United States Patent [19]

Katakabe

[11] **3,792,488**

[45] **Feb. 12, 1974**

[54] **FIXING APPARATUS**

[75] Inventor: **Noboru Katakabe**, Osaka, Japan

[73] Assignee: **Matsushita Electric Industrial Co., Ltd.**, Osaka, Japan

[22] Filed: **Aug. 9, 1972**

[21] Appl. No.: **279,265**

[30] **Foreign Application Priority Data**

Aug. 18, 1971 Japan 46-63148

[52] **U.S. Cl.** ..... **95/89 G**, 355/10, 355/27, 355/100

[51] **Int. Cl.** **G03d 3/00**

[58] **Field of Search** .... 355/10, 27, 100, 106; 95/13, 95/14, 89 G, 94 G, 89 R

[56] **References Cited**

UNITED STATES PATENTS

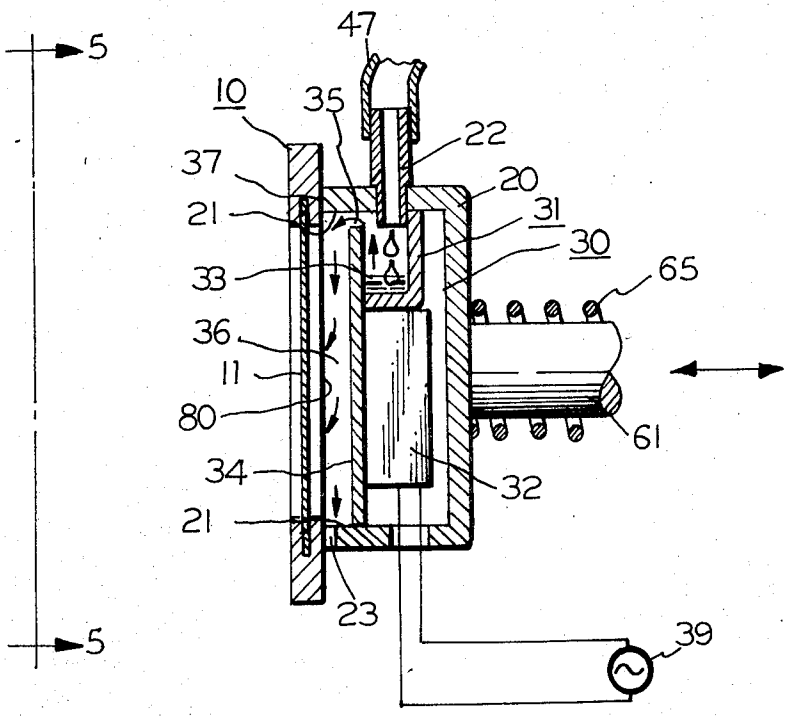
3,589,810	6/1971	Umahashi	355/100 X
3,174,420	3/1965	Aizawa	355/106 X
3,697,173	10/1972	Sasaki et al.	355/27
3,149,550	9/1964	Lohse et al.	95/89 R
3,646,315	2/1972	Marcoux	219/210
2,856,829	10/1958	Orlando	95/14
3,181,444	5/1965	Takats et al.	95/14 X
3,323,436	6/1967	Hater et al.	95/94 G X
3,528,355	9/1970	Blackert	355/27
3,534,673	10/1970	Muller	95/89 G X

Primary Examiner—Richard M. Sheer
Attorney, Agent, or Firm—E. F. Wenderoth

[57] **ABSTRACT**

A fixing apparatus is disclosed for fixing a developed visible image on a photoconductive surface of a film whereby a developed visible image is fixed on a photoconductive film by way of a small quantity of fixing solvent vapor. Further, the fixing solvent is easily and quickly evaporated by a low power heating element, and the used fixing solvent vapor is quickly discharged after the fixing. The apparatus has a fixing chamber having an aperture facing the film and an inlet through which fixing solvent is supplied. An evaporating device is mounted on the fixing chamber for evaporating the solvent and includes an evaporating chamber, a radiation plate parallel to photoconductive surface of the film and a heating element for heating the evaporating chamber. An engaging device is provided for moving the film and the chamber relative to each other so as to bring the aperture of the chamber into air-tight engagement with the film. A solvent supply device supplies a predetermined quantity of the solvent to the evaporating device through the inlet. The thus supplied fixing solvent is evaporated to a vapor which acts to fix the developed visible image on the film.

4 Claims, 5 Drawing Figures



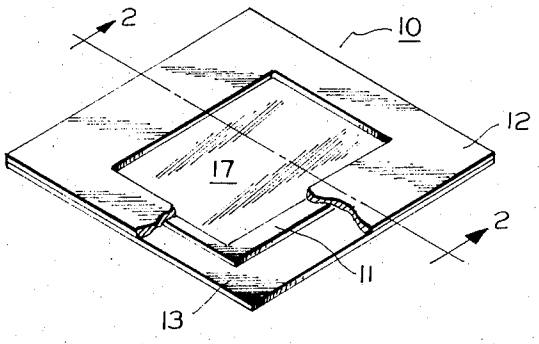


FIG.1

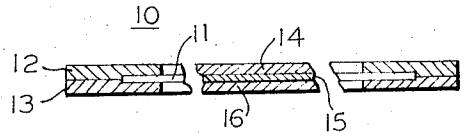


FIG.2

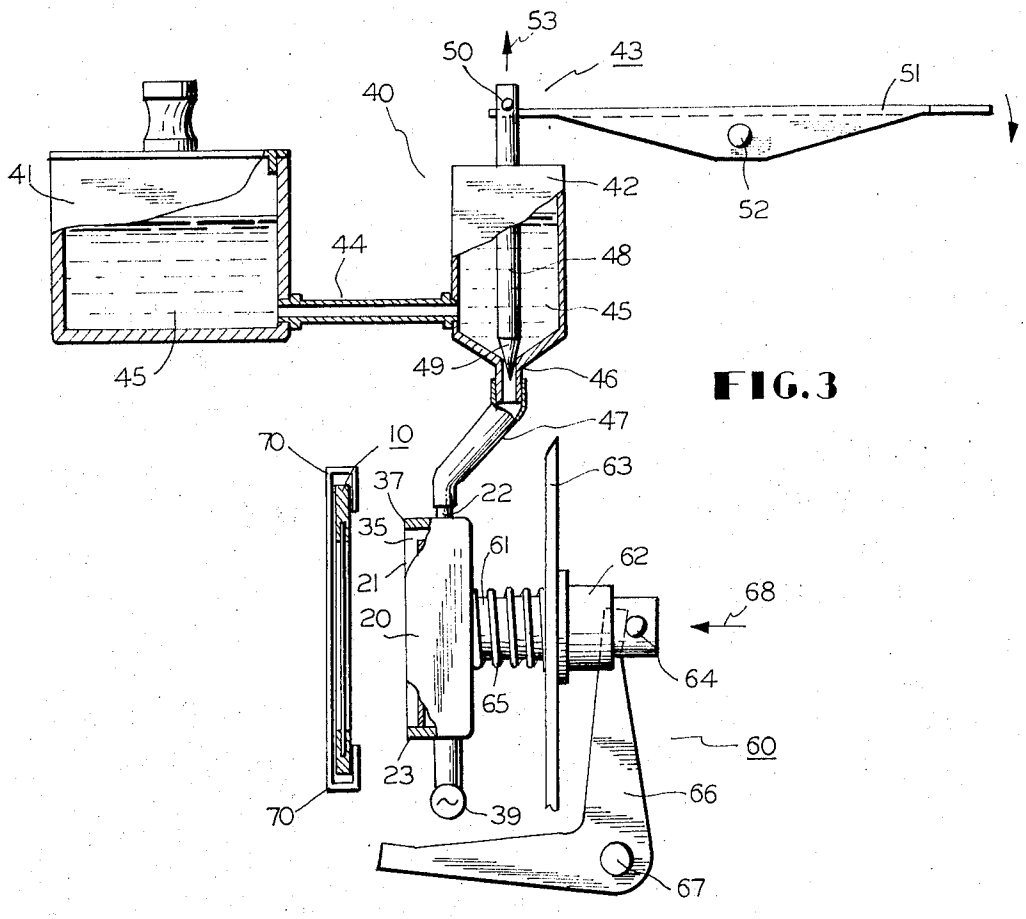


FIG.3

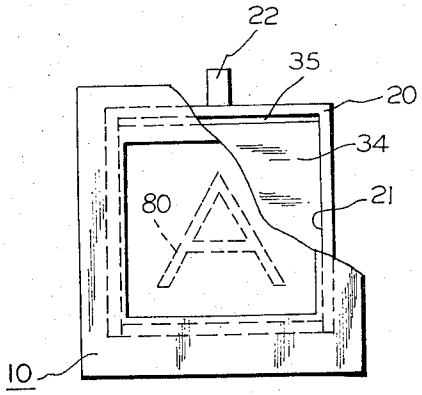

22
35
20
34
21
80
10

FIG. 5

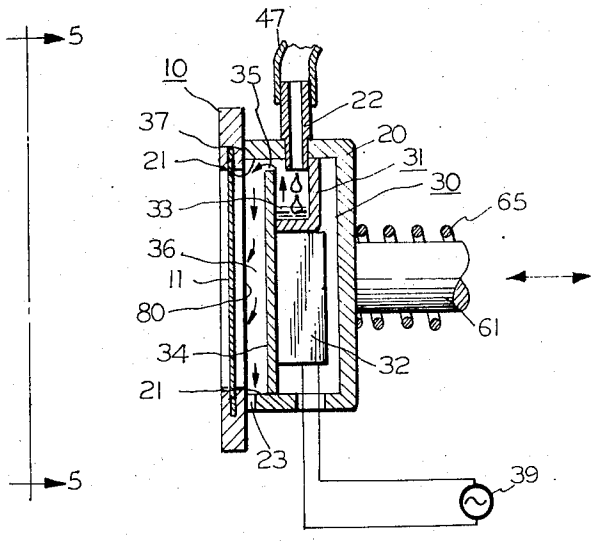

5
47
10
35
22
37
20
21
31
30
33
65
36
11
80
61
34
32
21
23
39
5

FIG. 4

FIXING APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to a fixing apparatus for fixing a developed visible image on a photoconductive film, and more particularly to a fixing apparatus for fixing a developed visible image on a photoconductive surface of a film by fixing solvent vapor.

In recent years, the various electrophotographic reproduction apparati have been developed and placed in practical use. In the process of electrophotography, a photoconductive film is first electrostatically charged and then exposed to an image so that an electrostatic latent image is formed on a photoconductive surface of the film. Subsequently, the film is developed by a liquid developer which usually contains finely divided toner particles in a volatile solvent. The visible image thus formed is then fixed to the surface of the film.

Conventionally, there are various methods by which the visible image is fixed. For example, there are methods such as fusing the image by the application of heat or coating the surface of the film with a resin solvent. In these methods, it is necessary to use a heating mechanism which produces considerable heat in the apparatus. It is known that exposure to continuous heat exposure has a deleterious effect on the photoconductor and film base. Therefore, dissipation of the heat or insulation of the photoconductor and film base from the heat must be carefully controlled. Moreover, it has become difficult to achieve an entirely satisfactory design of the heater mechanism with regard to a short warm-up time, low electric current requirements and protection against fire hazard. Further, these methods occasionally tend to cause the image to be distorted, and therefore it is difficult to produce a micro image having a resolution power of more than thirty lines per millimeter.

On the other hand, it has been suggested to fix the visible image in an atmosphere of vapor of the solvent. This solvent vapor process is referred to in the art as vapor fixing. There is one vapor fixing method, which is to soften the photoconductive film in the presence of the vapor of the solvent so as to fix a visible image formed by the toner to the surface of the film without image distortion. The photoconductive film suitable for this fixing method is essentially made from an organic material such as poly-N-vinylcarbazole, and the solvent used for fixing is a volatile organic solvent such as methylene chloride. The vapor fixing method is very useful in an apparatus for producing a micro-image on a film mounted beforehand an a slide mount or on aperture card. In addition, it is very important in the vapor fixing method for the vapor of solvent to contact only the photoconductive film during the fixing. If the liquid solvent is scattered on the photoconductive film, even though only a small quantity contacts the film such as in small spots, the image may be stained with scale-like spots. Furthermore, the solvent for fixing is characterized by various degrees of toxicity, and the problem of minimizing escape into the ambient atmosphere should be taken into account. Therefore, if a large volume of the vapor of the solvent leaks from the apparatus, it may produce a generally uncomfortable atmosphere for the operators of the apparatus. In the apparatus for continuously fixing a roll of film, ventilation equipment is required to avoid atmospheric contamination.

BRIEF SUMMARY OF THE INVENTION

Accordingly, it is an object of this invention to provide a novel fixing apparatus for fixing a developed visible image on a photoconductive surface of a film by vapor of fixing solvent.

It is another object of this invention to provide an improved fixing apparatus for intermittently fixing a developed visible image on a photoconductive film by using a small quantity of the vapor of a fixing solvent.

It is a further object of this invention to provide an improved fixing apparatus having a novel evaporating means for evaporating fixing solvent easily and quickly by means of a low power heating element.

It is further object of this invention to provide an improved fixing apparatus having novel means for quickly discharging the used vapor of the fixing solvent after the fixing.

These objects are achieved by the provision of a fixing apparatus according to the present invention which comprises a fixing chamber having an aperture facing the photoconductive surface of a film and an inlet through which fixing solvent is supplied to said chamber; evaporating means mounted on said fixing chamber and including an evaporating member for quickly evaporating said solvent, and a heating element for heating said evaporating member; engaging means for moving said film and said chamber relative to each other so as to bring said and aperture of said chamber into air-tight engagement with said film; solvent supply means for supplying a predetermined quantity of said solvent to said evaporating member in said chamber through said inlet, whereby the supplied fixing solvent is evaporated by said evaporating member to form a vapor of the solvent which acts to fix the developed visible image on the photoconductive surface of said film.

Further objects and advantages of this invention will become apparent from the following detailed description taken in connection with the accompanying drawings, in which:

FIG. **1** is a perspective view of a photoconductive film unit to be fixed in the apparatus according to this invention;

FIG. **2** is an enlarged sectional view taken along a line **2—2** of FIG. **1**;

FIG. **3** is a general side view of a preferred embodiment according to this invention, partly in section and partly broken away for the purpose of clearness;

FIG. **4** is a side sectional view of a fixing chamber in position for carrying out a fixing operation; and

FIG. **5** is a front elevational view taken along a line **5—5** of FIG. **4**, partly in section and partly broken away for the purpose of clearness.

DETAILED DESCRIPTION OF THE INVENTION

The drawings illustrate a preferred embodiment of the apparatus constructed in accordance with the present invention.

With reference to FIG. **1** and FIG. **2**, a photoconductive film unit **10** to be fixed by the apparatus according to the present invention has a transparent photoconductive film (**11**) mounted between a first mount (**12**) and a second mount (**13**). Each of the mounts (**12**) and

(13) has an opening (17) through which the finished image on the film (11) is easily projected. The film (11) is essentially composed of a photoconductive layer (14), a conductive layer (15) and a substrate (16). The photoconductive layer (14) is a transparent electrophotoconductive material such as an organic photoconductor which essentially consists of poly-N-vinlycarbazole, and the conductive layer (15) is a transparent material such as cuprous iodide. The substrate (16) is made from cellulose triacetate or polyethylene terephthalate.

The photoconductive film unit (10) is suitable for the use as a so-called lantern slide. A visible image is easily produced on the photoconductive film (11) of the unit (10) by means of an electrophotographic process which is well known. The details of such a method and apparatus have been described in copending U.S. pat. application Ser. No. 122,819 now U.S. Pat. No. 3,697,173. Therefore, a description of the methods and means for producing a visible image is omitted in the present patent application.

On the other hand, the solvent used in the preferred embodiment is a volatile organic material such as methylene chloride, methyl chloroform, toluene, trichloroethylene, benzene and chlorobenzene. The vapor of such solvents is suitable for easily softening the photoconductive layer (14) on which the image is to be supported. In view of the health of the operator of the apparatus, the preferred solvents are methylene chloride, toluene and methyl chloroform which are characterized by a low degree of toxicity.

The following will describe in detail means for fixing the visible image on the photoconductive film (11) with reference to FIG. 3, FIG. 4 and FIG. 5. A preferred embodiment of the apparatus is suitable for fixing a visible image in a substantially vertical plane. The fixing apparatus comprises a fixing chamber (20), an evaportating means (30), a solvent supply means (40), and an engaging means (60). The fixing chamber (20) has an aperture (21) formed in one side thereof, an inlet (22) through which the solvent (45) is supplied from the solvent supply means (40) to the chamber (20), and a vapor discharging outlet (23) formed at the lower portion thereof.

The aperture (21) faces the principal photoconductive surface of the photoconductive film unit (10). The size of said aperture (21) is larger than an effective image area on the film (11) (or larger than the opening (17) formed in the mounts (12) and (13)). Therefore, an edge (37) provided around the aperture (21) is contacted with the photoconductive film unit (10) by the engaging means (60) as described hereinafter. The inlet (22) is provided at the upper portion of the chamber (20) and is connected to the solvent supply means (40) by a flexible pipe (47). The vapor discharging outlet (23) formed in the lower portion of the chamber (20) is a slit which serves to discharge the vapor of the solvent (45) used for fixing from the chamber 20.

With reference to FIG. 4, the evaporating means (30) comprises an evaporating chamber member (31) and a heating element (32) for heating said evaporating member (31), and is mounted within the chamber (20) as shown in FIG. 4. The evaporating chamber member 31 encloses one side and the bottom of an evaporating chamber 33 for evaporating and the fixing solvent (45), and the upper end of a radiation plate (34) forms the other side of the chamber 33. The plate 34 has the upper end spaced from the top of chamber 20 to define a vapor vent (35). The evaporating room chamber (33) is positioned in the upper portion of the chamber (20) and receives the fixing solvent (45) through the inlet (22).

The radiation plate (34) is mounted within the chamber (20) in the vicinity of of the aperture (21), covering almost the full size of the aperture (21), and facing and being parallel to the photoconductive surface of the film (11). The vapor vent (35) at the upper end of the radiation plate (34) is higher than the top portion of the visible image on the film (11).

As shown in FIG. 5, the vapor vent (35) is in the shape of a slit defined between the radiation plate (34) and the inside of the top wall of the chamber (20). The heating element (32) is fixed to the evaporating chamber member (31) and the radiation plate 34 and heats the evaporating chamber (33) and the radiation plate (34) to a constant temperature which is at least higher than the boiling point of the solvent (45) employed. The heating element (32) can be made from material such as a nichrome wire, a semi-conductive ceramic, etc, and is energized by means of a conventional electrical power source (39). A heating element (32) suitable for this invention will be described in detail hereinafter.

There will be described in detail the solvent supply means (40) for supplying a predetermined volume of the solvent to the evaporating means (30) through the inlet (22) in the chamber (20). Referring to FIG. 3, the solvent supply means (40) comprises a receptacle (41), a pot (42) and a moving means (43). The receptacle (41) stores the solvent (45). Said solvent (45) is supplied to the pot (42) through a pipe (44). The pot (42) has a solvent outlet (46) which is connected to the inlet (22) of the fixing chamber (20) by the flexible pipe (47). The moving means (43) comprises a slide rod (48) movable in the pot (42), and a lever (51) for moving the rod (48). One end of the rod (48) having a tapered portion (49) is usually engaged in the solvent outlet (46) so as to close it, and the other end of the rod (48) has a pin (50) which connects the rod (48) with the lever (51). Said lever (51) is pivotally mounted on a shaft (52).

When the tapered portion (49) is engaged in the outlet (46), the solvent (45) does not flow from the pot (42). When the rod (48) is moved upward by the lever (51) (in the direction of arrow (53)), the solvent (45) flows from the pot (42) and is supplied to the evaporating chamber (33) in the chamber (20) through the outlet (46), the pipe (47) and the inlet (22). The lever (51) is driven by a conventional solenoid (not shown). If the movement of the lever (51) is controlled so that is is held in the pivoted position for a given time, a predetermined quantity of the solvent (45) is supplied to the evaporating chamber (33) for every movement of the lever (51). A predetermined quantity suitable for this invention is approx. 0.05 CC.

There will be described in detail the structure of the engaging means (60) for moving the chamber (20). The engaging means (60) comprises a shaft (61) fixed to the chamber (20), a guide (62) supported on a support (63) and through which shaft 61 is slidable, a crank lever (66) pivotally mounted on a pin (67), and a compression spring (65) around shaft 61 between the chamber (20) and the support (63). The shaft (61) guided in the guide (62) is horizontally movable and

has a pivot (64) by which the shaft (61) is coupled to the crank lever (66). The crank lever (66) is usually moved in clockwise direction around the pin (67) by a driving means (not shown) such as a motor and a solenoid, whereby the shaft (61) moves in a direction opposite to the arrow (68) against the bias of the spring (65) as shown in FIG. 3.

Accordingly, the chamber (20) is normally positioned at a point spaced a distance from the photoconductive film unit (10) so as to allow the film unit (10) to move to another station. On the other hand, the movement of the crank lever (66) in a counterclockwise direction causes the chamber (20) to contact the film unit (10) under the bias of the spring (61).

The following will describe the operation of the preferred embodiment of this invention. The photoconductive film unit (10) having a visible image (80) thereon is supported in a substantially vertical plane by a guide rail (70). At the fixing station, the chamber (20) faces the film unit (10), being spaced therefrom a distance as shown in FIG. 3. In addition, the visible image (80) is composed of a toner such as finely divided graphite particles.

First of all, the crank lever (66) is moved in a counterclockwise direction around the pin (67) so that the edge (37) of the chamber (20) is brought into contact with the mount of the film unit (10) under the bias of the spring (65) as shown in FIG. 4. Upon the completion of this movement, a space (36) is formed between the film unit (10) and the radiation plate (34). The space (36) is substantially air-tight except for the vapor discharging outlet (23). Subsequently, the predetermined quantity of the solvent (45) is supplied to the evaporating chamber (33) through the inlet (22) by means of the solvent supply means (40).

Both the evaporating chamber 33 and the radiation plate (34) have been previously heated to the constant temperature by the heating element (32). Accordingly, the supplied solvent (45) is immediately evaporated in the chamber (33) so that the vapor of the solvent (45) is introduced into the space (36) through the vapor vent (35).

The vapor filling the space (36) automatically moves from the vapor vent (35) to the vapor discharging outlet (23), because the specific gravity of the vapor of the solvent (45) is greater than the air. The movement of the vapor causes the vapor to contact the photoconductive surface of the film (11) having the visible image (80) in the space (36). Accordingly, the photoconductive layer (14) (as shown in FIG. 2) is softened by exposure to the vapor of the solvent (45) so that the visible image (80) is fixed to the surface of the film (11) during fixing operational periods.

The radiation plate (34) previously heated as aforementioned serves to keep the atmosphere in the space (36) at a constant temperature, whereby the vapor supplied from the chamber (33) is never liquified in the space (36). If the vapor is liquified in the space (36), the film (11) and the image (80) are stained with scale-like spots. In order to further prevent directly scattering the liquid of the solvent (45) onto the surface of the film (11) during the generation of the vapor within the evaporating chamber (33), the vapor vent (35) is positioned above the top portion of the film (11) and is a narrow opening as aforementioned.

In FIG. 4, it is desirable in order to minimize the consumption of the solvent (45) that the gap between the film (11) and the radiation plate (34) be as narrow as possible. This gap is approx. 1.0mm–2.0mm in the preferred embodiment. When the gap is 1.0mm, 0.05cc of solvent is enough to fix one film unit (10).

Upon the completion of the fixing, the chamber (20) is returned to the initial position (as shown in FIG. 3) by the movement of the crank lever (66) so that the fixed film unit (10) is permitted to move to another station. The timing of the above operation is easily controlled by a conventional means such as a solenoid, motor, microswitch, etc.

A heating element (32) suitable for this invention consists of a semi-conductive ceramic material having a positive temperature coefficient of electrical resistance. The semi-conductive ceramic consists essentially of barium titanate and an additive combination of aluminum and silicon oxide. This ceramic has been disclosed in U.S. Pat. No. 3,373,120. The heating element (32) made from this ceramic has a characteristic such that an electric current flowing through the element decreases with increasing ambient temperature and vice versa. Therefore, with this heating element (32), the evaporating member to be heated and the atmosphere within the space (36) are automatically controlled so that they are kept at a given temperature (approx. 80°C) which serves to effectively evaporate the solvent (45), even if the temperature of the heating element (32) is temporarily decreased by the latent heat of the vaporization of the solvent (45).

On the other hand, with a prior art heating element such as a nichrome wire it is difficult to control the temperature thereof automatically and it is necessary to have additional equipment for control, such as a heat sensing switch. However, the contact in such a switch, which turns the electric current on or off depending upon the ambient temperature, is apt to become oxidized, contaminated and welded together over a long period of operating time and finally ceases working.

As aforementioned, the apparatus according to this invention is characterized by the following features.

The apparatus according to this invention fixes a visible image to the surface of the photoconductive film without image distortion in the presence of the vapor of the solvent. Therefore, it is very useful in an apparatus for a micro image on a transparent film such as so-called microfilm, and is also suitable for use in an apparatus for intermittently fixing one frame of film mounted beforehand on a slide mount or an aperture card.

The capacity of the space (36) for receiving the vapor during the fixing can be minimized by the effective combination with the chamber (20) and the evaporating means (30) as shown in FIG. 4 so that the consumption of the fixing solvent (45) is reduced to a small quantity such as 0.05cc per one film unit. Therefore, the apparatus according to the present invention will discharge less vapor to the atmosphere, reducing ventilation requirements, and does not cause discomfort to the operator.

The evaporating chamber (33) and the vapor vent (35) are spaced from the surface of the film so that the film is protected against the stains caused by the undesirable contact of the liquid of the solvent with the film.

Further, the vapor used for the fixing is automatically discharged from the chamber through the discharging

outlet because the fixing chamber is facing to the film in a substantially vertical plane.

A heating element having a positive temperature coefficient of electrical resistance automatically controls the temperature of the parts to be heated. Therefore, it is not necessary to provide additional equipment for controlling temperature and also the high electric power source.

As above mentioned, this invention provides a compact and unexpensive fixing apparatus having low electric current requirements, as compared with conventional fixing apparatus.

It is apparent that various modifications may be made without departing from the substantial properties in the invention. The above described specific example is intended merely to illustrate the various inventive facets in a certain selective embodiment of the invention, the scope of which it is intended shall be limited only by the following claims.

What is claimed is:

1. A fixing apparatus for fixing a developed visible image in a substantially vertical plane on an organic photoconductive film, comprising:

a fixing chamber having an aperture located in a substantially vertical plane over which the film with a visible image on an organic photoconductive layer is to be positioned in said substantially vertical plane and having an inlet through which a volatile organic solvent is supplied into said fixing chamber;

evaporating means mounted in said fixing chamber and comprising an evaporating chamber member, said member defining a portion of an evaporating chamber for evaporating a volatile organic solvent to a vapor, a radiation plate, said radiation plate positioned adjacent said evaporating chamber and defining a portion of said evaporation chamber, said radiation plate facing in parallel to the plane of said aperture and further defining a narrow space within said fixing chamber with respect to the plane of said aperture, and a heating element thermally coupled with said evaporating chamber member for heating said evaporating chamber member;

engaging means for moving the organic photoconductive film and said fixing chamber relative to each other so as to bring said aperture of said fixing chamber into airtight engagement with the organic photoconductive film; and

solvent supply means coupled to said inlet for supplying a predetermined quantity of the volatile organic solvent to said evaporating chamber in said fixing chamber through said inlet, the supplied volatile organic solvent being evaporated by said evaporating chamber member into a vapor of solvent and forming a vapor atmosphere in said narrow space during the fixing of the developed image, so that the developed visible image on the film is fixed.

2. An apparatus as recited in claim **1**, wherein said fixing chamber further includes a vapor discharging outlet at the lower portion thereof, said narrow space in said chamber communicating with the outside by means of said vapor discharging outlet thus discharging vapor from said narrow space.

3. An apparatus as claimed in claim **2**, wherein said radiation plate has its upper end spaced from the top of said fixing chamber so as to provide a vapor vent which is higher than the top portion of the visable image of the photoconductive film and serving to cause the vapor to exhaust from said evaporating chamber into said narrow space.

4. An apparatus as claimed in claim **1**, wherein said heating element is a semi-conductive ceramic material having a positive temperature coefficient of resistance for heating said evaporating chamber member and maintaining said space at a temperature maintaining the vapor atmosphere during the fixing.

* * * * *