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(54) IMPROVEMENTS IN AND RELATING TO ELECTROPHOTOGRAPHIC COPYING

(71) I JOHN MICHAEL PAYNE a British Subject of 13 Crowson Crescent, Northborough, Peterborough do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:

This invention concerns electrophotographic copying.

The basic principle behind electrophotographic photocopying processes is the fact that when a paper which is coated with a suitable photocopying material such as zinc oxide is subjected to an electric charge it will retain that charge unless exposed to light. By imagewise exposing the paper to light the charge is dissipated and this factor can be used to build up an electrostatic image in place of an optical image by forming an optical image of a document or scene onto the charged paper whereupon the charge will be dissipated in areas of the optical image which are brightly lit and will be less dissipated or not dissipated at all in areas which are less brightly lit or are dark. The paper containing the electrostatic charge pattern can then be placed in a solution of carbon black and dispersant or carbon powder can be cascaded over the paper and it is found that the carbon black will be attracted to those areas which are still charged. If employed the dispersant is then allowed to evaporate and the carbon is left on the paper or if a powder has been cascaded onto the paper is impregnated into the paper by being rolled between rollers which may be heated.

By using suitable powders and microencapsulated inks, it has been possible to dispense with the heated rollers and simply cold roll the paper so as to impregnate the latter with the carbon.

Depending on the way in which the optical image is formed, it may be necessary to provide for image reversal within such apparatus and this can either be achieved optically by using additional lenses or an intermediate plate may be used sometimes in the form of a drum on which the electros-

tatic image is formed and to which the carbon powder or carbon black is attracted and against which an ordinary plain piece of paper can then be pressed so as to transfer the carbon from the plate or drum to the plain paper.

With these points in mind it is an object of the present invention to provide a photocopying process which is of general application to all photocopiers but is of particular application to an apparatus which is designed to be of a portable nature.

According to the present invention, there is provided an electrophotographic process in which a photoconductive plate (including a sheet of paper or a drum) is uniformly charged electrically and then imagewise exposed to light to form an electrostatic charge pattern corresponding to an image which is to be copied for attracting thereto a printing medium (toner) such as powder or encapsulated ink, characterised by a piezo-electric crystal generator for generating the electrostatic charge to be applied to the plate.

A piezo electric crystal will produce a high voltage if compressed and an equal and opposite polarity high voltage when the pressure is released and the crystal is allowed to assume its undistorted condition. This dual polarity high voltage can be used to advantage by using one polarity to charge the photocopy plate (i.e. paper or drum etc.) and the other polarity to charge the carbon powder or carbon black usually referred to as toner. This dual charging action greatly enhances the attraction of the toner powder to the charged plate. To this end the apparatus preferably includes means for applying a compression force to the crystal and releasing same and synchronous means for diverting the charge of one polarity to the toner and the charge of the other polarity to the plate. Typically the synchronous means for diverting the charges of different polarity comprise diodes but alternatively mechanically operated switches operated in synchronism with the application and withdrawal of the compression force may in addition or alternatively be used.

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In order to produce a uniform charge over the plate whether it be a sheet of coated paper or a drum, the electrical output from the generator is applied either to a line of charge transmitting elements each operating on the so-called points discharge principle and located relative to the surface of the drum so that as the latter rotates the charge is transferred equally and evenly to the surface of the drum or in the case of a plain plate, the transmitter comprises a grid of conducting elements such as wires or thin strips of foil and the grid is located above the sheet at a distance therefrom such that whilst the electrical charge from the grid ionises the air and transfers to the plate as required, at the same time does not produce an in-focus image of itself on the plate when the optical image is projected onto the plate after charging.

Alternatively the charge can be produced from a single point discharge device. The use of an earthed frame produces a more even spread of charge, the frame comprising a ring of wire or conductive strip material which bounds the area over which the charge is to be applied.

Where a flat plate is incorporated the grid used to charge the plate may alternatively be hingeable or slidable between two positions a first dormant position which the grid normally occupies (in which it does not protrude into the optical system which is incorporated to produce an optical image on the charged plate) and a second active position (in which the grid is spaced at an appropriate distance from the plate and lies fully in the optical system to allow charge to be transferred to the plate from the grid). In operation the apparatus is designed to move the grid from the dormant position to the active position just prior to the generation of the high voltage charge and after the charge has been transferred to the plate is adapted to move the grid back to its dormant position so that the plate is ready to have the optical image exposed thereto.

The invention will now be described by way of example with reference to the accompanying drawings.

Fig. 1 is a diagrammatic side view of a first apparatus embodying the invention,

Fig. 2 is a similar view of a second apparatus embodying the invention,

Fig. 3 is a plan view of the second apparatus sectioned on the line AA,

Fig. 4 is a similar view of a third apparatus embodying the invention,

Fig. 5 is a similar view of a fourth apparatus embodying the invention,

Fig. 6 is a plan view of the fourth apparatus sectioned on the line BB, and

Fig. 7 is an end view of the feed and transport of the adhesive backed and plain transparent sheet material incorporated in

the fourth apparatus.

Apparatus for producing photocopies from transparencies so that no reversal of the image is required is shown in Fig. 1. This first apparatus comprises a flat bed of electrically insulating material 10 on which a sheet 12 of coated photocopy paper can be laid, a piezo electric crystal generator 14 and a diode 16 and discharge conductor 20 for transferring charge of one polarity from the generator 14 to the paper 12. An optical system including a lens 44 produces an image on the coated paper 12 after the latter has been uniformly charged. Rollers 24, 26 and a bath of toner (or developer) 28 serve to apply a printing medium to the paper, i.e. cause toner to be attracted to those areas of the paper which bear the charged image, a second roller pair 30, 32 being provided for squeezing the impregnated paper to fix the image.

The means for applying the toner, e.g. powder or encapsulated ink, to the paper may comprise a bath through which the paper is drawn or a reservoir of powder or ink having a transfer roller for picking up powder or ink and transferring the latter to the surface of the paper as the latter is rolled thereover.

The rollers 30, 32 for fixing the powder or ink to the surface of the paper may be heated by heaters (not shown) or may be cold. Alternatively, not shown, an aerosol spray may be provided for forming a quick drying transparent film of cellulose of the like over the surface of the paper after the carbon or ink has been applied thereto and an image formed thereon.

The document 42 to be copied is laid face down on a glass plate 34 and covered by a flexible light-tight cover 36. The document 42 is illuminated by fluorescent tubes 38, 40. A reversed image of the document is formed by lens 44 on the sheet of charged paper 12.

The paper 12 can be inserted through an opening 46 and is conveyed to and from its position on the plate 10 by transport rollers 48 and 50.

Figs. 2 and 3 illustrate a second apparatus which includes a frame 52 for holding a transparency and which can be slid into the apparatus to cause the transparency to be brought into contact with the sheet of paper 12 on which the image is to be formed so as to produce a so-called contact print. A number of fluorescent tube lights 54 provide a source of light for illuminating a transparency 56 to form an image thereof on the charged paper 12 so as to produce an electrical charge pattern required for the later stages of the process.

Alternatively, not shown, the light source may comprise a translucent plate through which ordinary ambient lighting can pass.

An optical condensing system (not shown) may be incorporated so as to produce substantially uniform illumination of the transparency from ambient light or from a light source incorporating one or more flash-lamps or fluorescent tubes.

A light source incorporating a gas discharge tube which may be activated from a piezo electric crystal generator may be incorporated in any of the embodiments herein described, so that a secondary source of electricity (either batteries or supply mains) is not required for the light source. In fact the same piezo electric crystal generator may be employed for charging the toner or developer, the paper (or plate) and for energising the light source. To this end each of the apparatus shown in Figs. 1 to 3 is assumed to have such a source and a switch 58 is provided for directing the charge from the electrostatic generator 14 as appropriate to the different parts of the apparatus.

Fig. 3 shows the plan layout within the apparatus of Fig. 2. The frame 52 can be slid into and out of the housing 60 to locate the transparency 56, laid thereon, above the sheet 12. After exposure to the light the frame 52 is withdrawn.

A diode 62 (see Fig. 2) ensures that only the appropriate polarity charge reaches the tubes 54 and multiple flashes may be employed to increase the exposure.

In the embodiment of Fig. 2 a roller or brush 64 loaded with toner is moved across the sheet 12 and back to its rest position. Thereafter a roller 66 loaded with lacquer or simply pressing down on the sheet, is moved over the latter and back again to fix the remaining toner onto the sheet, which can then be removed as a finished photocopy from the housing 60 by drawing out the plate 10 by its handle 68. Handles 70 and 72 are provided on the rollers 64 and 66 respectively.

Where reversal of the image is necessary this can be achieved optically using an intermediate lens as in Fig. 1 between the illuminated document and the sheet of charged paper. Alternatively, an intermediate step in the process can entail the use of an intermediate master which may be disposable or comprise part of the Fig. 2 apparatus.

Dealing first with the disposable type of plate, this may comprise a transparent or translucent sheet of plastics material one surface of which is coated with a suitable material which can be charged and then imagewise exposed to light so as to produce an electric charge pattern thereon corresponding to the image as previously described, which is then developed. By using a transparent medium to form an intermediate master with a reverse image, with the coated surface being that which is

exposed to the light, a transparency can be obtained which can then be used in a contact type process in the same apparatus using a sheet of ordinary coated paper to which the contact light image is applied after charging. The sheet of ordinary coated paper after exposure is then subjected to toner and fixing as previously described to produce a print the correct way round.

It will be appreciated that the intermediate master may be used to produce other prints by the contact process without the need to produce one or more intermediate copies and the intermediate process is therefore most cost effective when a large number of copies of a single document are required. The transparent or translucent intermediate sheet is then discarded at the end of the run or can be stored if required for future use.

Where the apparatus is to be used generally and in the main for single copies from different documents, the cost of the disposable intermediate sheets can be mitigated by using a re-usable intermediate sheet of suitable transparent or translucent material coated with the suitable medium and the image formed thereon as previously described with reference to the disposable sheet. The intermediate plate containing the reversed image is then developed and a reversed print obtained on the coated surface of the intermediate plate and fixed in position using a fixing means which can be removed subsequently so as to remove all traces of the powder or ink so as to render the surface clean and reusable. To this end an aerosol spray or lacquer roller may be used to semi-permanently fix the toner in place so as to produce the reverse intermediate master needed for subsequent contact prints.

The reverse intermediate master so produced is then used in conjunction with a sheet of coated paper in the same apparatus so as to expose the sheet of coated paper (after it has been charged) to an optical image of the reversed intermediate master which when exposed to toner and fixed produces a print the correct way round.

After the appropriate number of copies have been obtained, the surface of the intermediate plate can be cleaned and rendered reusable.

It is of course important that the apparatus previously described (and to be described) is contained within a light-tight housing such as 60 (see Fig. 2) so that after the coated paper or plate (photocopy paper or plate) has been charged electrically, no light falls thereon except as provided by the exposure to the optical image of the document or transparency to be formed thereon.

Where an intermediate plate is required and either a disposable or semi-permanent

plate is used, the size of the latter can be reduced by not employing a contact process but by using a lens to form a reduced image of the document or scene to be copied and using a disposable or semi-permanent intermediate transparent plate of commensurate size with the reduced size image. One form of such apparatus is shown in Fig. 4. Having exposed the intermediate plate to the reduced size image and forming the reversed transparency thereon, the optics can be reversed so as to produce an enlarged image of the transparency on a sheet of ordinary coated photocopy paper which can then be processed to form a print in a manner as previously described.

The apparatus of Fig. 4 comprises a light-tight housing 74 having a glass plate 34 and flexible cover 36 for locating a document 42 as in Fig. 1. Likewise fluorescent tube lights 38 and 40 are provided for illuminating the document and power therefor is obtained from a piezo electric source 14 when switch 76 is in position (1).

A lens 78 forms a reduced size image of the document on a photocopy plate 80 carried on a movable support 82.

A first roller/brush 84 from a toner bath 86 is slidable across the plate 80 after exposure and a second roller 88 from a lacquer bath 90, for temporarily fixing the image on the plate.

Below the plate 82 is a condensing lens assembly 92 and further fluorescent tube source 94 and reflector 96.

In position (2) switch 76 conveys charge from the source 14 to a charging conductor 20 and in position (3) switch 76 conveys charge to the tube 94.

In use a reversed charged, imagewise exposed and developed image is first formed on the photocopy plate 80, from a document 42. The switch is then put to position (3) and in darkness a sheet of charged photocopy paper is placed face down on the glass plate 34, so that when the source 14 is operated the light from 94 forms an image of the transparency on the charged photocopy paper, which can then be processed through a toner bath and fixer (not shown) to produce a finished photocopy.

The advantage of this particular method is that if a lens is to be employed to reverse an image so as to obtain a full size reversed image the spacing between the document to be copied and the plate or sheet of paper must be twice the focal length of the lens. Since a fairly long focal length lens will normally have to be employed, the apparatus is liable to become cumbersome in size if such a distance has to be employed and by adopting this alternative method, a smaller focal length lens may be used with no degradation of optical quality.

In another method which may be based

on the full sized contact reversal process previously described or may incorporate a reduced size intermediate plate as just described with reference to Fig. 4, the intermediate plate may be formed by imagewise exposing a charged surface, applying toner thereto but instead of fixing the toner in place, applying a sheet of transparent material having a suitable adhesive transparent backing onto the said surface (with the adhesive side in contact with the said surface) thereby to pick up the toner remaining on the charged areas of the surface. The transparent sheet can then be removed from the said surface and the toner adhering to the adhesive backed surface thereof fixed in place by means of a second sheet of transparent material which may or may not incorporate an adhesive surface but if it does the two sheets of transparent material are located so that the two adhesive backed surfaces are in contact. The toner adhering to the first adhesive surface is trapped between the two sheets of transparent material and a transparency is thereby formed which can then be used for projection purposes to form either a full sized contact print or where a reduced sized image has been used, either to produce a reduced sized contact print or by suitable enlargement a full size or even enlarged size print on a sheet of coated paper. The surface which is charged may subsequently be cleaned as by a traversing roller or brush before being re-charged for subsequent exposures.

Apparatus for performing the method just outlined is shown in Figs. 5 and 6. This apparatus is very similar to that shown in Fig. 4 and the same reference numerals have been used to depict items in common. The chief differences lie in the provision of

(a) a cleaning roller/brush (not shown) in place of the lacquer roller 88, by which the surface of the photocopy plate 80 can be thoroughly cleaned of toner powder,

(b) a roll 100 (see Figs. 6 and 7) of adhesive backed transparent sheet (similar to Sellotape (Registered Trade Mark) ) with means (not shown) for drawing the tape over the plate 80 and lowering the tape with the adhesive side on the underside into contact with the toner marked charge pattern on the plate (after the latter has been exposed and toner applied thereto by toner roller 84).

(c) a second roll 102 of non-adhesive backed transparent tape,

(d) a pair of rollers 104, 106 forming a nip between which the two transparent sheets are squeezed, with the adhesive layer in contact with the upper side of the non-adhesive sheet, so that the two are stuck firmly together and the toner powder adhering to the underside of the first sheet is sand-

wiched firmly therebetween, and

(e) a guillotine 108 (see Fig. 7) for severing the region of the sheet bearing the "transparency".

- 5 By removing the plate support 82 and plate 80 and inserting in place the transparency and with switch 76 in position (3), a sheet of charged photocopy paper placed on glass plate 34 can be exposed to the transparency and subsequently processed through a toner bath and fixed as previously described.

15 It is to be understood that this last aspect is not limited to the use of coated photocopy paper as the final medium for impressing the final image thereon but can also be used with a plain paper copier in which an intermediate photocopy member is used.

20 Where a full size reverse plate or a suitable master document is available so that it can be laid in contact with a sheet of sensitized paper in a reflex image forming technique the flat surface on which it is laid may comprise the light source and may comprise 25 a translucent sheet with one or more point light sources behind it or may comprise a sheet of semi-conductor material which glows when a suitable potential is applied thereto. However it is to be understood that 30 the invention is not limited to any particular form of light source or any particular form of producing uniform illumination of the said flat bed.

35 The procedure for forming an image on a charged sheet by a reflex process is then as follows:—

1. The sheet of transparent coated paper is laid on the flat bed and in complete darkness is charged electrically.
- 40 2. Still in complete darkness the document which is to be copied is laid face down onto the charged surface with the printing or other material which is to be copied in contact with the charged surface.
- 45 3. The reverse side of the coated paper is then exposed to light for a prescribed interval of time.
4. Again in the dark, the document is removed and toner powder applied thereto.
- 50 5. The toner powder which adheres to the charged areas on the paper is then fixed in position either by being rolled so as to impregnate the paper or sprayed with a quick drying material which produces a transparent film over the entire surface of the paper and may for example comprise 55 cellulose or an aerosol.
6. Alternatively instead of fixing the toner powder on the sheet of paper, a sheet 60 of adhesive backed transparent material such as a sheet of Sellotape (Registered Trade Mark) or the like is applied to the surface of the sensitized paper containing the toner image so that the toner remaining 65 on the paper is picked up by the adhesive

backed transparent medium. The picked-up toner can be fixed in position by peeling the adhesive backed material from the sensitized paper and sticking the adhesive backed surface onto another sheet of transparent material which may be plain or may itself 70 have an adhesive surface which is laid in contact with the adhesive surface bearing the toner of the first transparent sheet material.

75 The transparency so produced can then be used to produce positive prints by a photocopying process as described above, on suitable paper.

#### WHAT I CLAIM IS: 80

1. An electrophotographic process in which a photoconductive plate (including a sheet of paper or a drum) is uniformly charged electrically and then imagewise exposed to light to form an electrostatic charge pattern corresponding to an image 85 which is to be copied for attracting thereto a printing medium (toner) such as powder or encapsulated ink, characterised by a piezoelectric crystal generator for generating the electrostatic charge to be applied to the plate. 90
2. A process according to claim 1 characterised by a switching device which allows charge of one polarity only to be 95 applied to the plate.
3. A process according to claim 2 characterised by a second switching device which allows charge of opposite polarity to the said one polarity to be applied to the 100 toner to enhance the attraction of the toner to the charged plate.
4. A process according to any one of claims 1 to 3 characterised in that the charging step is effected by a line of charge 105 transmitting elements each operating on the so-called points discharge principle and located relative to the surface of the plate and means for moving relating to the charge transmitting elements so that charge is 110 transferred equally and evenly to the surface of the plate.
5. A process according to any one of claims 1 to 3 characterised by a grid of conducting elements such as wires or thin strips 115 of foil located above the sheet at a distance therefrom such that whilst the electrical charge from the grid will ionize the air and transfer charge to the plate as required, at the same time the plate will not produce an 120 in-focus image of itself on the plate when an optical image is projected onto the plate after charging.
6. A process according to claim 5 characterised in that the plate is hingeable 125 or slidable between two positions, a first dormant position which the grid normally occupies (in which it does not protrude into the optical system which is incorporated to produce an optical image on the charged 130

- plate) and a second active position (in which the grid is spaced at an appropriate distance from the plate and lies in the optical system to allow charge to be transferred to the plate from the grid).
- 5 7. A process according to any one of claims 1 to 3 characterised by a single point discharge device and an earthed frame comprising a ring of wire or conductive strip material which bounds the area over which the charge is to be applied, to produce an even spread of charge over the surface.
- 10 8. A process according to any one of the preceding claims characterised by a light source for illuminating a document to be copied and switch means for connecting the generator thereto to apply electrical energy to the light source to illuminate the document.
- 15 9. A process according to any one of the preceding claims characterised by an optical system for producing a reversed image of the illuminated document on the electrically charged plate, so that the final photocopy of the document appears the correct way round.
- 20 10. A process according to any one of claims 1 to 8 characterised by a transparent photoconductive plate on which a reversed image of an illuminated document is formed and which is then available as an intermediate master to form the photocopy which is the correct way round.
- 25 30 11. A process according to any one of the preceding claims characterised by movable rollers or brushes for conveying printing medium to the surface of a charged plate after exposure of the latter.
- 35 12. A process according to claim 11 characterised by movable rollers or brushes for conveying a fixing medium such as lacquer to the surface of the plate after the printing medium has been deposited thereon.
- 40 13. A process according to claim 11 or 12 characterised by means for removing the printing medium and any fixing medium applied to the plate, to allow the latter to be re-used.
- 45 14. A process according to any one of the preceding claims characterised in that all the parts thereof are contained in or on a light-tight housing.
- 50 15. A process according to claim 9 characterised by a further light source for projecting an image or the reversed image on the charged plate onto a charged sheet of sensitized paper to produce a photocopy thereon after applying printing medium thereto and fixing the adhering printing medium thereon.
- 55 60 16. A process according to claim 15 characterised in that the optical system producing the reversal image on the charged plate produces a reduced size image of the illuminated document and the same optical system is employed in reverse to produce an enlarged photocopy of the reversed image.
- 65 17. A process according to claim 1 characterised by a first supply of adhesive backed transparent sheet material for applying to the plate after printing medium has been applied thereto, with the adhesive side in contact with the plate to pick up thereon the printing medium adhering to the charged regions of the plate and a second supply of transparent sheet material for applying to the adhesive covered surface of the first sheet material to sandwich printing medium picked up from the charged plate, therebetween.
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Fig. 1.

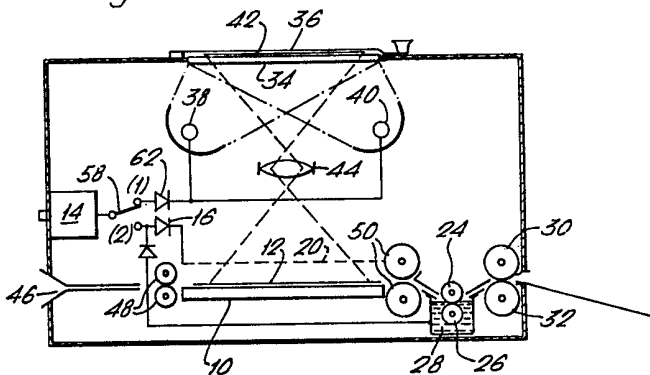


Fig. 2.

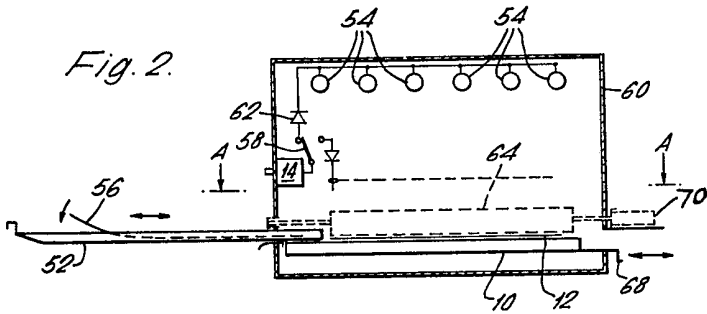
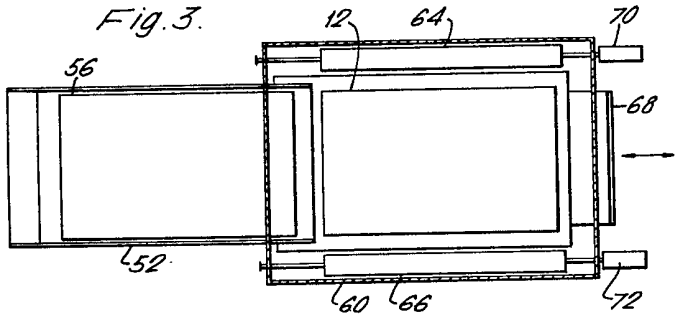


Fig. 3.



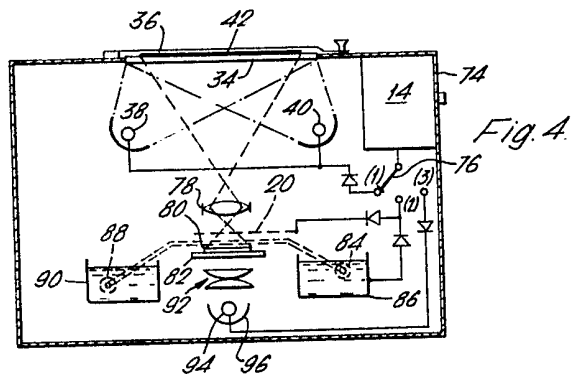


Fig. 4.

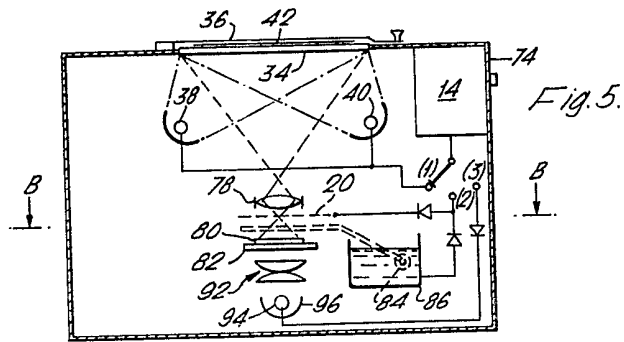


Fig. 5.

Fig. 6.

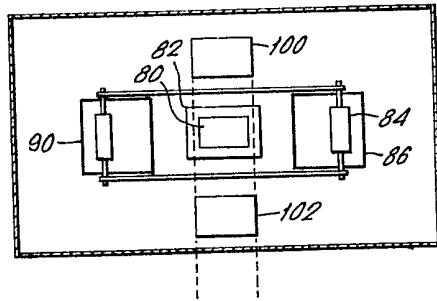


Fig. 7.

