PATENT SPECIFICATION

Application Date : Dec. 4, 1934. No. 34872/34. **448,264**

Complete Specification Left: Feb. 21, 1935.

Complete Specification Accepted: June 4, 1936.

PROVISIONAL SPECIFICATION

Improvements in or relating to Colour Photography

We, WALTER CHAPMAN, a British Subject, of 71, Grovelands Road, Palmer's Green, London, N.13, and DUFAYCOLOR LIMITED, a British Company, of 19, New Bridge Street, London, E.C.4, do hereby declare the nature of this invention to be as follows:—

This invention consists in improvements in or relating to colour photography and has reference to the reproduction of colour photographs of the kind associated with a multi-colour screen composed of regular figures (e.g. lines and squares) by printing on to a photographic emulsion also associated with a multi-colour screen composed of regular figures. One form of multi-colour screen (see Patent Specification No. 322,432) is composed of a series of lines of one colour alternating with lines of squares of two other colours and the present invention will hereinafter be described with reference to this form of screen, (which will be referred to as the form described) although the invention is not limited to this particular regular screen.

Among the objects of this invention are to provide a method whereby the moire effects, which occur when photographs of the kind referred to are printed, are reduced or eliminated without at the same time causing undue loss of definition of the image, and whereby the colours of the master are particularly faithfully and brilliantly reproduced on the copy.

The present invention provides the method of contact printing a master photograph (negative or positive) on multi-colour screen material on to multi-colour screen copy material in which the master and copy are passed preferably continuously across a printing gate in the form of a narrow slot (3 to 4 mm. in width and of length at least equal to the width of the picture) and in which the beam of light used for printing is arranged to fill the length of the slot and to converge in a direction corresponding to the width of the slot so as to produce on the copy screen an image of each element of the master screen diffused in the direction of the width of the slot.

Preferably the beam is arranged to diverge to fill the length of the slot and is obtained by placing in front of the light source a large angle condenser, which projects an image of the light source, and in front of the condenser a convex cylindrical lens arranged with its axis parallel to the length of the slot, and to project this image on to the printing gate. The beam may be arranged to converge just to fill the width of the slot. If desired the beam may be divided into two converging beams by placing an opaque strip along the axis of the cylindrical lens or by forming on the lens two flat faces at a large angle to one another.

The clear aperture of the cylindrical lens, at right angles to its axis will be governed at its maximum by the aperture of the large angle condenser, but should this maximum angle of illumination give too much diffusion then the aperture of the cylindrical lens may be cut down to decrease the angle of incidence on the printing gate. This angle of incidence of the printing light could also be modified by altering the magnification of the image thrown by the cylindrical lens: modifying the focus of the cylindrical lens if necessary to obtain an image of the light source which just fills the gate.

To produce the best results the diffusion of the elements of one colour of the master-screen should be such that the images of these elements completely cover the copy screen. Since however the colour elements of the screen of the form described are not all equal, the continuous line having only a width of one half of the side of a square element it is preferred to employ a series of cylindrical lenses having various foci and apertures and to select empirically that lens giving the best compromise between diffusion and definition to suit the pitch of colour screen and thickness of base material employed.

When printing multi-colour screen photographs it is usually desirable to eliminate from the printing light those colours which would be transmitted by two or more colours of the copy screen and for this purpose sharp cut spectrum filters are employed, according to the

present invention, located between the cylindrical lens and the printing gate. The cross section of the beam is filled with one or more sets of filters; each filter being a parallel strip placed along the length of the cylindrical lens and of such width as to give the correct colour mixture. Preferably two sets of filters are employed, one set to each side of the axis of the lens, and the filters passing that colour (e.g. red) for which the greatest diffusion of the image is desired are arranged in the outermost positions. The greater the distance of the filters from the axis of the lens the greater will be the angle of incidence of the light passed by those filters on the screens and consequently the greater the diffusion of the images of the master elements of that colour.

It is important when printing colour photographs of the multi-colour screen type to employ a light source of constant composition and a feature of the present invention consists in placing in the path of the printing light a pair of overlapping neutral tint wedges and providing means for adjusting the degree of overlap of these wedges (which have the same rate of increase of opacity and are arranged to give in combination an area of uniform opacity) whereby the intensity of the light reaching the printing gate may be modified without altering its composition.

The degree of overlap of the wedges may be controlled automatically and the wedges moved in a series of steps to give a sufficient number of different intensities. If the master film has been graded and notched then the known " Debric " system may be used to provide two different electrical connections for each light change required. This system operates with a separate film perforated in accordance with the grading of the master film and moved step by step between spring contacts in accordance with the notching of the master film. The electrical connections given by this system may be employed to give eight positions for the wedges by means of six electro-magnets by the following arrangement.

The two wedges are connected together for simultaneous movement in opposite directions, for example by means of racks on each wedge working on opposite sides of a single pinion, and a main lever is pivotally connected at one end to one of the wedges. This lever is provided with a fulcrum at its centre and movable with the lever into two positions by two electromagnets and the other end of the lever is also movable into two positions by two further electromagnets. By energising suitable combinations of the four magnets four positions of the wedges may be obtained.

To obtain an additional four positions of the wedges the following arrangement is adopted. A pair of parallel operating levers are placed one each side of the end of the main lever remote from the wedges and are normally separated by a distance equal to the maximum travel of that end of the lever plus the width of the main lever. Each of these operating levers is pivoted about its centre and by movement of the levers by a still further pair of electromagnets, they may be made by engagement with the end of the main lever to move it into either of a further pair of positions intermediate between the two positions given by the magnets operating on the end of the main lever. These intermediate positions in combination with the two positions to which the fulcrum of the main lever may be moved give the four extra positions of the wedges.

The operating levers move the main lever to the intermediate positions by applying pressure to its end and, in order to ensure that the main lever does not move too far, that end of each of the operating levers which operates the main lever is subdivided at a point along its length and the two parts are pivoted together. The subdivided portions, which are the operating members contacting with the main lever, are extended from their pivots along the length of the operating levers away from the main lever and the extended ends of the two subdivided portions are bent into contact with one another. Stops are provided on the operating levers (or subdivided portions) to prevent rocking movement of the extended end of either of the subdivided portions with respect to its operating lever in the inward direction towards the other operating lever. The effect of this arrangement is that on actuation of an electromagnet to rock one of the operating levers so that the subdivided portion of that lever is moved inwardly towards the other lever (which remains stationary) the main lever is pushed into an intermediate position. At the same time the contacting ends of the subdivided portions cause the subdivided portion of the stationary operating lever to rock about its pivot on that lever and its operating end also to move inwardly. The relative dimensions of the levers and subdivided portions are so selected that at the end of the desired movement of the main lever the subdivided portions are each in contact with the main lever and

accurately locate its position by gripping it on opposite sides.

By this arrangement the wedges may be moved into any one of eight positions (the relative length of the various levers and movements of the magnets being suitably chosen) and in each case the operating magnet may be caused to move a part up to a fixed stop thus ensuring that the desired position is accurately attained. Furthermore, it is only necessary to energise two of the magnets to obtain any one of the eight positions.

Dated this 4th day of December, 1934.

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COMPLETE SPECIFICATION

Improvements in or relating to Colour Photography

We, WALTER CHAPMAN, a British Subject, of 71, Grovelands Road, Palmer's Green, London, N.13, and DUFAYCOLOR LIMITED, a British Company, of 19, New Bridge Street, London, E.C.4, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention consists in improvements in or relating to colour photography and has reference to the reproduction of colour photographs of the kind associated with a multi-colour screen composed of regular figures (e.g. lines and squares) by printing on to a photographic emulsion also associated with a multi-colour screen composed of regular figures. One form of multi-colour screen (see Patent Specification No. 322,432) is composed of a series of lines of one colour alternating with lines of squares of two other colours and the present invention will hereinafter be described with reference to this form of screen, (which will be referred to as the form described) although the invention is not limited to this particular regular screen.

Among the objects of the invention is to provide a new or improved apparatus for printing multi-colour screen photographs in which a light beam of form particularly well adapted for printing such photographs is employed. A further object is to provide a printing apparatus whereby the moire effects, which occur when photographs of the kind referred to are printed, are reduced or eliminated without at the same time causing undue loss of definition of the image, and whereby the colours of the master are particularly faithfully and brilliantly reproduced on the copy.

It has already been proposed to employ, during printing of multi-colour screen photographs, devices which produce on the copy screen a plurality of images, or a diffused image, of each of the master screen elements for the purpose of reducing moire and of improving the colours of the copy.

The present invention provides apparatus for use in contact printing a master photograph (negative or positive) on multi-colour screen material having a multi-colour screen composed of regular figures on to copy material also having a multi-colour screen composed of regular figures and comprising in combination a printing gate in the form of a narrow slot (usually about $\frac{3}{8}$ inch in width) and extending across the full width of the picture being printed, a light source, and an optical system comprising a large angle condenser arranged to project an image of the light source, and a cylindrical lens with its axis substantially parallel to the length of the slot and with its principal focus at (or closely adjacent to) the plane of the image of the light source aforesaid, the arrangement being such that the cylindrical lens directs light from that image through the printing gate.

In this apparatus the printing beam diverges in the direction of the length of the slot and may be arranged to fill the slot in that direction while it may be substantially parallel in a direction across the width of the slot, if an image of the light source which is of small dimensions and a plain cylindrical lens are employed.

In order, however, to produce a diffusion of the images of the master screen elements on the copy screen for the purpose of reducing moire and of improving the colours it is preferred to produce an image of the light source projected by the condensing lens which in a direction across the slot is larger than the width of the slot.

The term "contact printing" as used in this specification is intended to mean that the master and copy materials are either in contact or are separated by only a small distance during the printing steps but it is to be understood that in every case the master and copy multi-colour screens are separated by a small amount

(usually the thickness of one or both of the base materials) and it is this separation which enables the desired diffusion of the images to be obtained.

The light transmitted through the cylindrical lens, from any portion of the image lying off a central plane passing through the optical axis of the system and parallel to the printing slot, will emerge approximately parallel from any given point on the image when an enlarged image as described above is employed; but its direction of emergence will be inclined to the light from the central line of the image and in a direction towards the central plane referred to.

Preferably the cylindrical lens has a width at least double that of the printing slot in order that the lens may be of practical dimensions and consequently the light emerging from the lens will illuminate an area much wider than the printing slot. According to a preferred feature of the present invention the light emerging from the cylindrical lens is divided into two portions which overlap at the printing gate by forming on the cylindrical lens two facets at an angle less than 180° with each other and with their line of intersection parallel with the axis of the lens. With this arrangement the proportion of useful printing light is considerably increased.

It is important when printing colour photographs of the multi-colour screen type to employ a light source of constant colour composition and therefore any arrangement which is employed for varying the light intensity must be such as not to vary the colour composition as would be the case if for example a variable resistance were employed in the circuit of an electric lamp. According to a further preferred feature of this invention adjustable masking plates inserted in the light beam are employed to moderate the light intensity by cutting out by absorption variable proportions of the beam without varying the composition of the remaining light. These masking plates are so arranged as not to reduce substantially the overall dimensions of the image of the light source produced by the condensing lens, this image being of extended dimensions in this case.

The invention will now be described by way of example with reference to the accompanying diagrammatic drawings in which:—

Figure 1 represents a section of the optical system in a plane containing the axis of the cylindrical lens and the centre line of the printing slot;

Figures 2, 3 and 4 are sections through the optical system in a plane at right angles to that of Figure 1;

Figure 5 illustrates the variable masking plates in three positions;

Figure 6 illustrates one way in which movement of the masking plates may be effected;

Figure 7 is a view of part of the mechanism shown in Figure 6 in a plane at right angles to the plane of that Figure, and

Figure 8 shows one form of light filter.

Referring first to Figures 1 to 3, the light source is represented by 1 and may be, for example, a projector type of electric filament lamp, and has large overall dimensions compared with the width of the printing slot 2 as shown in Figures 2 and 3. An image of the light source is formed in a plane 3 by means of a large angle condensing lens 4, a mask 5 being provided to delimit the dimensions of the image, and to cover the grid slots not required (as will be described later). A cylindrical lens 6 is arranged with its principal focus in the plane 3, and with its axis parallel to the length of the printing slot so that as shown in Figure 1 the diverging beam from the image of the light source at 3 passes through the lens without deviation in the direction of the length of the slot and at least fills the slot in this direction. In the direction corresponding to the width of the slot, however, light from any point of the image emerges from the cylindrical lens substantially parallel although, as shown in Figure 2, the beam as a whole will not be parallel due to the substantial size of the light source.

The width of the cylindrical lens is made at least twice that of the slot in order that the lens may be of practicable radius with the result that, with a plain cylindrical lens as shown in Figure 2, the beam emerging from the lens is of width greater than that of the printing slot whereby a considerable amount of available light is wasted. In order that the maximum amount of light may be usefully employed two facets are cut on the lens as shown at 7 in Figure 3, the angle between the facets being so chosen that the beams from the two halves of the lens overlap at the printing slot and substantially fill the width of the slot.

To produce the best results as to brilliancy of colour and minimum moire the diffusion of the images of the master screen elements of one colour on the copy screen should be such that these images completely cover the copy screen. Since, however, the colour elements of a screen of the form described, to which form the present example refers, are not all equal in size and shape, the continuous line

having only a width of one half of the side of a square element, it is preferred to select empirically that lens which has the best focal length and aperture to give the best compromise between diffusion and definition to suit the pitch of colour screen and thickness of base materials employed. In Figure 3 the master film is represented by 9 and the copy film by 10 and it will be seen that with a suitable small spacing between the two films the image of a master screen element 11 will be considerably enlarged on the copy screen as shown at 12 and will overlap more than one element of the copy screen. Each element of the master screen will have an enlarged image formed on the copy screen and these images will of course overlap one another, thereby ensuring that each element of the copy screen is illuminated by light passing through a master element of similar colour.

When printing multi-colour screen photographs it is usually desirable to eliminate from the printing light those colours which would be transmitted by two or more colours of the copy screen and for this purpose sharp cut spectrum filters 8 are employed, located between the cylindrical lens and the printing gate. The cross-section of the beam is filled with one or more sets of filters; each filter being a parallel strip placed along the length of the cylindrical lens and of such width as to give the correct colour mixture. Preferably two sets of filters are employed, one set to each side of the axis of the lens. A suitable set of filters is shown in Figure 8 in which 13 represents the blue strips, 14 the red strips and 15 the green strips, the transmission of the several strips being so narrow that none of them passes any substantial amount of light which would be transmitted by any of the screen elements of different colour.

In order that the intensity of the printing light may be varied without varying the colour composition of the light or the overall dimensions of the image formed by the condensing lens a pair of masking plates 16 are provided in the path of the beam at the plane of the image (which in this case is of extended size) and are arranged to cut out by absorption variable proportions of the light. The masking plates are of grid formation, as shown in Figure 5, and the two grids are movable in the same or in parallel planes. When the masking plates are together as shown in Figure 5A light passes through a series of slots 18 giving minimum light intensity, with a large effective light source. To obtain maximum light intensity the masking plates are separated until they are outside the mask 5 as shown in Figure 5C. A position of the masking plates giving an intermediate light intensity is shown in Figure 5B. It is to be observed that in every position of the masking plates a printing light of comparatively large overall dimensions is provided and the variation in these dimensions is so small that it will not be material.

The following is a table giving, as a specific example, ten positions of masking plates having the relative dimensions shown in Figure 5 in which the effective aperture is increased by approximately 20% at each step. Between positions 4 and 5 the outermost pair of slots move behind the mask 5 and between positions 8 and 9 the inner slots move behind the mask.

Position.	Total Width of Slots.	Width of Centre Opening.	Total Width of Opening.
No. 1	.16	0	.16
No. 2	.16	.04	.20
No. 3	.16	.09	.25
No. 4	.16	.15	.31
No. 5	.08	.30	.38
No. 6	.08	.39	.47
No. 7	.08	.49	.57
No. 8	.08	.64	.72
No. 9	0	.90	.90
No. 10	0	1.12	1.12

The operating mechanism for moving the masking plates is shown in Figures 6 and 7. The masking plates are slidably mounted on guides 19 and coupled to each plate is a bell-crank 20 actuated by a single rod 21 attached to a bar 22 of uniform width. The bar 22 is constrained to move only in a direction at right angles to its length and in the plane of the rod 21 and bell-cranks 20 by fixed guides, not shown. Closely adjacent to the bar 22 is a fixed bar 23 cut in a series of steps each of which corresponds to one step of the masking plate movement. The width of the bar 23 is the same as that of the bar 22 at each step except at each of the end steps where the width is slightly less than that of the bar 22. A pair of stops 24 are attached to the bar 23 at each end thereof to limit the maximum movement of the bar 22. A series of levers 25, 26 and 27 arranged for actuation by electro magnets are provided for moving the bar 22, which movement is transmitted to the masking plates by the rod 21 and bell-cranks 20. The end levers 25 are simple levers and move the bar against the stops 24. The intermediate levers are arranged like a pair of scissors as shown in Figure 7 with one end of the lever 27 pivoted to a fixed member 28 and the correspond-

ing end of the lever 26 arranged for actuation by an electro magnet 29.

If the electro magnet is energised the "scissor" levers are closed against the bar 23, which forms a fixed stop, and at the same time move the bar 22 into coincidence with the appropriate step of bar 23 and the masking plates into corresponding position.

The electro magnets, one for each pair of levers 26, 27 and one for each of the end levers 25, are controlled from markings on the master film (e.g. notches or staples in the film) which are made at positions of change of density in the film by known methods.

With the arrangement shown in Figures 1 to 3, the light intensity at the centre of the beam is greater than that at the edges of the beam. If it is desired to obtain a more even distribution of light intensity a mask of circular, strip or other form may be inserted on the centre line of the beam as shown at 17 in Figure 4 or alternatively as shown at 17^1. The use of a mask so placed reduces the amount of light which is more or less normal to the screen without reducing that which reaches the screen at a substantial angle. A mask arranged in this manner may be employed in the methods described with reference to Figure 2 or Figure 3.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Apparatus for use in contact printing a master photograph (negative or positive) on multi-colour screen material having a multi-colour screen composed of regular figures on to copy material also having a multi-colour screen composed of regular figures and comprising in combination a printing gate in the form of a narrow slot (usually about $\frac{3}{8}$ inch in width) and extending across the full width of the picture being printed, a light source, and an optical system comprising a large angle condenser arranged to project an image of the light source, and a cylindrical lens with its axis substantially parallel to the length of the slot and with its principal focus at (or closely adjacent to) the plane of the image of the light source aforesaid, the arrangement being such that the cylindrical lens directs light from that image through the printing gate.

2. Apparatus as defined in claim 1, further characterised in that the overall dimensions of the image of the light source in a direction across the slot are larger than the width of the slot.

3. Apparatus according to claim 1 or claim 2, wherein the cylindrical lens has two facets formed on its surface at an angle less than 180° with each other and with their line of intersection parallel with the axis of the lens, the arrangement of and the angle between, the facets being such that the light from each half of the lens overlaps at the printing gate either completely or to a considerable extent that from the other half.

4. Apparatus according to claim 2 or claim 3 having masking plates located in the light path for moderating the light intensity without substantial variation in the size of the image produced by the condenser and consisting of two grids which may be moved in a single plane or in parallel planes from a position in which the grids are closely adjacent and light is passed substantially only between the bars of the grids, giving minimum light intensity, to a position in which the grids are widely separated and light is free to pass between the grids giving maximum light intensity.

5. Apparatus as claimed in claim 4 and having means for automatically moving the masking plates in steps.

6. Apparatus as claimed in claim 5 wherein the masking plates are moved by electro-magnets operating scissor levers having between their arms a member attached to the masking plates and arranged by a closing movement of the arms to move that member into coincidence with a fixed stop which is embraced by the arms substantially as described.

7. Apparatus as claimed in any one of claims 1 to 6 and comprising sharp-cut filters located in the path of the light beam and arranged to cut out light of colour which would be transmitted by any two colours of the screen.

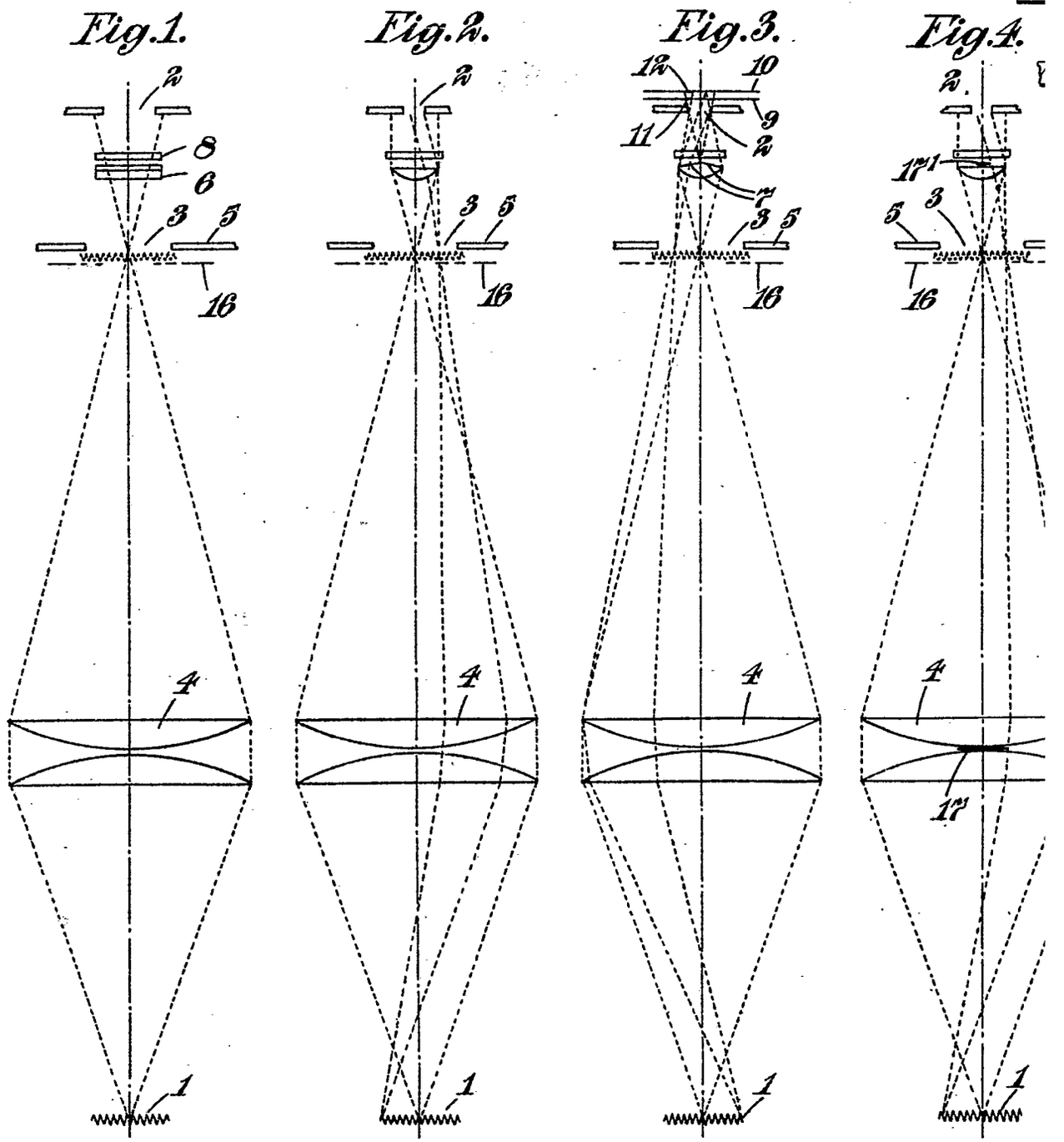
8. Apparatus as claimed in any of claims 1 to 7 and having a mask on the centre line of the light beam to obtain a more even distribution of light at the printing gate.

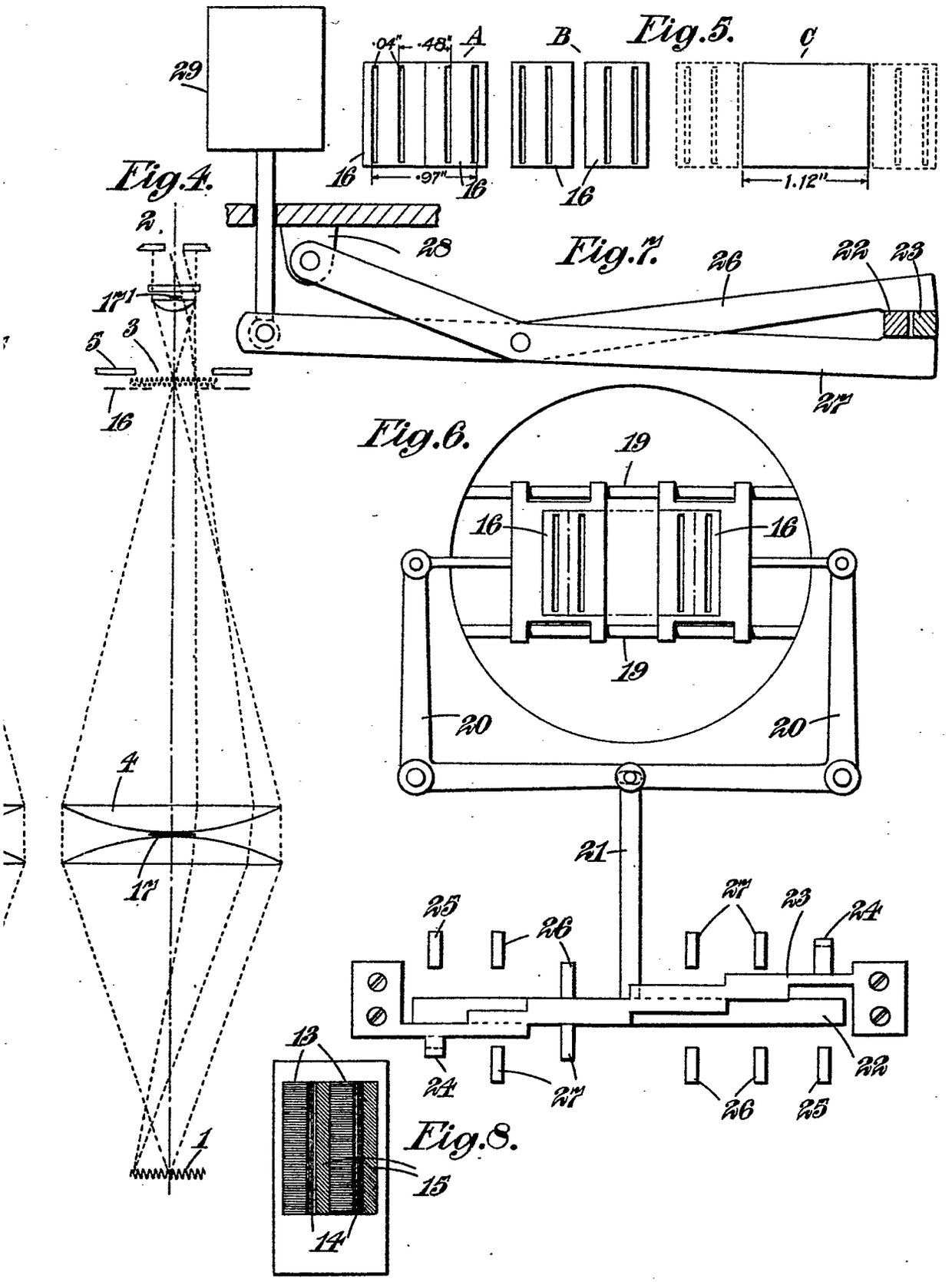
9. Apparatus according to any one of the preceding claims and substantially as herein described.

Dated this 21st day of February, 1935.

BOULT, WADE & TENNANT,
111/112, Hatton Garden, London, E.C.1,
Chartered Patent Agents.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1936.





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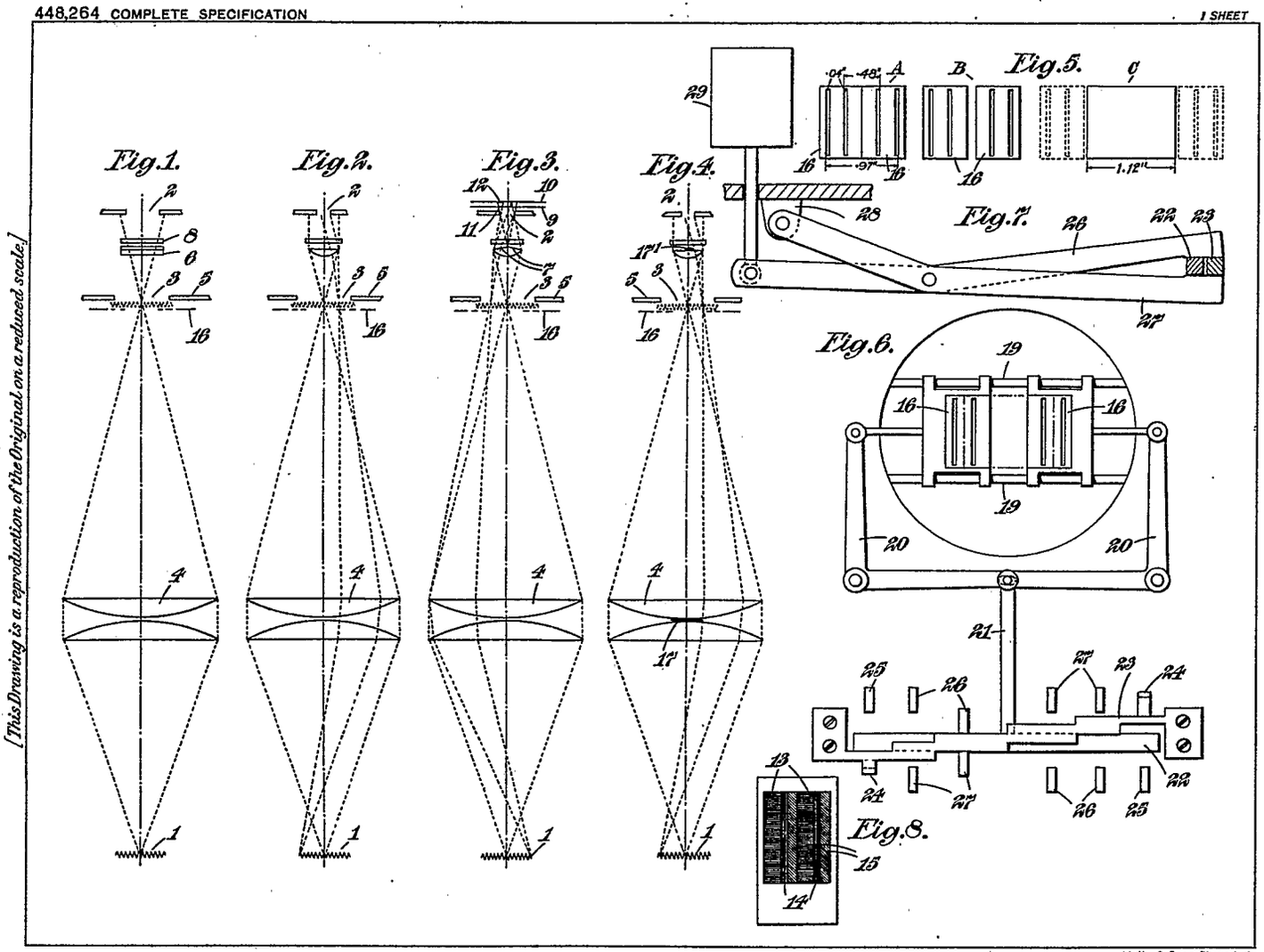

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