Sept. 16, 1941. R. M. EVANS ET AL 2,256,385

PROJECTION PRINTER

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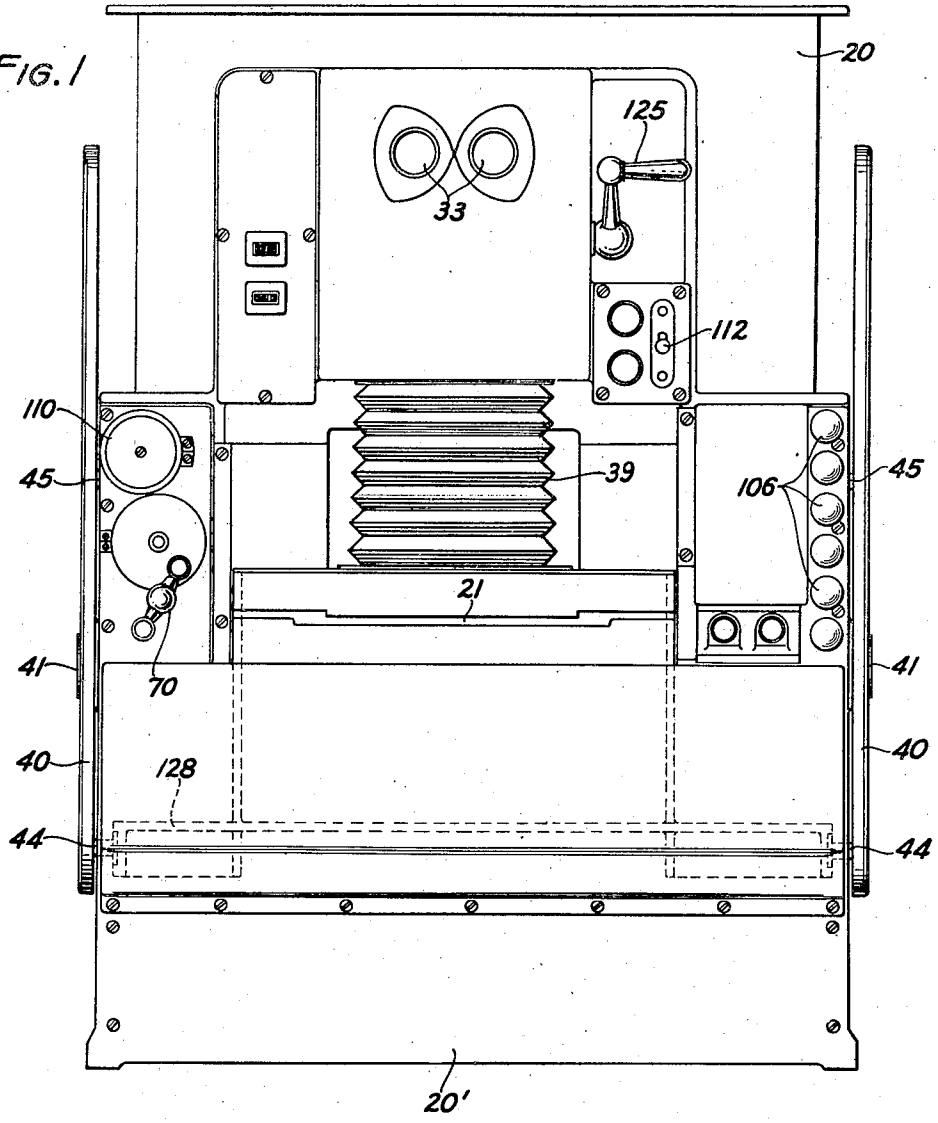
FIG. 1



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BENJAMIN E. LUBOSHEZ
INVENTORS

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FIG. 2

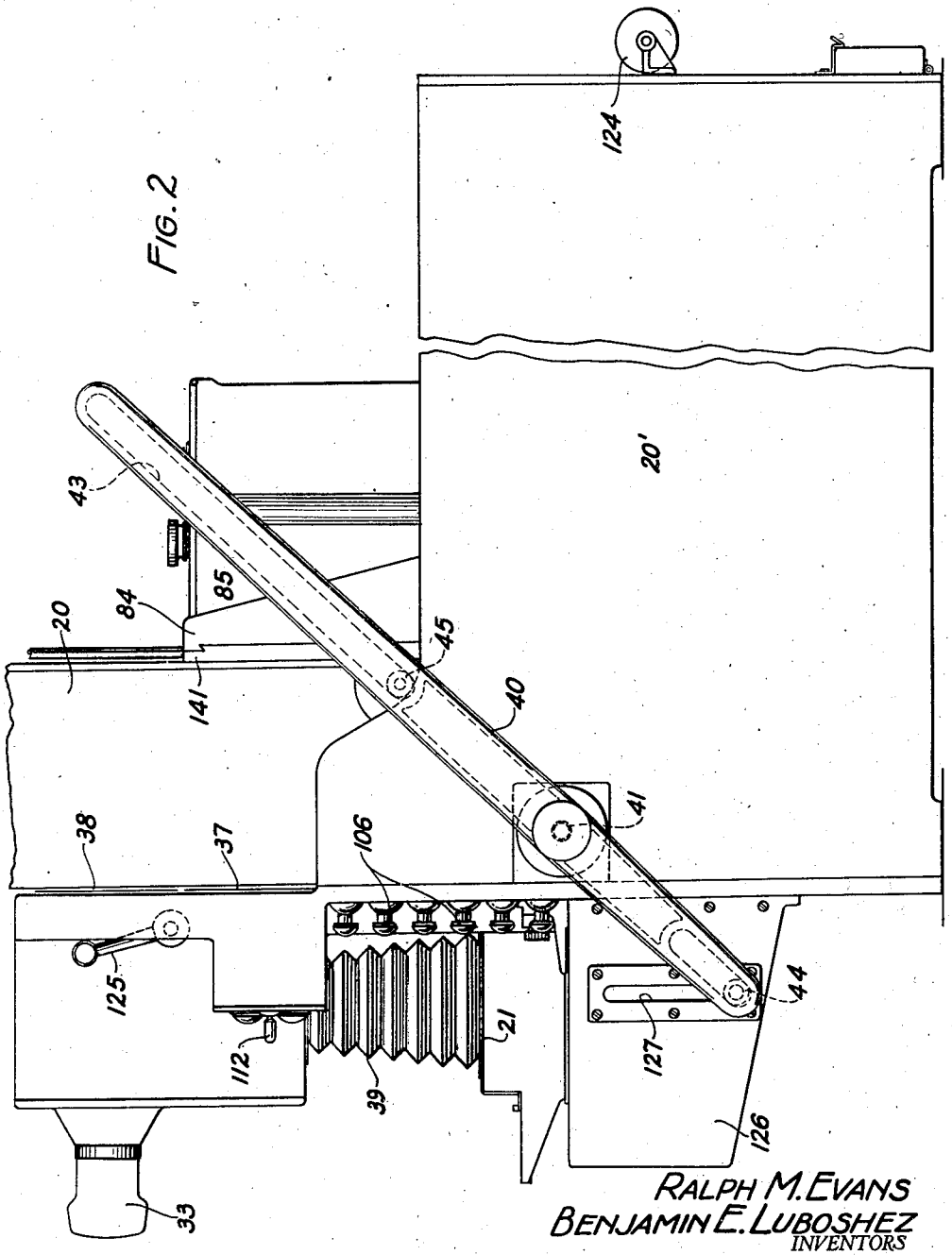

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FIG. 4

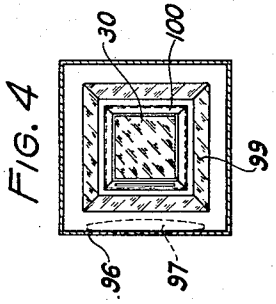

FIG. 3

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FIG. 7

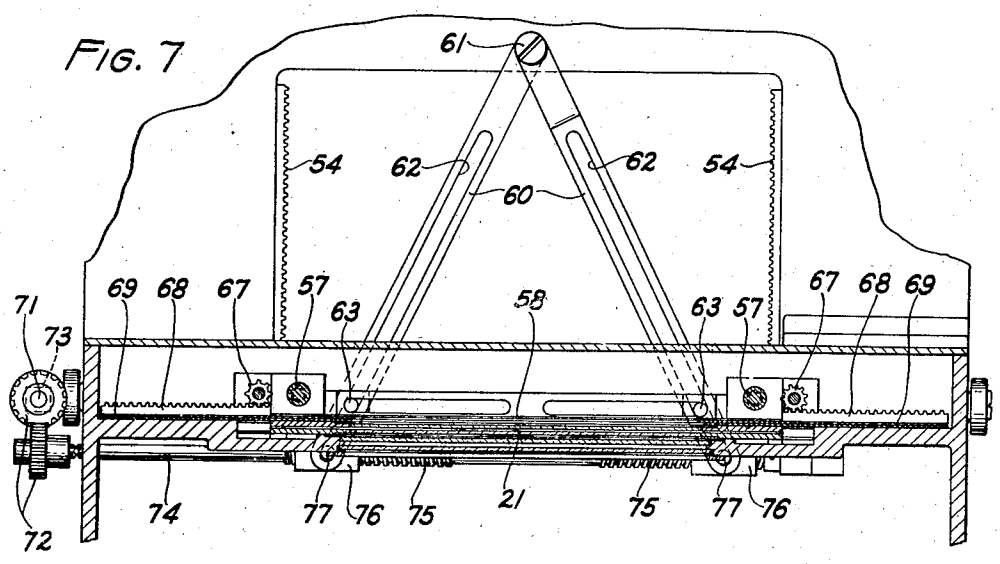

FIG. 8

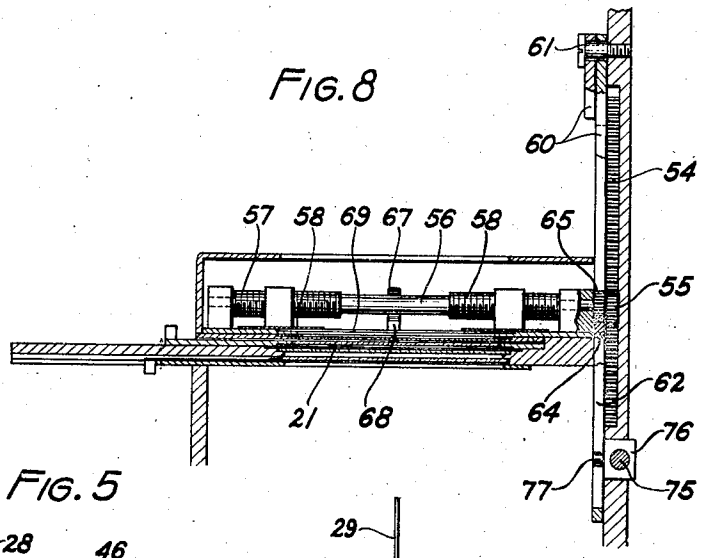

FIG. 5

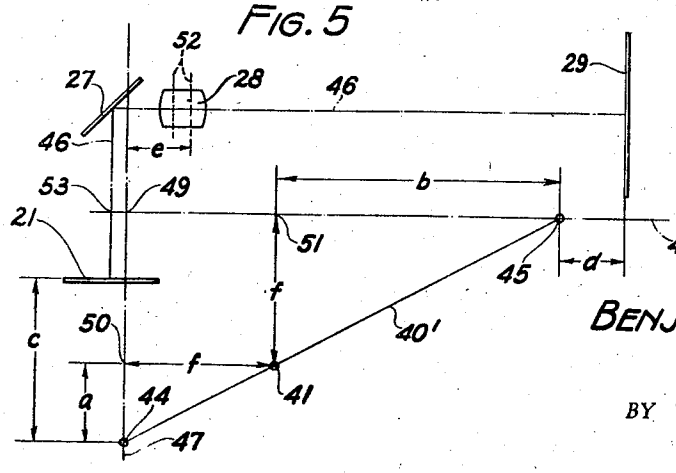

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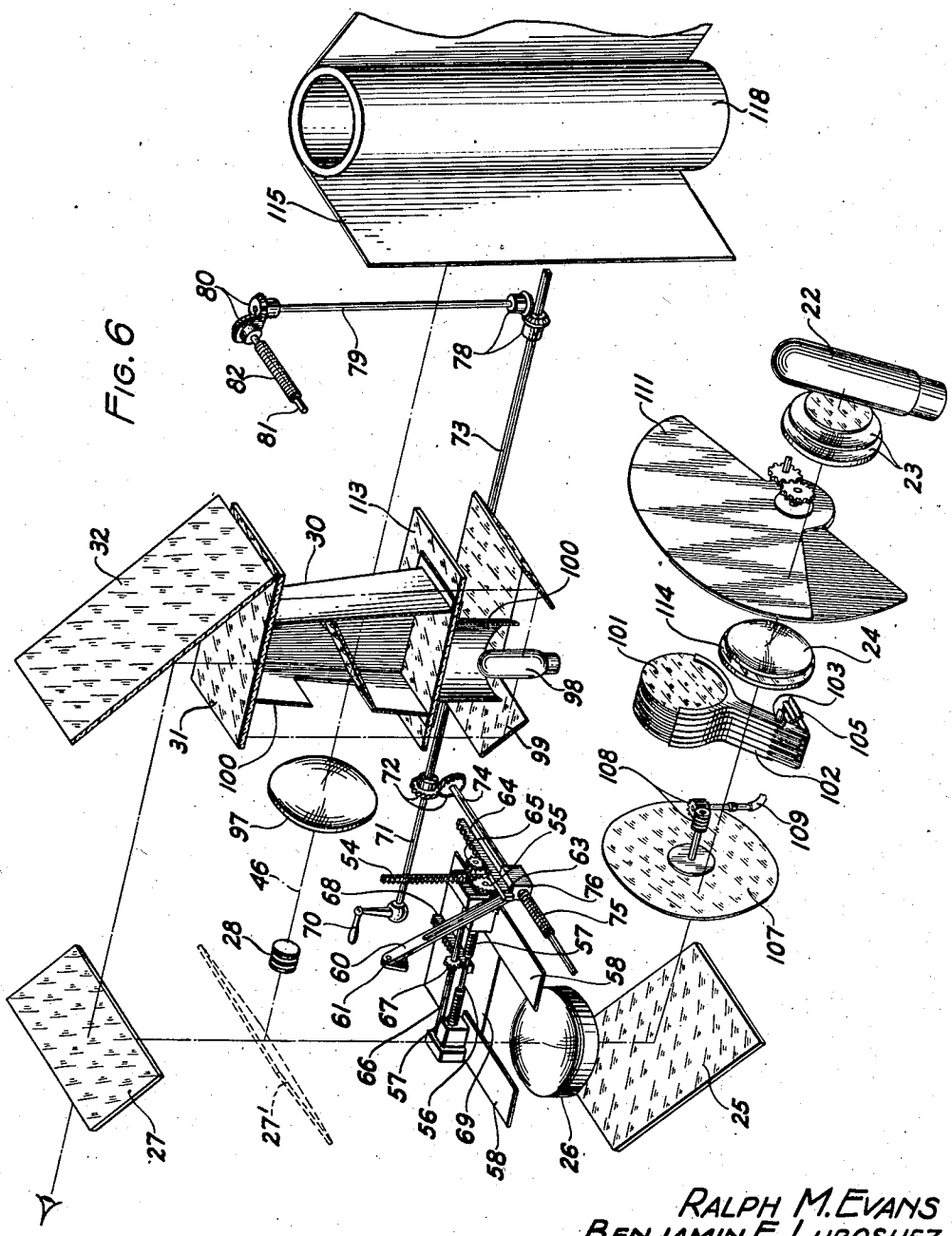
FIG. 6



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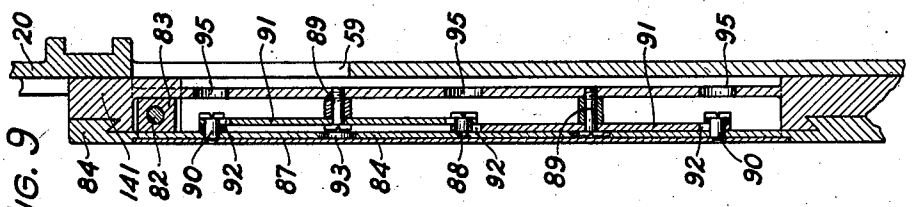

FIG. 9

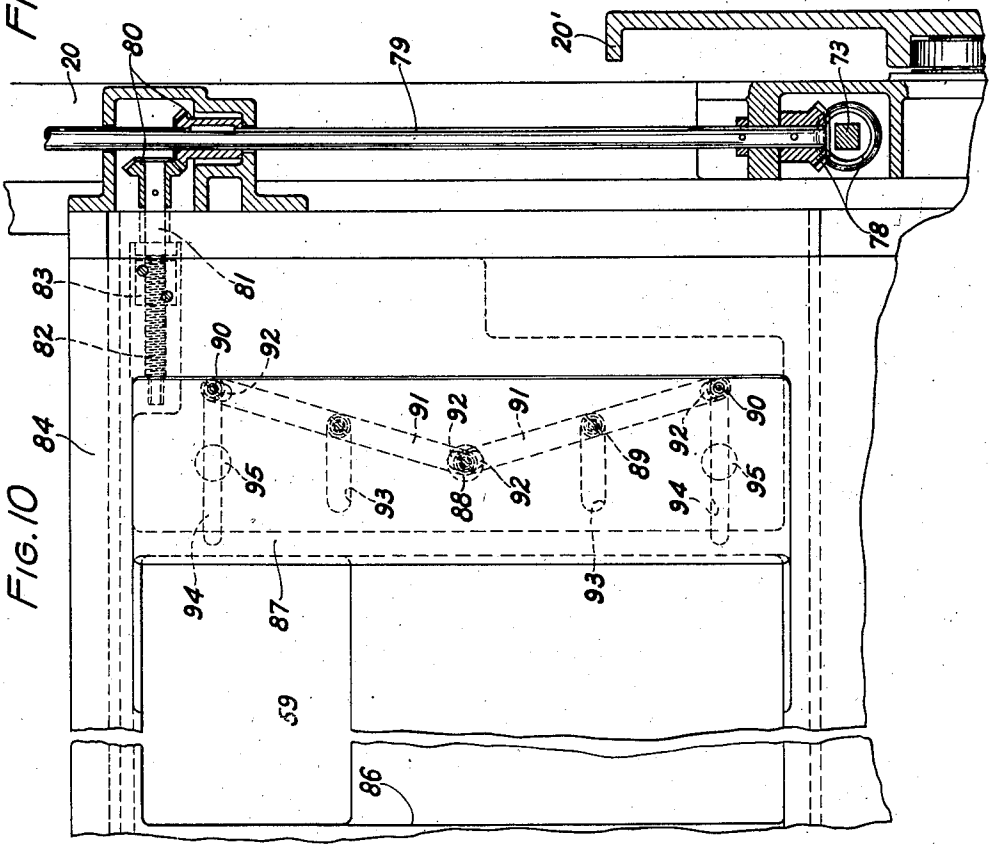

FIG. 10

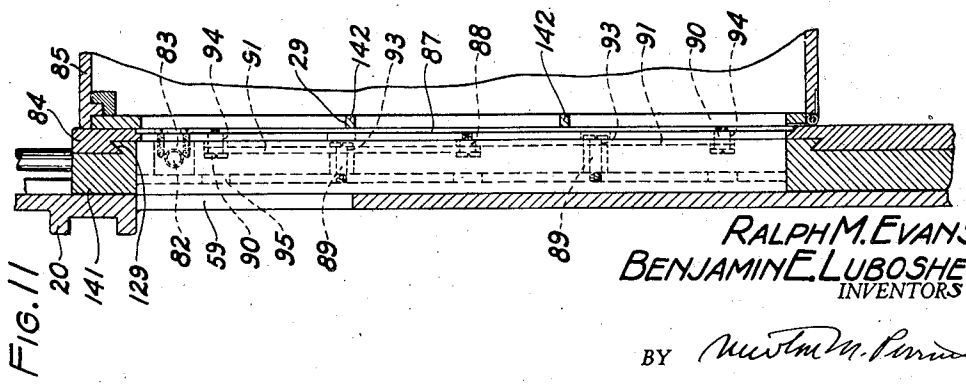

FIG. 11

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PROJECTION PRINTER

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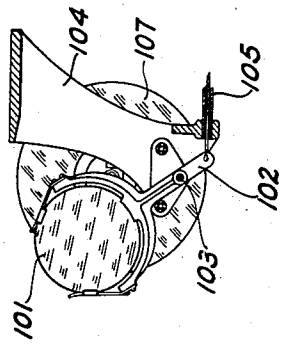

FIG. 12

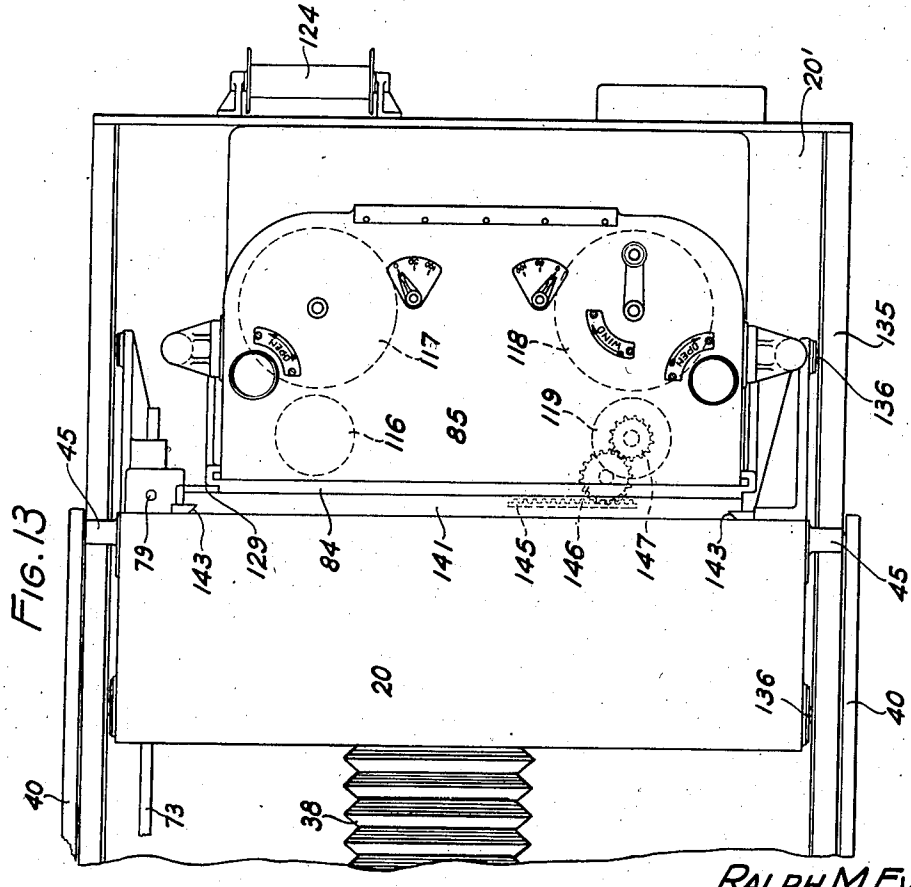

FIG. 13

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FIG. 15

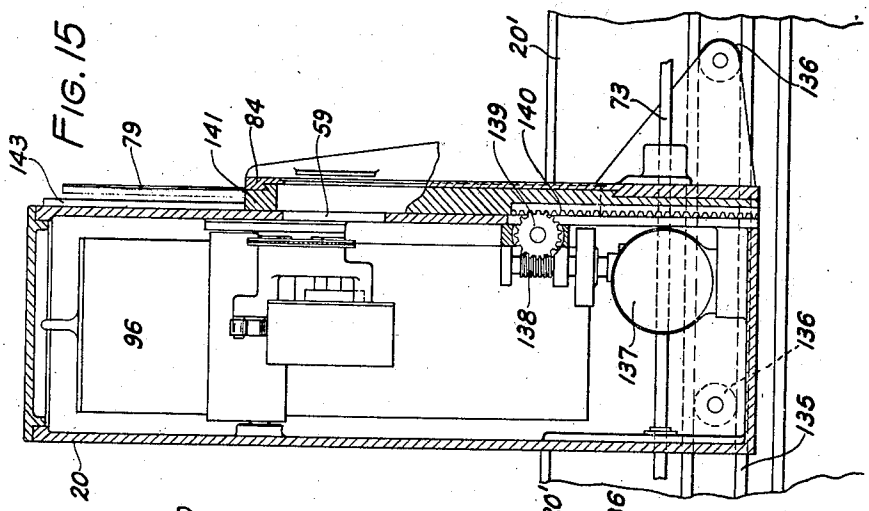
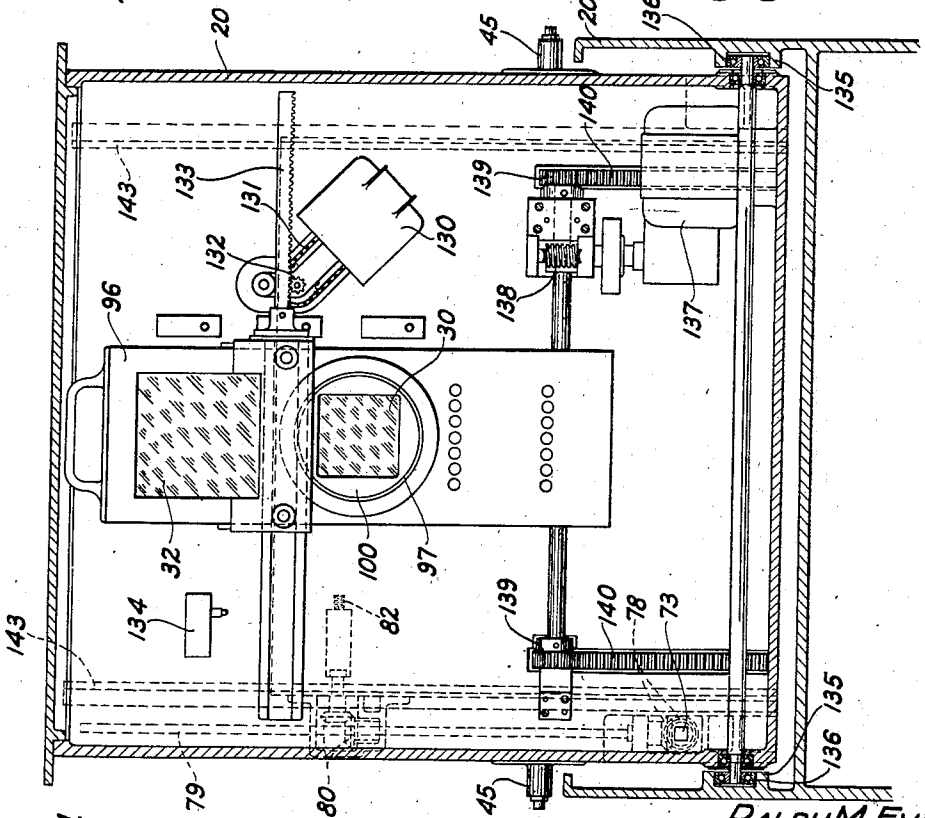


FIG. 14



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PROJECTION PRINTER

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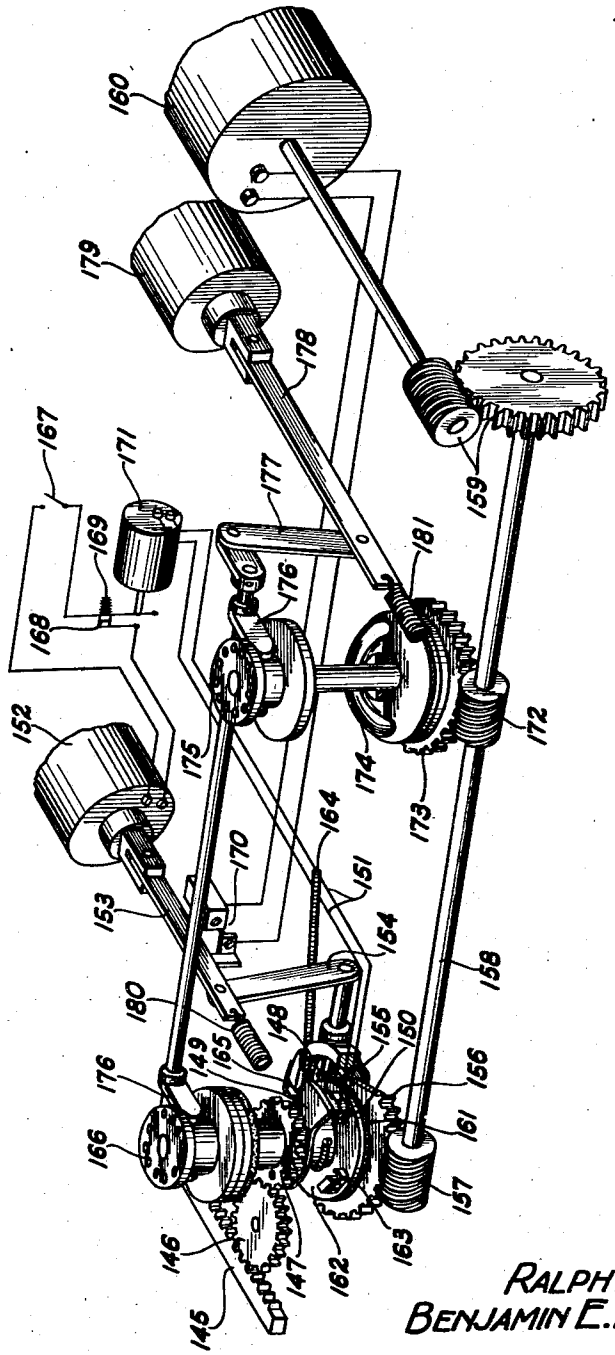
FIG. 16



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Patented Sept. 16, 1941

2,256,385

UNITED STATES PATENT OFFICE

2,256,385

PROJECTION PRINTER

Ralph M. Evans and Benjamin E. Luboshez, Rochester, N. Y., assignors to Eastman Kodak Company, Rochester, N. Y., a corporation of New Jersey

Application August 7, 1940, Serial No. 351,762

11 Claims. (Cl. 88—24)

This invention relates to projection printers for photographic purposes.

It relates generally to the same subject matter as copending applications Serial Nos. 351,761 and 351,763 filed concurrently herewith by one of us (Luboshez).

It is a general object of the invention to provide a projection printer for making prints, usually on paper, from transparencies.

It is a particular object of the invention to provide a projection printer for making color prints from color transparencies. The specific objects of the invention are listed below:

1. It is an object of the invention to provide a printer with means for correcting errors in color balance of the original. This is not the type of correction corresponding to masking.

2. It is an object of the invention to provide means for judging when the color balance has been fully corrected.

3. It is an object of the invention to provide a simple compact optical system for providing a white border adjacent to the original to be printed or to an image thereof which border will not interfere either with this image or with the one exposing the sensitive material upon which the print is to be made.

4. It is an object of the invention to provide means for correcting for errors in color balance of the sensitivity of any particular photosensitive material being used.

5. It is an object of the invention to provide a means for satisfying object No. 4 which means can be fixed in place for any one roll of printing paper and need not be moved during the judging of the color balance of the original and which will not interfere with this judging. Furthermore, it is arranged so that it does not interfere with the correction made in accordance with this judging.

According to the invention, the general and specific objects listed above are accomplished by combining the following features in a printer. A projection printer is provided having a record gate preferably horizontal for holding the original color transparency and a printing gate preferably vertical for holding color sensitive paper upon which prints are to be made. A lens (preferably with a reflector) is provided for focusing an image of the record gate on the printing gate. The gates are movable to permit differences in magnification and as they are moved, correct focus is maintained by suitable coupling means therebetween. According to the invention specifically described here the following features are included to provide color correction.

Color correction in color photography as applied to the making of a duplicate or print of a colored photographic record may be divided into four types. Two of these, one depending upon subjective color responses and the other on deficiencies in the final printing colors are not involved here since they have to do with the interrelation of the separate colors. I refer to the types of color corrections such as those involving masking. The other two types are concerned with the relative amounts of the separate colors, i. e. with color balance. To correct for error in color balance in the original record, for example the original may be too blue or too magenta, color filters are provided to be positionable in the light beam somewhere between the light source and the image which is to do the printing. Preferably these filters are placed in the light beam before the light reaches the original to correct the appearance of the original itself. Various filters are used, all of them relatively thin optically and are positionable separately or in combination in the light beam.

To aid in judging the hue as well as the density of the original, an image of the original is formed on a viewing screen for example by a removable mirror such as a reflex mirror. The borders of this viewing screen around the image are colored white preferably by direct illumination with white light. We have found that any errors in overall hue of the record appear very pronounced and it is quite easy to judge the correct hue when this white border is provided whereas, when looking directly at the original, the eye has a tendency to adapt itself and small deviations from true colors cannot be detected. As a control on the density of the image so that the comparison with a white border of fixed intensity is made easier and/or so that a constant printing time may be used an adjustable wedge is also provided in the light beam.

In order to illuminate the borders on the viewing screen uniformly with white light, a lamp is placed behind the removable mirror and is surrounded by a truncated four-sided pyramidal mirror which reflects light from the lamp past the removable mirror on all sides and to the borders of the viewing screen as required. Various baffles including the removable mirror itself prevent light from this lamp reaching the image on the viewing screen or reaching the printing gate.

The above described arrangement incorpo-

rates into our printer a new principle which results in a thoroughly practical instrument whereas prior printers of comparative design were prohibitively costly to operate and maintain. For either colored still pictures or colored motion pictures, printing lamps have to be carefully standardized as to color temperature and intensity and can be used only for a minor portion of their total life because their color and intensity varies with age beyond all tolerance limits. Similarly, since the printing beam is quite intense, any filters therein soon fade and must be replaced.

According to the present invention all this is avoided by referring everything having to do with color and intensity to a single easily maintained standard, the above described borders. The lamp used to illuminate the borders is considerably undervoltage which results both in a longer useful life for the lamp and practically no deterioration of any filters placed in the comparison beam.

The standard borders provide even more than a photometer for the printing lamp since when the comparison of the image and the borders, together with necessary adjustments, is completed, correction has been made for any discrepancies in color or intensity of the printing lamp, color or density of filters used, color or density of the original transparency being printed and, as will be described below, sensitivity or color sensitivity of the printing paper. The whole unit containing the reflex mirror and comparison system is removable and interchangeable with other similar units each of which may be separately standardized to correspond to a particular roll of printing paper.

To correct for the other source of color error, namely the color balance of the sensitivity of the photosensitive material being used, a compensating filter must be placed in the printing beam. It is not desirable to have this filter in the beam between the record and the printing gates, particularly between the removable mirror and the printing gate since this is liable to interfere with the definition of the image at the printing gate. Therefore, it is placed with the other filters near the light source. However, while the color balance of the original is being tested and corrected, it would not do to have this additional filter in the path since its effect would be corrected-out when the image on the viewing screen was made to look right as compared with a white border. On the other hand, it is a nuisance to have to remove this filter while the color balance of the original is being checked and to replace it for every print. Therefore, we place an identical filter in the path of the light illuminating the "white" borders. That is, these borders are not exactly white, but "white" is not an exact term anyway. The balance of the color of the original record is made with respect to the white borders with both filters in place and hence their effects cancel one another as far as the color judging is concerned, but the one in the printing beam is still there during the printing to correct for improper color balance, if any, of the particular roll of paper being used. The filters for this purpose, i. e. to correct for errors in color balance of the sensitive paper, are preselected by sensitometric tests of the paper and each roll carries reference to the filter to be used. One simple method of selection comprises printing a white or gray image on the paper and if the resulting print after processing deviates from gray, selecting the filter whose color is complementary to that of the resulting print, i. e. the filter which when placed over a light illuminating the paper makes the paper look gray. Of course, the fact that light travels twice through the color layer when paper is viewed by reflected light and only once through the filter must be taken into account in selecting a complementary color filter.

Other objects and advantages of the invention will be apparent from the following description when read in connection with the accompanying drawings in which:

Fig. 1 shows a front elevation of the printer.

Fig. 2 shows a side elevation of the printer.

Fig. 3 shows a side elevation in cross section.

Fig. 4 shows a horizontal cross section of the viewing screen.

Fig. 5 is a geometrical diagram of the focusing system.

Fig. 6 is a perspective view of the optical system.

Fig. 7 is a front elevation of the record gate masking system.

Fig. 8 is a side elevation of this record gate masking system.

Fig. 9 is a side elevation of the printing gate masking system.

Fig. 10 is a rear elevation of the printing gate masking system.

Fig. 11 is another side elevation, opposite to that of Fig. 9, of the printing gate masking system.

Fig. 12 is an end view of the filter holding device.

Fig. 13 is a top view of the roll holder for the printing paper.

Fig. 14 is a front view of the viewing screen system.

Fig. 15 is a side view of the viewing screen system.

Fig. 16 is a perspective view of the paper advancing mechanism.

Since Figs. 1 and 2 are outside views, the cooperation of the details is not apparent therein. Therefore, the following description will be made with reference to the other figures, the optical system being shown best in Figs. 3 and 6. However, reference to the first two figures when reading the description will bring out one of the main advantages of the invention, namely the absolute convenience of all controls to the operator.

Figs. 3 and 6 will now be described together. The printer housing consists mainly of two parts—a camera 20 carried by a supporting housing 20'. The camera 20 carried by wheels 136 (in grooves 135 see Fig. 14) is movable horizontally on the supporting housing 20' and all of the features are carried directly or indirectly by these two supports 20 and 20'. Light from a lamp 22 travels in a substantially horizontal line through suitable condensers 23 and relay lenses 24 to a reflector 25 whence it is reflected vertically upward through a field lens 26 to a record gate 21 in which the original is mounted horizontally. From that point the light continues upward to a reflector 27 which is positionable in either of two positions labeled 27 and 27'. In the position 27', it reflects light through a lens 28 to a vertical printing gate 29 through a window 59 in the camera 20, back of which window 59 the sensitive paper is mounted. In the other position of the reflector 27, the light is reflected horizontally in the opposite direction through an eyepiece 33 to the eyes of the operator who may then observe the record in the record gate 21 directly. The eye-piece 33 is thus in a most

convenient position above and near the record gate 21. Stops 35 and 36 are provided for limiting the movement of the mirror 27 to these two positions 27 and 27'. The hinge 34 about which the mirror 27 rotates is above the optic axis 46 as it travels through the lens 28. The mirror 27 is operated by a handle 125 (shown in Figs. 1 and 2) connected to the shaft of the hinge 34. Even if no other viewing means were present to cooperate with this one, the use of a hinged mirror alternatively to send light to the camera and to the observer simultaneously and in a very simple manner accomplishes an obviously desirable feature.

A removable mirror 30 is positioned in the path of the light from the lens 28 to the printing gate 29 so that it reflects light upward to a viewing screen 31 on which an image is formed. A reflector 32 above the viewing screen 31 permits this image to be seen in the eye-piece 33.

In order to change the magnification of the print, the record gate 21 carried by a supporting member 128 is moved upward and the printing gate 29 is moved horizontally. Correct focus is maintained by means of lever 40 which rotates about a point 41 and has longitudinal slots 42 and 43 therein in which studs 44 and 45 move. The stud 44 is carried by the supporting member 128 and is constrained to move vertically in a slot 127 in the housing 126. This housing 126 for the condenser 26 is rigidly attached to the housing 20'. The stud 45 is constrained to move horizontally while the printing gate and all of the members associated therewith (i. e. camera 20) are carried by the wheels 136 moving in grooves 135 as best seen in Fig. 14.

The geometry of this focusing system is best shown in Fig. 5. In this figure the vertical line of motion of the stud 44 is labeled 47 and the horizontal line of motion of the stud 45 is labeled 48. These lines of motion intersect at a point 49. Actually of course, if the lever 40 had an offset in it, the studs 44 and 45 might not have coplanar motion but in any case it would be equivalent thereto. The pivot 41 of the lever 40 is positioned a distance equal to the focal length of the lens 28 from each of these lines of motion 47 and 48. Thus the points 41, 49, 50, and 51 form a square whose side equals f, the focal length of the lens 28. The line 40' representing the lever 40 forms two triangles 44, 50, 41, and 41, 51, 45. It will be noted that by simple geometry these two triangles are exactly similar and remain similar to one another as the line 40' rotates about the point 41. Therefore $a:f$ equals $f:b$. That is $a \times b$ equals f^2. Now going over from simple geometry to optics it is known that if distances a and b obey this rule, the distance $a+f$ will always be conjugate to the distance $b+f$ for a lens of focal length f. Therefore the distance 44—49 (i. e. from 44 to 49) would always be conjugate to the distance 49—45 with respect to the lens 28. This principle is incorporated into the present printer by making the distance from the record gate 21 to the lens 28 along the optic axis 46 equal to the distance 44—49 and the distance from the lens 28 to the printing gate 29 equal to the distance 49—45. Actually the distances must be measured to the principal planes 52 of the lens 28 and that is what is meant by measuring the distance to the lens 28. As far as the optical principles of the system are concerned the lens 28 may be either side of the reflector 27. To get the above relation of distances, the distance c between the printing gate 21 and its stud 44 is made exactly equal to the distance between the point 53 and the lens 28, where the point 53 is the intersection of the optic axis 46 and a horizontal plane through the horizontal line 48. Similarly the distance e between the lens 28 and a plane through the vertical line 47 is made equal to the distance d between the stud 45 and the printing plane 29. The planes through the lines of motion are of course the ones perpendicular to the plane of the drawing; they are in each case orthogonal to the optic axis. Although there is only one horizontal plane through the line 48 there are an infinite number of vertical planes through the line 47 and hence the term orthogonal is used to specify the planes in each case. It will be noted that the distances d and e are actually negative since they are measured back from the lens and from the printing gate respectively. As the record gate is moved vertically and the printing gate is moved horizontally, the distance 21—53 changes, but the distance from 21 to the lens 28 always remains equal to the distance between the stud 44 and the point 49 and the corresponding correlation is maintained with respect to the printing gate.

The arrangement for masking the record gate is best illustrated in Figs. 6, 7, and 8. The width of the printing gate is made constant in this printer, which is, of course, the most economical method of using paper in rolls. Therefore, as the magnification is changed, it is necessary to mask the record gate (as far as the width is concerned) to a degree which is inversely proportional to the magnification. This width masking is provided by masks 58 which are moved by screws 57 carried on a shaft 56. Vertical motion of the printing gate to change the magnification causes a pinion 55 to move along a rack 54 which is held rigidly by the printer housing 20'. This pinion 55 is thus rotated and rotates the shaft 56 and the screws 57 causing the mask 58 to move in and out as the printing gate is moved up and down.

The length masking of the record gate is more complicated by the fact that different shaped records are often to be printed. The length masking operation may be divided into two parts, that which must follow the change in magnification in the same way that the width masking does and that which is somewhat independent of the magnification and depends mainly on the shape of the record being printed. Adjacent to the record gate are provided two arms 60 which are pivoted at a point 61 which is rigidly fastened to the printer housing 20'. These arms 60 carry longitudinal grooves 62 therein in each of which moves two studs 63 and 77. The studs 63 are carried by racks 64 which move with the record gate. Thus as the record gate moves up, the stud 63 moves along the groove 62 pulling the horizontal rack 64 with it. This motion of the rack 64 causes a pinion 65 to rotate which rotates its shaft 66 and another pinion 67 thereon, which other pinion moves a rack 68 horizontally causing the length masks 69 to move in. Thus for successive prints of records of the same shape but different sizes, different magnifications are obtained by vertical motion of the record gate and both the width and length masking of this gate move in accordance with the change in magnification.

In this general connection, attention is drawn to the fact that the magnification necessary is very easily selected by the operator when viewing the record directly, i. e. when the rotatable re-

flector is in the position 27. The operator merely has to raise or lower the horizontal record gate until the automatic masking of the width of this gate is brought to the area desired at which time the focus and magnification are exactly that to give a print of the fixed width being made. That is, the operator merely selects the width of the record to be printed and the necessary magnification is automatically assured.

When prints of different shape are used, the length masks have to be changed independently of the width masks. For this purpose a crank 70 rotates a shaft 71 and gears 72 which in turn rotate a shaft 74 having screw threads 75 thereon. These screw threads 75 cause nuts 76 to move horizontally carrying the stud 77 referred to above. This horizontal movement of the stud 77 causes the arm 60 to rotate about the pivot 61, the stud 77 moving a short distance along the groove 62. This movement of the arm 60 causes the other stud 63 to move carrying the rack 64 and moving the length mask 69 in the same way as before. It will be noted that the stud 77 moves only horizontally with respect to the printer whereas the stud 63 moves vertically with changes in magnification. Thus the correlation between the horizontal movement of the stud 77 and the movement of the mask 69 is always modified by the magnification factor. When a high degree of magnification is being used, the record gate is very high and the studs 63 are high in the grooves 62 and close together. In this case a relatively large horizontal movement of the stud 77 is required to give a relatively small change in the length masking.

The shaft 71 which is rotated by the crank 70 has a square portion 73 extending back toward the printing gate. This square portion carries a set of bevel gears 78 which can move along the shaft 73 as the magnification is changed, but which in any position will be rotated by rotation of this shaft 73. These gears 78 in turn rotate a shaft 79 and another set of gears 80 which operate through a shaft 81 and screw threads 82 to change the length masking of the printing gate. The length masking of the printing gate 29 as formed by the plate 84 is best shown in Figs. 9, 10, and 11. In these figures the plate 84 has an aperture therein which in part constitutes the printing gate. Actually the top and bottom edges of the printing gate and hence its width is defined by the front plate of a roll holder 85 which carries the paper and is carried by the plate 84. In the arrangement shown the roll holder 85 can be used successively in three positions so that three strips of pictures may be made. The edges of the printing gate between the three positions are defined by strips 142 extending across the aperture in the roll holder. One end of the printing gate 29 is defined by the edge 86 of the aperture in the plate 84. As the length masking crank 70 is rotated causing rotation of the screw thread 82, the whole plate 84 carried by a nut 83 operating on the screw 82 is moved horizontally. The plate 84 is carried by a groove 129 and moved in this groove only a relatively small distance as is best seen in Fig. 13.

The other end of the printing gate is defined by a movable mask 87 carried by the plate 84. As the plate 84 is moved by the screw 82 and nut 83, it carries with it a pivot 88. This pivot 88 acts as the common point for two connected levers 91 which are pivoted at the points 89. These points 89 are rigid with respect to a plate 141 which in turn is rigid with respect to the camera housing 20 as far as any horizontal motion is concerned. The other ends of the levers 91 carry pivots 90 which are fastened to the mask 87. Suitable slots 92 are provided in the levers 91 for longitudinal motion of the pivots 88 and 90. Slots 93 are provided in the plate 84 to permit assembling of the pivots 89 and to permit movement of the plate 84 with respect to these pivots, especially in the case of the pivot which extends into this plate by reason of the fact that one of the levers 91 is on top of the other and is immediately adjacent to the plate 84. Slots 94 are provided in the plate 84 to permit the pivots 90 to extend through from the mask 87 to the levers 91 which are on the opposite side of the plate, and to permit these pivots 90 to move with respect to the plate 84. Holes 95 are provided in the plate 141 to permit assembly of the pivots 88 and 90.

As the plate 84 moves in one direction carrying the edge 86 with it, the mask 87 moves in the opposite direction with the same speed with respect to the plate 141 and the printer housing 20. It will be noted that the movement of the mask 87 with respect to the plate 84 is at twice the speed of the movement of the plate 84 with respect to the plate 141. Thus the light to the printing gate passes through the window 59 in the camera housing 20, the top and bottom of the gate are formed by the roll holder 85 with its cross strips 142 and the ends of the gate are formed in the adjacent plate 84 by edge 86 and mask 87.

Referring back to Fig. 3 particularly with reference to Figs. 4, 14, and 15, the viewing system will now be described.

The movable mirror 30 is carried by a housing 96 in the front of which is a window to admit light from the lens 28. A lens 97 positioned in this window reduces the size and increases the brilliance of the image on the viewing screen 31 with respect to the image which, in the absence of the reflector 30 reaches the printing gate 29. Around this image on the viewing screen 31 are provided borders which are illuminated by white light by means of a lamp 98 positioned behind the mirror 30. Light from this lamp 98 is reflected by an inverted four-sided pyramid mirror 99 upward to the borders of the viewing screen 31. It is of course desirable to prevent any light from this lamp 98 reaching the image on the screen 31 and for this reason suitable baffles 100 are provided. If one were to remove the viewing screen 31 and to look down from this point, one would see an arrangement such as that shown in Fig. 4 wherein the central area consists of the mirror 30 surrounded by sloping baffles 100 having a window in one side thereof which baffles are surrounded by the mirror 99 and the viewing system housing 96. The lens 97 is shown by broken lines in this figure. The arrangement is also very well shown in the perspective view in Fig. 6.

While the operator is viewing this image on the viewing screen 31, the white border there around makes it very easy for him to detect any discrepancies in the color balance of the original which is in the printing gate 21. For example, an original may be slightly too green; but viewing it separately it would not show up this defect because the eye would adapt itself, whereas the overall green appearance is exaggerated by the presence of a pure white border and hence the operator is made definitely aware of even the slightest discrepancy. By means of various color filters 101 in the optical system somewhere be-

tween the lamp 22 and the removable mirror 30, preferably between the lamp 22 and the record gate 21, the overall hue of the record is changed until it has the correct color as compared to the white border of the viewing screen 31. As shown in Fig. 12, these filters are mounted on individual handles 102 pivoted on a bar 103 which is supported by an arm 104 connected to the printer housing 20'. The movement of these filters 101 is controlled by individual flexible cables 105 connected to buttons 106 shown in Figs. 1 and 2.

For two reasons, namely for most convenient comparison of color and in order to permit exposure of a fixed time it is also desirable to vary the density of the image striking the printing gate, and correspondingly the density of the image on the viewing screen 31. For this purpose a density wedge 107 as best seen in Fig. 6 is positioned in the light beam and is operated by gears 108 through a rotatable flexible shaft 109 which is connected to a dial or knob 110 shown in Fig. 1. Thus the filters 101 and the density wedge 107 are used to correct for errors in color balance in the original transparency and in the light source 22 and for variations in intensity of the image striking the printing gate.

In a color printing system of this type there is another source of possible error in color balance which can be corrected for. We refer to the fact that the sensitivity of the color sensitive paper on which the print is to be made, may vary somewhat from the correct value. From a theoretical point of view there are two ways of considering this effect. Since the white borders on the viewing screen 31 are used to define what is the correct hue of the pictures which strike the printing gate, the color of the light from the lamp 98 must be that for which the sensitivity of the printing paper is balanced. To provide for variations of sensitivity balance, a filter 113 corresponding to the sensitivity of the particular roll of paper to be used is placed in the path of the light from the lamp 98 to the borders of the viewing screen. Because of the adaptation of the human eye, the borders of the viewing screen will still be considered to be white and a balance of the color of the image appearing thereon until it appears correct with respect to this white, may be made. At such a time, the image striking the viewing screen 31 (hence the image striking the printing gate 29 when the removable mirror 30 is removed) will have the correct hue to give correct color balance on the particular sensitive paper used. In order to insure that correct color balance can be easily obtained with the filters 101 even when the filter 113 is in place, a filter 114 roughly identical in spectral transmission to the filter 113 is positioned adjacent to the filters 101. Of course this is necessary only if the filters 101 do not cover a sufficient range to provide the correct color hue when the filter 113 is in place. That is, the filters 101 are usually made to cover only the range variations in hue of transparencies and may not extend to a range including variations in color balance of the sensitive paper.

Looking at this subject from another point of view, the filter 114 which is selected to correspond to the sensitivity of the paper being used is placed in the illuminating system at the time prints are being made. If this filter 114 can be easily removed during the judging, and replaced while the exposure is being made on the printing gate 29, only one filter will be needed. However, since the filter 114 has to stay in place and is not changed during the whole of one roll of sensitive paper, it is decidedly inconvenient to have to remove this filter between the exposures in order to prevent it interfering with the balancing out of discrepancies in the color balance of the original transparency. Therefore, the filter 114 is placed permanently in place and the filter 113 is placed in the illuminating system that gives the white borders on the viewing screen 31 whereby the effect of the filter 114 on the color balance of the original is balanced out. That is, either or both of the filters 113 and 114 are necessary, but both are preferable since if 114 only is used, it must be removed from the optical system during judging and if filter 113 only is used, the filters 101 may not have sufficient range to compensate for the effect of the filter 113. Actually filter 113 is selected with critical accuracy and filter 114 need only be approximately the same since adjustable filters 101 will make up for any discrepancies in the color of 114 or for that matter in their own color since everything is referred to the standard borders.

A suitable shutter 111 is provided in the optical system and is arranged so that it may be held open during masking and judging, held closed while the viewing system carried by the housing 96 is removed from the optical system and operated once giving a fixed exposure. As shown in Fig. 6, the shutter 111 is provided with an adjustable sector to vary the amount of the exposure in the well-known way. The shutter 111 is operated preferably electrically by a button 112 shown in Fig. 1.

In Fig. 13, the paper holding means is illustrated from above. As pointed out above the camera housing 20 carries a plate 141 which is constrained to move in vertical grooves 143 to permit different strips of the roll of paper to be used. This plate 141 has a horizontal groove 129 on which plate 84 carrying the printing gate moves under the action of the screw 82 which forms part of the length masking system. This plate 84 carries the roll holder 85 in which are located the supply roll 117 and the take-up roll 118 carrying the sensitized paper 115. Rollers 116 and 119 adjacent to the printing gate plane guide the paper through this plane. As far as the printing gate is concerned roller 116 constitutes the supply roll and roller 119 constitutes the take-up roll.

So that no paper will be wasted, the take-up mechanism is arranged so that after each exposure the area exposed plus a slight and fixed margin between prints is moved past the printing gate and onto the take-up system. Since according to the invention one side of the printing gate acts as the mask for one end of that gate, the amount of paper on the take-up roll does not have to be moved even though the length masks are changed. This is, of course, the reason for having one end of the printing gate fixed and having a double speed mask operating over the other end. The so-called fixed end of the printing gate is the one next to the take-up roll. Means are provided for assuring that the amount of the paper advanced after each exposure will be just exactly that necessary to bring the exposed area plus a suitable margin past the gate independent of the length of that exposed area.

This paper advancing system is best explained with reference to Fig. 16 which illustrates the driving mechanism which forms part of the paper holding system 85. At this point, attention is drawn to the fact that in the cross section shown in Fig. 3 only the rewind mechanism consisting

of motor 120, shaft 121, and clutch system 122 for operating the supply roll 117 as a take-up roll during rewinding is shown. The take-up system shown in Fig. 16 is similarly fixed below the rollers 118 and 119. Since the actual take-up roll 118 cannot conveniently be used for controlling the exact amount of paper taken up (the amount taken up depends on the diameter of the roll and how much paper has already been wound thereonto) the roller 119 is used as the driving roller and is accurately controlled. The roller 119 is driven by studs thereon extending into the plate 166 and the take-up roll 118 is driven by studs thereon extending into the plate 175. Normally the switch 168 is closed by a spring 169. Hence when the switch 167 is closed in order to advance the paper, a solenoid 152 pulls the core 153 against the force of a spring 180 causing a switch 170 to close and a lever arm 154 to rotate pawls 155 upward. The closing of the switch 170 starts the motor 160 which, through the gears 159, shaft 158, and worm gear 157 causes a gear 156 to rotate. The pawls 155 push this gear upward so that through a friction drive 161 the wheel 166 starts to rotate. On the same shaft, there is mounted a rotatable plate 162 which under the force of the friction drive, rotates carrying an electrical contacting member 163 with it. When this rotation proceeds far enough, the contacting member 163 engages contacts 150 mounted on a stud 148. Through wires 151 the closing of this contact 150 causes a solenoid or relay 171 to operate and open the switch 168 which turns off the solenoid 152 releasing the switch 170 and the pawls 155 stopping further operation.

Thus the friction drive 161 is released and under the action of a spring 164 the plate 162 carrying the contacting member 163 is drawn rapidly back to its original position wherein the member 163 is against a back stop 165. Obviously the position of the contacting post 148 carrying the contacts 150 determines how far the wind-up operations will proceed before being cut off. This contacting post 148 is carried by an arm 159 mounted on a gear 147 which is free to rotate on the shaft of the driving system. This gear 147 is adjusted through a pinion 146 which moves on a rack 145 which, as shown in Fig. 13 is mounted on the plate 141 which is horizontally fixed with respect to the camera housing 20. The pinion 146 is carried by the printing gate plate 84 and hence as this gate 84 is adjusted for length masking, the pinion 146 moves along the rack 145 and at the same time turns the gear 147 adjusting the position of the contacting stop 148. Thus this driving system constitutes means for accurately advancing the paper by an amount equal to the exposed area plus a suitable margin between prints. The actual take-up roll 118 is driven by the same motor 116 through gears 172 and 173 and the roll engaging member 175. Since this must be a slip drive to compensate for changes in diameter of the paper roll, a spring 174 is provided and the driving is done through this spring.

For rewinding, it is necessary to release the engagement between the rollers 118 and 119 and the driving wheels 166 and 175 respectively. This is done by a solenoid 179 whose core 178 is moved against a spring 181 causing the crank 177 to turn which in turn moves pawls 176 downward releasing the engagement between the driving wheels and the rolls as required.

The mechanical details of the viewing system are shown in Figs. 14 and 15. The viewing housing 96 carrying the mirrors 30 and 32 and the baffles 100 and lens 97 is positioned to move horizontally on suitable guides and is driven by a rack 133 and pinion 132. This pinion 132 is driven by a chain drive 131 by a motor 130. As the housing 96 moves completely out of the optical path an electric switch 134 is operated to shut off the motor 30 to prevent any further motion. As best shown in Figs. 1, 2, and 3 bellows 39 are provided to permit vertical motion of the record gate 21 and bellows 37 and 38 permit horizontal movement of camera 20 relative to lens 28 and eye-piece 33.

These Figs. 14 and 15 also illustrate the device for raising the plate 141 in the grooves 143. For this purpose racks 140 are mounted on the plate 141 and are driven by a motor 137 through suitable gears 138 and pinions 139.

These figures also illustrate the position of the focusing studs 45 and the wheels 136 upon which the whole camera mechanism 20 is mounted to move in grooves 135 in the printer housing 20'. This motion of camera 20 relative to the support 20' requires that some provision be made for the wire carrying current to the motors 120 and 160, etc. The wires (not shown) are held in the housing 20' and fed out over a roller 124 mounted on the rear thereof and back to the motors in the camera 20.

The operation of the printer is as follows. The transparency is loaded into the record gate 21. The magnification is set using the width of the transparency in auto-masking and auto-focusing as described above. The length masking is set. The mirror 27 is swung down to the position 27' in the objective beam, permitting viewing of the image on the ground glass 31. Then color balance is made with the filters 101, via buttons 106 and the exposure level is set with the wedge 107, via dial 110. The printing cycle is started by closing a switch button 112 shown in Fig. 1 which closes the shutter, preferably electrically. The viewing box 96 moves clear of the beam incidentally opening a switch 134, see Fig. 14, to prevent its being driven too far. An exposure is made by operating the shutter. The paper is advanced as described above. Incidentally, this may be repeated for multiple printing without bringing the viewing box back into the beam. Otherwise the viewing box is moved back into the beam, the shutter is opened for viewing and the objective mirror 27 is swung up to the upper position (27) for viewing the next transparency. Obviously, everything is done automatically as far as mechanical operations are concerned and only the minimum of skill is required on the part of the operator.

Having thus described our invention, we wish to point out that it is not limited to the specific structure shown, but is of the scope of the appended claims.

What we claim and desire to secure by Letters Patent of the United States is:

1. A projection printer for making a color print from a color transparency comprising a gate for holding the transparency, means for illuminating the transparency gate, a gate for holding color sensitive material upon which the print is to be made, a lens for focusing an image of the transparency gate on the print gate, a viewing screen substantially at right angles to the print gate, a removable mirror in front of the print gate for reflecting the image to said viewing screen, means for illuminating with sub-

stantially white light the borders of the screen which surround the image whereby the color of the image may be compared with that of the borders, color filters positionable in the light beam forming the image on the screen for altering the overall hue of said image to a natural hue compared with the white borders, means for moving said filters in and out of said light beam and a supporting housing for said gates, said illuminating means, said lens, said mirror, said viewing screen, and said filters and filter moving means.

2. A projection printer according to claim 1 in which there is also included an adjustable density wedge in said light beam and means for adjusting it.

3. A projection printer according to claim 1 in which a filter whose color is that which corrects the color balance of the color sensitive material is in the light beam illuminating said borders whereby when said overall hue is altered to a natural hue compared with the borders as white, correction both of the color balance of the original and for the color balance of the sensitive material is made.

4. A projection printed according to claim 1 in which a filter whose color is that which corrects the color balance of the color sensitive material is in the light beam illuminating said borders, and a filter of approximately the same color is in the light beam forming the image.

5. A projection printer according to claim 1 in which the means for illuminating the borders of the screen consist of a lamp behind the removable mirror and removable therewith, a truncated four-sided pyramidal mirror surrounding said lamp for reflecting light from the lamp past the removable mirror on all sides and to said borders and means for preventing light from the lamp reaching the image area inside said borders.

6. A projection printer for making a color print from a color transparency comprising a gate for holding the transparency, means for illuminating the transparency gate, a gate for holding color sensitive material upon which the print is to be made, a lens for focusing an image of the transparency gate on the print gate and a removable viewing box positionable between the lens and the print gate and having at least two windows therein, said box consisting of a housing, a viewing screen carried in the housing and visible through one of the windows, a mirror in the housing for receiving light through the other window from the lens and for reflecting it to said screen, the screen being positioned at the plane whereat the image is formed which corresponds to the one on the print gate, a positive lens adjacent to said other window for reducing the size and increasing the brilliance of the image on the screen compared to the alternative one on the print gate, means for illuminating the borders of the screen adjacent to the image area thereof, said illuminating means consisting of a lamp in the housing behind the mirror, an inverted pyramidal mirror carried in the housing for receiving light from the lamp and reflecting it past the first mentioned mirror on all sides to the screen, baffles including the first mentioned mirror for preventing light from the lamp reaching the image area of the screen and means for holding in the path of the light from the lamp to the screen borders, light filtering material whose color corresponds to that for which said color sensitive material is balanced.

7. A projection printer for making a color print from a color transparency comprising a gate for holding the transparency, means for illuminating the transparency gate, a gate for holding color sensitive material upon which the print is to be made, a lens for focusing an image of the transparency gate on the print gate, color filters positionable in the path of the light from said illuminating means for altering the overall hue of the printing beam, a density wedge adjustable in said light path for altering the intensity of the printing beam and a unit for standardization of the printing beam, said unit consisting of a viewing screen positioned in a plane optically equivalent to said print gate whereby on the screen is formed an image corresponding in color and intensity to the one on said print gate, borders on the screen adjacent to the area in which the image is formed, means for illuminating the borders with light of predetermined color and intensity, and a housing with a window to admit light from the lens, a window through which to view the viewing screens and borders and containing said screen and border illuminating means.

8. A projection printer according to claim 7 in which the standardization unit is completely removable as a unit for separate calibration.

9. A projection printer according to claim 7 in which the standardization unit includes filters positionable in the path of the light illuminating said borders whereby the border color may be adjusted to correspond to the sensitivity of the color sensitive material being used.

10. A projection printer according to claim 7 in which the standardization unit includes a positive lens in line with the light admitting window for reducing the size and increasing the brilliance of the image on the viewing screen whereby a correspondingly increased level of illumination is permitted for the comparison borders.

11. A projection printer according to claim 7 in which the standardization unit has the viewing screen substantially at right angles to the print gate, a mirror is positioned behind the light admitting window to reflect the light to the screen and the border illuminating means consists of a lamp behind the mirror, a pyramidal mirror for receiving light from this lamp and reflecting it past the mirror on all sides to the screen borders and baffles for preventing light from the lamp reaching the image area of the screen.

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CERTIFICATE OF CORRECTION.

Patent No. 2,256,385. September 16, 1941.

RALPH M. EVANS, ET AL.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 6, first column, line 46, for "arm 159" read --arm 149--; page 7, first column, line 26, claim 4, for "printed" read --printer--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 23rd day of December, A. D. 1941.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)

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