of characters is stretched or contracted to increase or decrease its overall length. However, none of these known methods has proved to be entirely satisfactory either because the apparatus required is unduly complex or because the result does not comply with the relatively high standards normally demanded in the printing industry. Accordingly it is the object of the present invention to provide an improved method of and apparatus for line justification whereby at least some of the disadvantages of known methods and apparatus are overcome.

According to one aspect of the invention there is provided a method of justifying a line of characters which comprises the step of applying anamorphic magnification to said line of characters in such a manner that at any time only a small portion of the length of said line of characters is subjected to said anamorphic magnification.

According to another aspect of the invention there is provided a method of justifying a line of characters which comprises the steps of applying anamorphic magnification to said line of characters and varying the relative interword and/or intercharacter spacings therein.

The invention also provides according to yet another aspect thereof apparatus for justifying a line of characters comprising an anamorphic optical system, means for transmitting through said optical system an optical image of a continuously changing small portion of said line of characters or optical images of discrete juxtaposed small portions of said line of characters so as to subject said optical image or images to anamorphic magnification, and means which serve, when said anamorphically magnified optical image or images is or are projected onto a receiving surface, substantially to eliminate any relative movement between said magnified optical image or images and said receiving surface.

An embodiment of the invention will now be described with reference to the accompanying drawings in which:

FIGURE 1 illustrates a portion of a length of tape carrying unjustified visible lines of characters along its length.

FIGURE 2 illustrates, schematically, means for moving the tape and an associated optical system,

FIGURE 3 illustrates a schematic layout of line justification apparatus according to the invention, and

FIGURE 4 illustrates mechanism for setting the cams shown in FIGURE 1.

In the embodiment to be described the lines of characters to be justified are carried in sequence along the length of a tape **1** as shown in FIGURE 1 which may

be made of a material such as that known as "Kalfax" which is manufactured by the Kalvar Corporation of New Orleans, U.S.A. The light sensitivity of "Kalfax" material extends into the ultra-violet range so that latent images of selected characters can be produced thereon by projecting ultra-violet light onto the "Kalfax" material through positive or negative representations of the characters which may be carried by a suitable matrix. Moreover latent images produced on "Kalfax" material can be developed or rendered visible very rapidly (for example in about 2 seconds) by heating the material.

The lines of characters may be produced on the tape **1** by any suitable means such as photographic type composing apparatus. Each line of characters on the tape **1** has associated therewith a "Start Of Line" indication which is shown in the form of a perforation **2** which is at a predetermined distance x along the tape from the first character in the line. FIGURE 1 shows the perforations **2** for lines n and $n+1$. Each line of characters on the tape **1** also has associated therewith an "End Of Line" indication which is located at a predetermined distance y from the last character in each line, and said "End Of Line" indication may take the form of a perforation **3**. FIGURE 1 illustrates the perforations **3** for lines n and $n+1$ at distances y from the last characters thereof. The distances x and y are constants chosen for a particular length of line, and the distance between the perforations **2** and **3** for a particular line will be a measure of the amount by which the length of that line needs to be changed for justification purposes. If the lines of characters on the tape **1** are to be converted into page form it is necessary to provide an indication as to the required "leading," i.e., the spacing between adjacent lines in accordance with the maximum height of the characters in the lines. Thus each line of characters on the tape **1** may have associated therewith a "leading" indicating which is shown in the form of a perforation **4** which is at a predetermined distance z from a reference line such as one of the longitudinal edges of the tape **1**. In FIGURE 1 the perforation **4** for line n is at a distance z_n from the bottom edge of the tape **1**, and in the case of line $n+1$ the perforation **4** is spaced from the bottom edge by a distance z_n+1. Any or all of the perforations **2**, **3** and **4** may be punched, preferably automatically, in the aforementioned photographic type composing apparatus, and the presence of one or more of these perforations for a particular line may be taken as an indication that said line has been checked and accepted. It follows, therefore, that if, for example, one or both of the perforations **2** and **3** from which the amount of required justification is derived is/are missing, this omission may be taken as an indication that the associated line of characters is to be rejected.

Instead of providing a "leading" indication in the form of a perforation **4** which is located at a predetermined distance from one of the longitudinal edges of the tape **1**, the perforation **4** for a particular line of characters may be located at a predetermined distance along the tape **1** from the perforation **2** associated with that line of characters, and preferably in this case the perforations **2**, **3** and **4** for each line are located at different fixed predetermined distances from one of the longitudinal edges of the tape **1**, and these different fixed distances are the same for each line of characters.

Referring to FIGURE 2, the tape **1** is stored on a spool **5** from which it is unwound in the direction of arrow **6** to pass between guide rollers **7**, and then through an elongated gate **8** having longitudinal flanges for guiding the tape **1** and being provided with a window long enough to accommodate and expose the longest line of characters

and wide enough to accommodate characters of maximum height. Any suitable means which may include another spool similar to the spool **5** is provided to wind-up and receive the tape **1** after it has passed through the gate **8**.

The tape **1** is withdrawn from the spool **5** and moved into the gate **8** by an endless belt **9** which passes around a pair of spaced pulleys **10** at least one of which is driven continuously at a constant speed such as by an electric motor shown diagrammatically by the reference **11** so that the belt is driven in the direction of the arrows **12**. The belt **9** carries a claw **13** which is urged outwardly by a spring **14** so that the claw **13**, having made contact with the tape **1** beyond the right-hand end of the gate **8**, will ride over the surface of the tape **1** until it locates an "End Of Line" perforation **3** whereupon the spring **14** will cause the claw **13** to enter the perforation **3**, so that the tape **1** is moved by the belt **9** through the gate **8**. Associated with the gate **8** is an arresting claw **15** which is urged downwardly by a relatively strong spring **16**. When the belt **9** has reached a position at which the claw **13** is substantially aligned with the claw **15**, the latter is tripped and causes the claw **13** to become disengaged from the perforation **3** in the tape **1**, whereafter the tape **1** is held stationary in the gate **8** by the claw **15**, and the claw **13** continues its movement with a belt **9**.

The belt **9** also carries a pin **17** which is normally engaged in a slot **18** provided in a casing **19** of an optical carriage **20** which is guided for rectilinear movement by means of guide bars **21**. It will be seen, therefore, that as the tape **1** is moved into the gate **8** in the direction of the arrow **6**, the carriage **20** is simultaneously moved in the opposite direction towards its starting position in alignment with or beyond the last character of a line of characters on the tape **1**. When the claw **13** has become disengaged from the tape **1** and the pin **17** passes around the right-hand pulley **10**, the carriage **20** will reverse its direction of movement and commence to move in the direction of the arrow **6**.

In FIGURE 3 the belt **9** and the driving means therefor have been omitted for the sake of clarity. The gate **8** is coupled to a lead screw **23** by means of a nut **22** which is secured to the gate **8** and is in operative engagement with the lead screw **23** which has a splined extension **24**. The lead screw **23** is rotatably mounted in a bearing **25** but the arrangement is such that translational movement of the lead screw **23** with its extension **24** in the direction of the axis of the lead screw **23** can be effected so as to move the lead screw **23** into and out of the bearing **25**. The lead screw **23** is urged by a spring (not shown) to the left as viewed in FIGURE 3 and means for effecting said translation movement is provided by a wedge **26** which can be moved transversely of the longitudinal axis of the lead screw **23** and thus serves to control the position of the lead screw **23** relatively to the bearing **25**.

The splined extension **24** of the lead screw **23** passes through a reel **27** which has wound thereon a flexible tape **28** perferably made of spring steel. The reel **27** is mounted between arms **29** forming part of or secured to the carriage **20**. Coupled to the reel **27** is a spring (not shown) which tends to wind up the tape **28**. Also the reel **27** engages the spline or splines in the extension **24** so that if the tape **28** is withdrawn from the reel **27**, the consequent rotation of the latter is imparted to the extension **24** and hence to the lead screw **23**. When, however, the tape is rewound on the reel **27** due to the force of the aforementioned spring, the extension **24** and the lead screw **23** are rotated in the opposite direction. The free end of the tape **28** is joined to a slide **30** which is guided by the arms **29** of the carriage **20**. The slide **30** supports a roller **31** which is coupled by a link **32** to another roller **33**, the rollers **31** and **33** being arranged to run along the edge of a first lever **34** which is pivotally mounted on a fixed pivot **35**. The carriage **20** houses scanning means including a suitable source of radiation **36** which is focussed by a lens **37** to project a narrow rectangular beam through the tape **1** via a mask **38**. When it reaches the tape **1**, the beam has one dimension which is at lease equal to the maximum height of the characters on the tape **1** and the other dimension is equal to a small proportion of the length of a line of characters on the tape **1** such as ⅛" or less, so that as the carriage **20** is moved relatively to a line of characters on the tape **1** only an elemental portion of the line of characters is scanned at any instant. The preferred width of the scanning beam is such that each elemental portion of the line has a width which, in general, will be not greater than the space between adjacent words in the line of characters. An optical image of a continuously changing small portion of a line of characters is thus projected from the tape **1** and this optical image is reflected through an angle of 90° by a mirror **39** to an objective comprising spaced plano-convex lenses **40** between which is disposed an anamorphic optical system comprising, in the present embodiment of the invention, a pair of triangular prisms **43** which, as shown in FIGURE 3, have relatively small apical angles the prisms **43** being spaced from each other in the direction of the optical path along which said optical image is transmitted. The prisms **43** are arranged with their apical edges parallel to one another and on opposite sides of said optical path. Said optical image, after subjection to anamorphic magnification (if required) by the prisms **43** is reflected through an angle of 90° by another mirror **41** so that said optical image is directed to a receiving surface **42** sensitive to the radiation from the source **36**, so that a latent image of said optical image can be produced on the surface **42**.

The surface **42** may be provided by a roll of material such as the aforementioned "Kalfax" which has a width at least equal to the maximum length of a justified line of characters, and which is supported by suitable means, for example, in a rotatably mounted magazine **46**. An electric motor or other suitable means shown diagrammatically at **47** is provided to rotate the magazine **46**, so that the surface **42** can be positioned in such a manner that latent images are produced at appropriate locations on the surface **42**. The motor **47** is coupled to the magazine **46** by gearing **48**. It will be appreciated that if desired the supporting means constituted by the magazine **46** could be moved bodily to determine the location of the latent images on the surface **42**, instead of moving the surface **42** relatively to the magazine **46**. If the surface **42** is of "Kalfax" material the source of radiation **36** will be such as to produce predominately ultraviolet radiation and the optical components will be such as to transmit or reflect this radiation efficiently.

The first lever **34** is so coupled to a first setting member in the form of a rotatable snail cam **50** so that the angular disposition of the first lever **34** depends on the setting of said first member, that is to say, the angular disposition of the cam **50**. As shown, the lever **34** has a protuberance **49** which functions as a cam follower. The arrangement is such that variation of the angular disposition of the lever **34** causes a similar variation of the angular disposition of the link **32**, and means is provided to adjust the angular dispositions of the prisms **43** equally and oppositely in accordance with the setting of the cam **50**, which determines the angular disposition of the link **32** and hence of the lever **34**. Said means may comprise a Bowden cable **45**, the sleeve of which is secured at opposite ends to fixed points **45*a*** and **45*b*** on the carriage **20** and the slide **30** respectively, whilst one end of the inner wire is joined to levers **45*c*** coupled to the prisms **43** and the other end of the inner wire is joined to an extension **32*a*** of the link **32**. Each of the prisms **43** is mounted for rotation about an axis parallel to its apical edge, and since the prisms **43** are coupled to the cam **50** through the levers **45*c***, the cable **45**, the link **32**, and the lever **34**, it follows that alteration of the angular disposi-

tion of the cam **50** causes rotations of the prisms **43** by substantially equal and opposite amounts.

The shape of the cam **50** is such that its radius varies from a minimum indicated by the dotted radial line labelled —5 to a maximum indicated by the dotted radial line labelled +5, but beyond the arc between the radial lines —5 and +5 the radius of the cam **50** is unchanged except of course at the region where the minimum and maximum radii meet. A second setting member in the form of another rotatable snail cam **51** is coupled to the cam **50** by a universal and sliding joint **52** so that the cams **50** and **51** are coupled for simultaneous rotary adjustment. The radius of the cam **51** is constant over the arc between the dotted radial lines labelled +5 and —5 but beyond the radial line +5 the radius of the cam **51** increases to a maximum, and beyond the radial line —5 the radius of the cam **51** decreases to a minimum. A second lever **53** is arranged in co-operative relation with the cam **51** in such a manner that the lever **53** follows the cam **51** through the intermediary of a rollar **54** which is constrained to vertical rectilinear movement by a slot **55**. It will be seen that when the cams **50** and **51** are simultaneously rotated through a predetermined arc between their positions indicated by the dotted radial lines labelled +5 and —5, the angular disposition of the lever **34** will be changed, but during this movement of the lever **34** there will be no change in the angular disposition of the lever **53**. If, however, the cams **50** and **51** are simultaneously rotated beyond their +5 or —5 positions no further change in the angular disposition of the lever **34** will occur, but there will be a change in the angular disposition of the lever **53**.

The lever **53** has its fulcrum provided by a pivotal mounting **56**, but relative displacement between the lever **53** together with its pivot **56** and the cam **51** can be effected along a rectilinear path defined by a slot **57**. The lever **53** together with its pivot **56** are coupled to a drum **58** by a cord or wire **59** which is guided by a roller or pin **60**, and mechanism for imparting said relative displacement step-by-step is indicated diagrammatically at **61**, this mechanism functioning to move the lever **53** together with its pivot **56** by equal steps relatively to a zero line indicated in FIGURE 3, in which the lever **53** together with its pivot **56** are shown as having been displaced by ten equal steps relatively to the cam **51** which is disposed with its axis coincident with said zero line. The mechanism **61** is energized to cause a single-step displacement of the lever **53** together with its pivot **56** each time an electrical impulse is fed to the mechanism **61** in response to the detection of an interword space in a line of characters on the tape **1**. Means for detecting interword spaces includes a relay **62**, a light-sensitive device **63** such as a photo-electric cell or a photo-transistor, a source of radiation **64**, and a lens **65**. The radiation from the source **64** is focused by the lens **65** onto the tape **1** as it enters the gate **8**, and the radiation which passes through the tape **1** impinges on the device **63**, the arrangement being such that a maximum response sufficient to energize the relay **62** so as to feed an electrical impulse to the mechanism **61** is obtained from the device **63** only when the portion of the tape **1** through which said radiation passes does not carry a visible character image or a portion thereof, the length of the portion of the tape **1** affected being greater than any inter-character space but less than any interword space so that the number of impulses fed to the mechanism **61** is equal to the number of interword spaces in a line of characters on the tape **1** to be justified. When these impulses are fed to the mechanism **61** as indicated by the connection *a*, the lever **53** together with its pivot **56** are displaced to the left as viewed in FIGURE 3 away from the cam **51** by a number of equal steps corresponding to the number of interword spaces detected in a line of characters on the tape **1**.

Means are provided for effecting relative movement between that portion of the apparatus including the cam **51** the lever **53** together with its pivot **56**, the roller **54** and the means **58**—**61** for displacing the lever **53** together with its pivot **56** on the one hand, and means coupling the lever **53** to the wedge **26** on the other hand. For this purpose the dotted rectangle **68**, which represents a carrier for said portion of the apparatus, is linked by a chain **69** to a tension spring **70**. A pivoted pawl **71** co-operates with the chain **69** to permit the carrier **68** to be displaced by the spring **70** by equal steps in the direction of the arrow **66** towards a stop **67** each time the pawl **71** is rocked by suitable mechanism such as an electromagnet **72** in response to successive electrical impulses fed thereto, said steps being equal in amplitude to the steps by which the lever **53** together with its pivot **56** is displaced by the mechanism **58**—**61** but in the opposite direction. As indicated by a connection *b*, the electromagnet **72** receives electrical impulses from means for re-detecting the interword spaces in a line of characters on the tape **1** as the line is scanned by the scanning means **36**, **37** and **38**. Said re-detecting means includes a relay **73**, a lgiht-sensitive device **74** such as a photo-electric cell or a photo-transistor, a source of radiation **75**, and a lens **76**. As with the device **63**, the device **74** produces a maximum response sufficient to energize the relay **73** only when there is an interword space in the portion of the tape **1** through which the radiation from the source **75** passes to the device **74**, and it will be noted that the portion of the tape **1** through which the radiation from the source **75** passes is coincident with or overlaps the portion of the tape **1** through which the radiation from the source **36** is projected. The device **74** and the associated optical system **75**, **76** move with the carriage **20** and if desired these components may be mounted in or on the carriage **20**. As each interword space in a line of characters on the tape **1** is re-detected, the electromagnet **72** is energised to rock the pawl **71** so that the carrier **68** is displaced step-by-step towards the stop **67** in accordance with the number of interword spaces re-detected.

It has been assumed that the visible character images on the tape **1** are opaque and that the remainder of the tape **1** is transparent or translucent, but clearly the character images could be transparent or translucent on an opaque background of the tape **1** in which case the relays **62** and **73** would be arranged to be energised in response to minimum outputs from the devices **63** and **74**.

Means for coupling the second lever **53** to the translating means provided by the wedge **26**, comprises a roller **77** arranged to run along the upper edge of the lever **53**, and a rod **78** which links the roller **77** to the wedge **26**, the rod **78** being guided for rectilinear movement perpendicularly to the axis of the lead screw **23** and to the length of the slot **57** by means of a bearing **79**. Thus when the angular disposition of the lever **53** is such that the lever **53** is inclined with respect to the slot **57**, and when the carrier **68** is moved towards the stop **67**, the wedge **26** will be moved transversely of the axis of the lead screw **23** thereby to effect translational movement of the lead screw **23**, together with the nut **22** and the gate **8**, relatively to the stationary bearing **25**, so that relative movement will be effected between a line of characters on the tape **1** held in the gate **8**, and the receiving surface **42**.

A claw **80** (see FIGURES 3 and 4) is disposed at a starting position in the gate **8** in alignment with the position which would be reached by a perforation **2** (see FIGURE 1) associated with a line of characters of minimum length on the tape **1** when that line of characters has been correctly positioned in the gate **8**. The claw **80** is biassed as by a spring (not shown) to enter the perforation **2**, and if the line of characters is longer than the minimum length, the claw **80** is carried along with the tape **1**. The claw **80** co-operates with a pair of electrical contacts **81** which control the energisation of a servo-motor **82** (FIGURE 4). The contacts **81** are mounted on a nut **83** cou-

pled to a screw 84 which rotates with the motor 82. Also the motor 82 is coupled to the universally-jointed shafts by means of which the cams 50 and 51 (FIGURE 1) are rotatably mounted. If the claw 80 is moved by the tape 1, the contacts 81 (which are normally held open by the claw 80) are allowed to close and the motor 82 is energized to rotate in a direction such that the nut 83 follows the movement of the claw 80 and the cams 50 and 51 are rotated from their "minimum" or starting positions, that is to say, their positions at which the cam follower 54 most closely approaches the shaft of the cam 51. When a line of characters on the tape 1 (and hence the perforation 2 associated therewith) reaches its final position in the gate 8, as already explained with reference to FIGURE 2, the movement of the claw 80 will cease at a position such as that illustrated in full-lines in FIGURE 3 and dotted lines in FIGURE 4, but the motor 82 will continue to rotate until the nut 83 carries the contacts 81 to a position at which they are opened by the then stationary claw 80. The distance between the starting and final positions of the claw 80 is proportional to the amount by which the line of characters on the length of the tape 1 in the gate 8 requires to be changed in order for the line to be justified. Since the amount of rotation imparted to the cams 50 and 51 by the motor 82 is proportional to the distance between the starting and final positions of the claw 80, it will be seen that the cams 50 and 51 will have been set in accordance with the required amount of justification whether it be positive (i.e. lengthening of the line) or negative (i.e. shortening of the line).

A further claw (not shown) is arranged to engage the "leading" perforation 4 associated with the line of characters held in the gate 8. As the tape 1 comes to rest in the gate 8 said further claw, which functions as a means responsive to a "leading" indication 4, is moved transversely of the tape 1 from a position corresponding to zero "leading" until the perforation 4 is engaged. The distance through which said further claw travels is arranged to be proportional to the amount by which the surface 42 is required to be moved between the justification of successive lines of characters in order that said lines, after subjection to anamorphic magnification, are directed to appropriate locations on the surface 42 so that the justified lines of characters will be properly spaced beneath one another in page form on the surface 42. The "leading" information derived from a perforation 4 for a particular line of characters may be converted in any suitable manner to an electric signal and fed to the motor 47 which thereupon rotates the magazine 46 to move the surface 42 by an appropriate amount. Alternatively said further claw could be mechanically coupled to the magazine 46 to produce the same result.

The operation of the apparatus according to the illustrated embodiment of the invention will now be described.

The claw 13 (FIGURE 2) which at the commencement of an operational cycle is passing around the right-hand pulley 10, engages the perforation 3 associated with a line of characters on the tape 1 to be justified, whereupon the tape 1 is moved in the direction of the arrow 6 until the arresting claw 15 is tripped so that the claw 13 is caused to become disengaged from the tape 1 and the claw 15 holds the tape 1 with the line of characters in correct position in the gate 8. As the length of the tape 1 moves into the gate 8, the number of interword spaces is detected by the device 63 whereupon the lever 53 together with its pivot 56 are moved by the mechanism 61 by a corresponding number of equal steps. Also as the length of the tape 1 enters the gate 8, the claw 80 engages the perforation 2 and (assuming that the line of characters exceeds a predetermined minimum length) the claw 80 is carried along by the tape 1 so that the motor 82 is energized to rotate the cams 50 and 51 to an extent proportional to the required amount of justification. The rotation of the cams 50 and 51 causes appropriate changes in the angular dispositions of the levers 34 and 53 respectively, the final angular disposition of the lever 34 with respect to the carrier 20 and the axis of the lead screw 23 being proportional to the amount of anamorphic magnification of the line of characters to be effected, that is to say, the amount by which the line of characters is to be stretched or contracted lengthwise for justification purposes. Such anamorphic magnification causes some distortion of the characters, because the widths of the characters are changed relatively to the heights thereof and hence there is a limit to the amount of anamorphic magnification which can be accepted. For the purposes of the present embodiment of the invention it is assumed that anamorphic magnification can be applied to limits at which the line of characters is lengthened or shortened by 5% of its original length. These limits are indicated by the +5 and −5 radial lines associated with the cam 50. If the required amount of justification exceeds one of these limits then the excess justification is achieved in the present embodiment of the invention by variation of the interword spacing. Thus the angular settings of the cams 50 and 51 and hence the angular dispositions of the levers 34 and 53 shown in FIGURE 3 indicate that justification of the line of characters on the tape 1 requires elongation in excess of 5%, this excess elongation being represented by the angular disposition of the lever 53 with respect to the length of the slot 57.

As the length of the tape 1 moves into the gate 8, the carriage 20 moves to the right as viewed in FIGURE 3, but after the tape 1 comes to rest in the gate 8 the pin 17 moves around the right-hand pulley 10 and the carriage 20 reaches its starting position in alignment with or beyond the last character in the line, and commences to move to the left whereupon either the source of radiation 36 is energized and/or a shutter (not shown) is opened, so that an optical image of a first elemental portion of the line of characters (which as previously described may be ⅛" or less in width) is transmitted through the anamorphic optical system including the prisms 43 to the surface 42, which as previously explained has been appropriately positioned in response to information derived from the "leading" perforation 4 in the tape 1. If, when a line of characters on the tape 1 is scanned due to movement of the carriage 20 to the left as viewed in FIGURE 3, the gate 8 (and hence the line of characters held therein) were to remain stationary with respect to the receiving surface 42, then any change in the length of the optical image of an elemental portion of the line of characters produced by the anamorphic optical system would result in relative movement of the anamorphically magnified optical image with respect to the surface 42. However, in accordance with the present invention, such relative movement is substantially eliminated by means which serve to cause compensatory relative movement in the opposite sense between the line of characters on the tape 1 and the receiving surface 42 in accordance with the setting of the cam 50. Thus, as the carriage 20 moves to the left relatively to the line of characters on the tape 1 and the surface 42, the rollers 31 and 33 run along the lever 34, the angular disposition of which is determined by the setting of the cam 50, whereby the slide 30 is moved away from the reel 27 thus causing the tape 28 to unwind so as to rotate the reel 27. It will be appreciated that the lever 34 is coupled to the lead screw 23 by the rollers 31 and 33, the link 32, the slide 30, the tape 28, the reel 27 and the splined extension 24. Thus rotation of the reel 27 effects rotation of the lead screw 23 and the direction of rotation imparted to the lead screw 23 is determined in accordance with the inclination of the lever 34 with respect to the axis of the lead screw 23. Thus with the lever 34 upwardly inclined as shown in FIGURE 3, the direction of rotation imparted to the lead screw 23 is such that the nut 22 is moved to the left as viewed in

FIGURE 3 so that the gate 8 and the line of characters on the tape 1 held therein are also moved bodily to the left lengthwise of the line of characters and relatively to the carriage 20 and the surface 42. This relative movement is so correlated to the degree of anamorphic magnification produced by the anamorphic optical system in accordance with the angular dispositions of the prisms 43 (as determined by the setting of the cam 50) that the anamorphically magnified image of an elemental portion of the line of characters as transmitted to the surface 42 remains substantially stationary with respect to the surface 42.

When the carriage 20 has moved to the left to an extent sufficient to scan the whole of the first word or group of characters in the line encountered by the scanning beam so that an interword space is reached, the latter is re-detected by the device 74 so that the pawl 71 is rocket to allow the spring 70 to withdraw the carrier 68 by one step, whereupon the lever 53 moves relatively to the roller 77, and if, as illustrated in FIGURE 3, the lever 53 is inclined with respect to the length of the slot 57 thus indicating that excess justification is to be achieved by variation of the interword spacings, the roller 77, the rod 78 and the wedge 26 are moved transversely of the longitudinal axis of the lead screw 23 in one direction or the other depending on whether the interword spaces are to be shortened or lengthened When, as in the example illustrated in FIGURE 3, the cam 51 is set beyond its +5 position, the lever 53 will be upwardly inclined with respect to the slot 57 pursuant to the requirement that the interword spaces are to be lengthened. Thus, as the carrier 68 is moved towards the stop 67, the wedge 26 is allowed to move downwardly as viewed in FIGURE 3 by the force of a spring (not shown). This movement of the wedge 26 results in translational movement of the lead screw 23 in the direction of its axis toward the left as viewed in FIGURE 3. This movement of the lead screw 23 is transmitted by the nut 22 to the gate 8 and the line of characters on the tape 1 held therein, but the splined coupling between the extension 24 of the lead screw 23 and the reel 27 allows this movement to take place relatively to the carriage 20. As the carriage 20 is moving continuously to the left, the effect of movement of the line of characters to the left is to expand the interword space. It should be noted that the wedge 26 normally occupies an intermediate position relatively to the lead screw 23 so that depending on whether the interword spaces are to be expanded or contracted the wedge is moved down or up as viewed in FIGURE 3 so that the gate 8 and the line of characters on the tape 1 are moved to the left or to the right.

As the movement of the carriage 20 to the left continues, an elemental and gradually changing portion of the line of characters on the tape 1 is scanned and the anamorphically magnified image thereof is projected to the surface 42. As each interword space is re-detected by the device 74, the gate 8 with the length of tape 1 therein is moved to the left so that each interword space is expanded by a constant proportion determined by the inclination of the lever 53. In FIGURE 3 the apparatus is shown in a position in which ten interword spaces have been detected by the device 63 (so that the lever 53 together with its pivot 56 have been displaced to the left relatively to the cam 51 by ten equal steps) and the fifth interword space has been re-detected by the device 74 so that the carrier 68 has been displaced through five equal steps towards the stop 67. Finally, after the complete line of characters has been scanned and a justified image thereof has been produced on the surface 42, the carriage 20 eventually reaches the end of its travel to the left, whereupon the length of the tape 1 in the gate 8 is released by withdrawal of the claw 15, the justification claw 80 and the further claw which engaged the perforation 4. At this time the source 36 is extinguished and/or a shutter associated therewith is closed. The withdrawal of the claw 80 is arranged to cause the motor 82 to be energized so that the claw 80 and the cams 50 and 51 are rotated to their starting positions. Also the cam 51 is moved bodily to a starting position in which it is approximately in line with the roller 77 and the pivot 56. It should be noted that during this bodily movement of the cam 51, the carrier 63 moves to the lift as viewed in FIGURE 3 relatively to the lever 53 and the roller 77, and hence it is desirable to arrange that the pawl 71 only controls movement of the carrier 68 in the direction of the arrow 66. When the cam 50 has been rotated to its starting position, the lever 34 will be downwardly inclined from right to left and the prisms 43 will be angularly disposed for the production of maximum negative anamorphic magnification, that is to say, maximum linear contraction of the image of an elemental portion of a line of characters.

When the direction of movement of the carriage 20 reverses as pin 17 (FIGURE 2) passes around the left hand pulley 10, and claw 13 again approaches the tape 1, the apparatus is ready to commence another operational cycle to justify the next line of characters on the tape 1. If one or more of the perforations 2, 3 and 4 associated with the next line of characters is missing, then the apparatus may be arranged to pass the portion of the tape 1 carrying said line through the gate 8 without the production of a corresponding image on the surface 42. Thus the absence of one or more of the perforations 2, 3 and 4 could serve to prevent the energization of the source 36 and/or the opening of a shutter associated therewith.

In the apparatus in accordance with the invention as described and illustrated, it will be seen that the method of line justification employed includes the step of applying anamorphic magnification to a line of characters by means of the prisms 43 in such a manner that at any time only a small portion of the length of the line of characters is subjected to anamorphic magnification. Preferably such magnification is applied to a continuously changing small portion of the line of characters. However, it is to be understood that said anamorphic magnification could be applied to discrete juxtaposed small portions of the line of characters, for example, by moving the carriage 20 intermittently during the scanning of the line of characters, and by energizing the source 36 and/or by opening a shutter associated therewith during intervals when the carriage 20 is stationary. Alternatively the source 36 could be energized intermittently and/or a shutter associated therewith could be opened intermittently as the carriage 20 is moved continuously.

A method of line justification according to the invention may include applying anamorphic magnification to a line of characters in combination with variation of the interword and/or intercharacter spacings. Although it is within the scope of the invention first to produce partial justification of a line of characters by varying the interword or intercharacter spacings and then applying anamorphic magnification to produce full justification of the partially justified line, it is preferred that when using a combination of anamorphic magnification and variation of interword and/or intercharacter spacings to obtain full justification of a line of characters, anamorphic magnification to produce stretching or contraction of the line of characters should be employed in the first place up to limits beyond which distortion of the characters would be unacceptable. By achieving line justification by a combination of anamorphic magnification (i.e. stretching or contraction of the line lengthwise thereof), and interword and/or intercharacter spacing variation, it is found that the result is more acceptable from an artistic point of view than when only anamorphic magnification is employed, or when only interword and/or intercharacter spacing is varied, especially when the amount of justification required exceeds +5% of the length of the line of characters.

It will be appreciated that if it is desired to vary the

intercharacter spacings in addition to or instead of varying the interword spaces, apparatus similar to that hereinbefore described could be employed, but the space detecting and re-detecting means would need to be modified to detect and re-detect intercharacter spaces, and to differentiate between intercharacter spaces and interword spaces.

In the foregoing description, reference has been made to the rejection of a line of characters if one or more of the perforations **2**, **3** and **4** associated with the line of characters on the tape **1** is absent. For this purpose the justifying apparatus could be so arranged that if the significant perforation is not present movement of the carriage **20** to the left for scanning the line of characters is prevented. Thus, instead of the endless belt **9**, a lead screw could be provided for reciprocating the carriage **20**, and if, when the carriage **20** is at its starting position, the significant perforation is not detected, then either rotation of the lead screw is stopped or the carriage **20** is decoupled from the lead screw. If a lead screw is employed to drive the carriage **20**, the arrangement may be such that the speed of rotation of the lead screw is increased during the movement of the carriage **20** to its starting position subsequent to the completion of the scanning of one line of characters and preparatory to the scanning of the next line.

If desired, the various mechanical devices such as the claws **13**, **15** and **80** employed in the apparatus described for detecting the perforations in the tape **1**, may be replaced by an arrangement in which the perforations are detected by means of the completion of electrical circuits therethrough. Thus, as the tape **1** carries a line of characters into the gate **8**, the associated perforations may be detected by electric contacts or feelers over which the tape **1** is caused to move when it moves through the gate **8**. Thus, an electric motor arranged to pull the tape **1** into and through the gate **8** by means, for example, of a rotatable capstan roller, may be energized as the justification of one line of characters on the tape **1** is completed, so that the tape **1** is then moved through the gate until an "End Of Line" perforation **3** associated with the next line of characters is detected by an electrical contact which thereupon serves to cause de-energization of said motor. In a similar manner the "Start Of Line" perforation **2** may be detected by one electrical contact which serves to cause energisation of the electric motor **82** and then by another electrical contact which causes the motor **82** to be de-energised. The period for which the motor **82** is energized is arranged to be proportional to the amount of justification required and hence the cams **50** and **51** are set to appropriate angular dispositions. A similar arrangement including yet another electrical contact may be employed for detecting the "leading" perforation **4** so as to cause energization of the motor **47** for a period sufficient to move the surface **42** by an appropriate amount. Alternatively, instead of utilising said electrical contacts to effect energisation and/or de-energisation of electrical motors such as the motors **47** and **82**, some or all of the electric motors may be energised continuously and coupled to the appropriate parts of the apparatus through electromagnetically controlled clutches, the latter being energised and/or de-energised at the appropriate times in response to making or breaking of electrical contacts which detect said perforations.

The "Start Of Line," "End Of Line," and "leading" indications associated with each satisfactory line of characters on the tape **1** may be provided by means other than perforations. For instance each such indication may be provided by an appropriately positioned visible mark on the tape **1**, and to detect said mark suitable detecting devices such as photo-electric cells may be employed. Interword and/or intercharacter spaces in a line of characters on the tape **1** could be indicated and detected in a similar manner, and different intercharacter and/or interword spaces in a line of characters could be indicated by coded groups of indicia, so that the different spaces could be detected by suitable means responsive to the particular code employed.

In the methods and apparatus described herein it has been assumed that in the lines of characters on the tape **1**, the characters have a normal aspect ratio. However, as more fully described in co-pending British application No. 4,367/58 said characters may themselves have been produced on the tape in anamorphically distorted form so that the characters are either reduced or increased in width relatively to their height. If it is assumed that +5% anamorphic distortion of characters in a justified line can be accepted, then the characters in the lines of characters on the tape **1** to be justified may be anamorphically distorted by −5%, that is to say, the widths thereof are reduced by 5% relatively to their heights. In this case, it will be appreciated that positive anamorphic magnification of the lines of characters for justification purposes can be applied up to +10% before the distortion limit in the direction of positive anamorphic distortion is reached, and hence the justifying apparatus can be simplified because only anamorphic magnification in a positive sense has to be catered for. The necessary modification of the apparatus described and illustrated to cater for only positive anamorphic magnification (and possibly for only lengthening of interword and/or intercharacter spaces) will be readily apparent in that the cam **50** and the anamorphic optical system will be arranged to cover a range of anamorphic magnification from 0 to +10% and the means for effecting relative movement between a line of characters on the tape **1** and the surface **42** to compensate for movement of an anamorphically magnified image directed to the surface **42** need operate in only one direction. Furthermore the levers **34** and **53** need not be arranged for angular adjustment to dispositions in which these levers are downwardly inclined from their pivots with respect to the axis of the lead screw **23**. From the foregoing remarks, it will be clearly understood that the present invention includes within its scope methods of and apparatus for justifying lines of characters when the characters in the lines of characters to be justified are themselves anamorphically distorted, the necessary anamorphic magnification for the purposes of the invention being so applied as to produce similar anamorphic distortion of the lines of characters but in a sense opposite to their original anamorphic distortion.

It will be appreciated that the invention can be employed, not only for justifying lines of characters produced by a photographic type composing machine, but also for justifying lines of characters when produced by ordinary printing methods such as by means of a typewriter. Moreover the lines of characters to be justified may be carried by a tape or a sheet or any other suitable member.

What I claim is:

1. Apparatus for justifying a line of characters comprising a first supporting means for supporting a surface carrying the line of characters to be justified, a second supporting means for supporting a receiving surface on which the justified line of characters is to be reproduced, a scanning system for successively forming optical images of changing small portions of the said line and successively projecting these images onto the receiving surface, an anamorphic optical system included in said scanning and projection system for anamorphically magnifying the optical images projected onto the receiving surface, a carriage on which the scanning system including the anamorphic optical system is mounted and which is arranged for movement in the direction of the length of the line of characters so that it may be moved relatively to said first and second supporting means, transport means operated by the movement of the said carriage for moving the first supporting means relatively to the movement of

the carriage in the direction of the length of the line of characters, a first adjustable setting member, means for adjusting said first setting member in accordance with the amount by which the length of the line of characters requires to be changed for justification, means for adjusting said anamorphic optical system in accordance with the setting of said first setting member, means adjusted by the said first setting member and coupled to said transport means so as to control the amount and directional sense of the first-mentioned movement imparted to the said first supporting means by said transport means, whereby any relative movement between the magnified optical image and the receiving surface during scanning and projection may be eliminated, additional actuating means for said transport means responsive to signals received when interword spaces are being scanned for actuating the transport means to impart additional movement ot the first supporting means in the direction of the length of the line of characters during each period when an interword space is being scanned, a second adjustable setting member for simultaneous adjustment with said first setting member, means adjusted by said second setting member and coupled to said additional actuating means to control the amount and directional sense of the additional movement imparted to the said first supporting member by said transport means during the scanning of the interword spaces, whereby the interword spaces of the line projected onto the receiving surface may be varied.

2. Apparatus according to claim 1, wherein said transport means comprises a lead screw coupled to said first supporting means for effecting movement thereof in the direction of the line of characters and said means adjusted by said first setting member comprises a first lever the angular disposition of which is controlled by said first setting member and which is coupled to means for effecting rotation of said lead screw in accordance with said angular disposition as said carriage is moved during scanning of the line of characters.

3. Apparatus according to claim 2, comprising a first detecting means for detecting interword spaces prior to the scanning of the line of characters, a second setting member arranged for simultaneous adjustment with said first setting member, a second lever arranged in cooperative relation with said second setting member, displacement means for effecting relative displacement between said second lever together with its fulcrum and said second setting member in accordance with the number of interword spaces detected, a second coupling means between said second lever and said additional actuating means, a second detecting means for redetecting said interword spaces as the latter are scanned and means for effecting relative movement between said second setting member together with said second lever and said second coupling means as each interword space is redetected whereby said additional actuating means is actuated to impart an additional movement to the lead screw and thus to the first supporting means during the scanning of interword spaces.

4. Apparatus according to claim 3 wherein said first and second setting members are in the form of rotatable snail cams, and the shapes of said cams are such that simultaneous rotation of said cams through a predetermined arc causes a change in the angular disposition of said first lever but no change in the angular disposition of said second lever whereas simultaneous rotation of said cams beyond said predetermined arc causes a change in the angular disposition of said second lever but no further change in the angular disposition of said first lever.

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