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Hurtig et al.

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[54] **DIAZO FILM DEVELOPER**

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[52] **U.S. Cl.** ..... **95/94 G,** 95/89 G

[51] **Int. Cl.** **G03d 7/00**

[58] **Field of Search** ..... 95/89 R, 89 G, 94 R, 94 G

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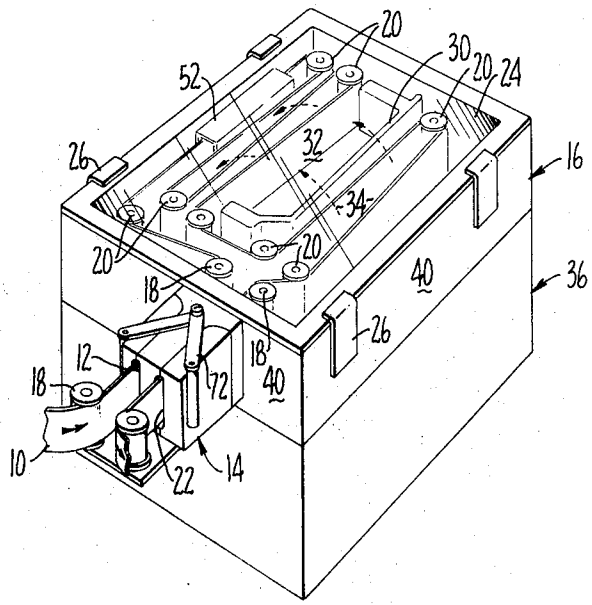
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Assistant Examiner—Fred L. Braun
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[57] **ABSTRACT**

A diazo film developer and method of developing roll-type diazo film, continuously fed into the developer through a seal, wherein the film is (1) subjected to a cycled air mixture containing water vapor cooled to the dew point whereby a water condensate is deposited on the surface of the film, (2) simultaneously subjected to an ammonia vapor which is absorbed by the water condensate to develop the film, (3) subsequently subjected to the cycled air mixture preheated to dry the film and scavenge excess ammonia gas.

12 Claims, 7 Drawing Figures



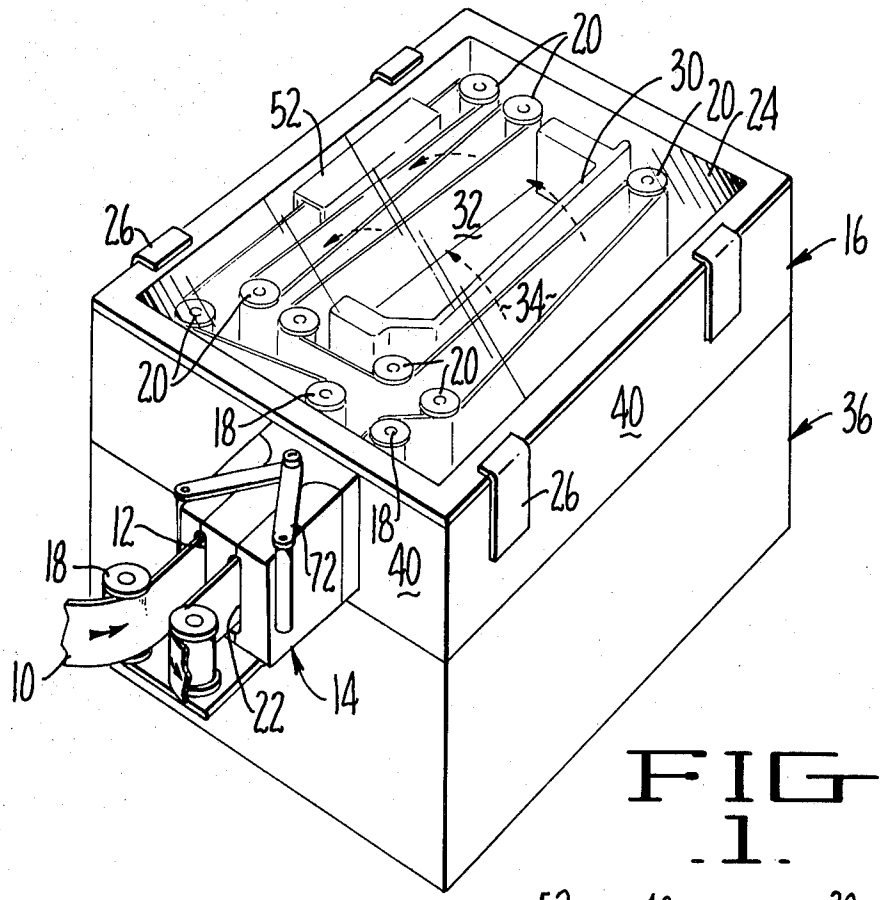


FIG. 1.

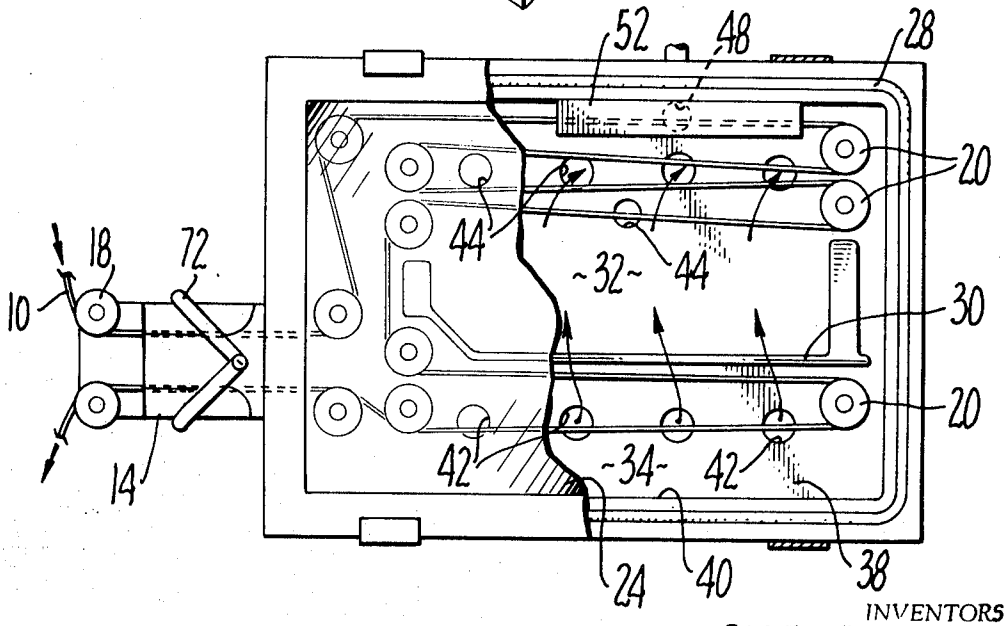
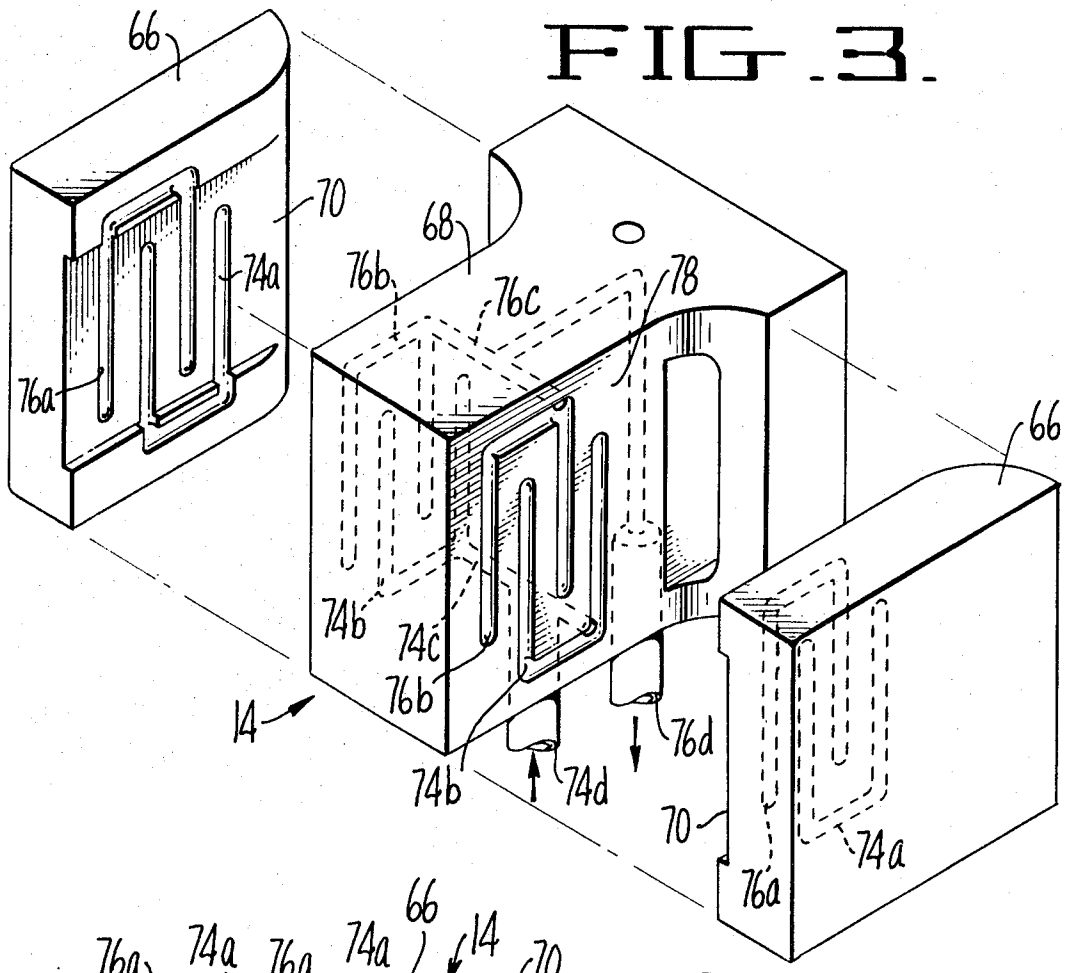


FIG. 2.

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FIG. 3.



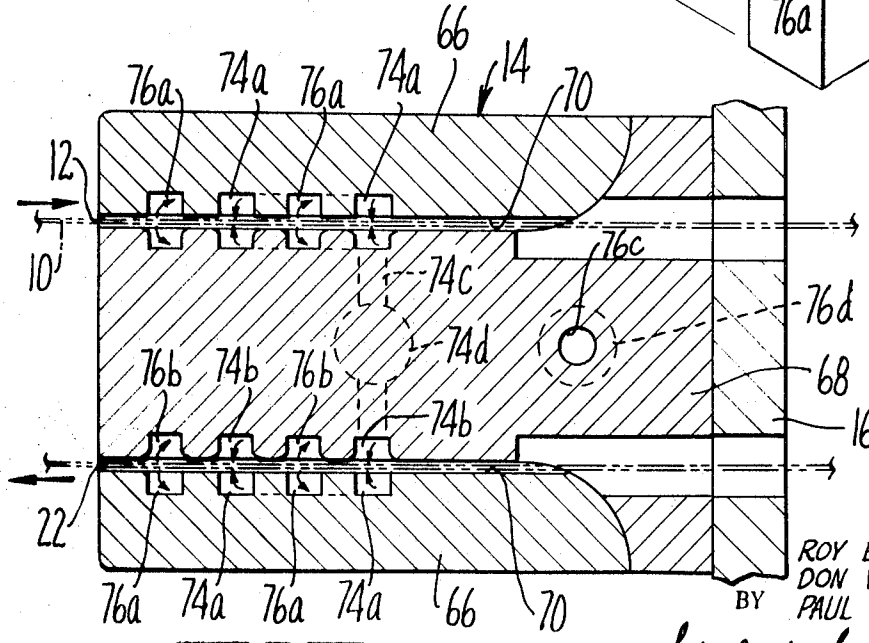


FIG. 4.

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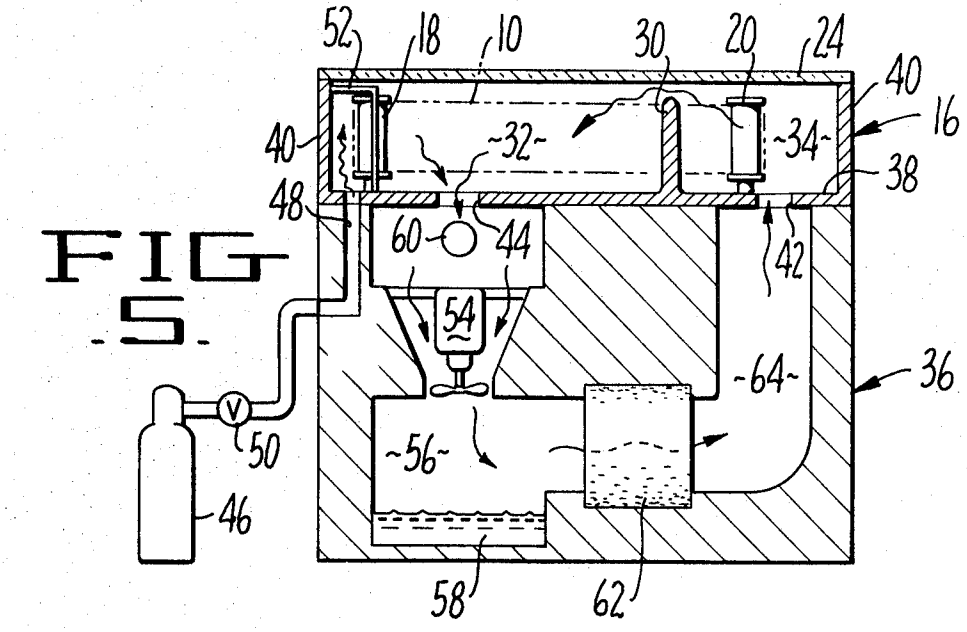


FIG. 5.

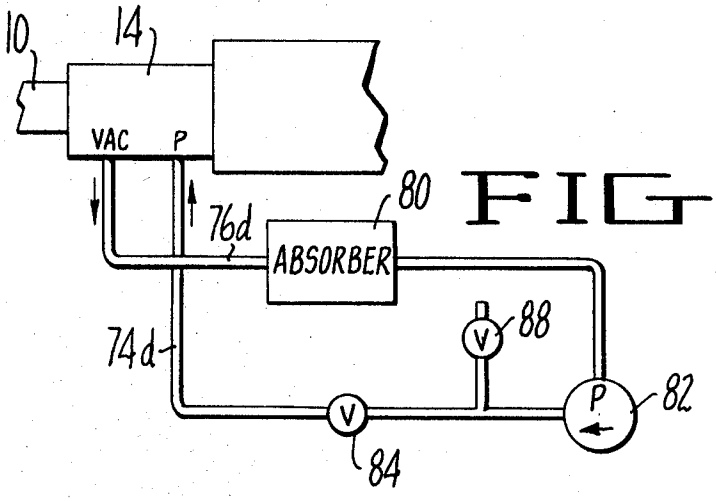


FIG. 6.

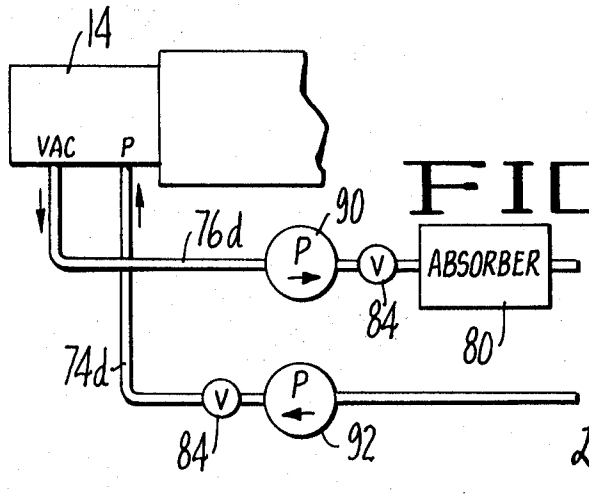


FIG. 7.

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DIAZO FILM DEVELOPER

SUMMARY OF THE INVENTION

Development of films containing light sensitive diazo compounds is most commonly accomplished with ammonia solution or gas mixtures. After exposure to light, particularly ultraviolet light, the diazo compound decomposes. The undecomposed diazo compound is prevented from reacting with a coupling compound for developing contrast while in an acid medium. To inhibit uncontrolled film development all film coatings are acidic. Ammonia is used in development to neutralize acid present in the film coating and to provide an alkaline medium in which the diazo coupling reaction can rapidly proceed.

It has been observed that operation with water is necessary in an ammonia film processor to achieve any development. This is presumably due to the fact that a liquid medium is needed in the film for the coupling reaction to proceed rapidly. Further evidence for this observation is the fact that anhydrous ammonia systems only work at pressures that provide condensation of liquid ammonia at the operating temperature.

The principal problems in construction of a diazo film developer concern the application of ammonia and the water carrier to the film in amounts proper for rapid development without wasteful excess.

Most of the prior art involves development of prints and copy paper. The instant invention provides a method and the apparatus for developing a diazo film strip which is continuously fed through the developer. Water and ammonia requirements must therefore be dept at a minimum if large quantities of film are to be rapidly developed in an apparatus of acceptable size. Additionally, because of the caustic nature of ammonia hydroxide and unpleasant odor of ammonia gas, ammonia escape from the developer must be kept at an absolute minimum to allow non-vented indoor usage.

The diazo developer invented coordinates a film cycle through the developer with a continuous air-mixture cycle which by condensation and evaporation deposits and removes water and ammonia during the development of the continuously supplied film.

The developer is compact and suitable as an accessory for film printing equipment such as a microfilm printer.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the diazo developer.

FIG. 2 is a plan view of the developer of FIG. 1.

FIG. 3 is an enlarged and exploded view of a film seal on the developer shown in FIG. 1.

FIG. 4 is a sectional view of the film seal.

FIG. 5 is a sectional view of the developer of FIG. 1.

FIG. 6 is a schematic of the film seal operation.

FIG. 7 is a schematic of an alternate film seal operation.

DETAILED DESCRIPTION OF THE INVENTION

The diazo developer shown in FIG. 1 accepts film 10 to be developed through an entrance slot 12 in a film seal 14 mounted to the upper portion 16 of the developer. As illustrated in both FIGS. 1 and 2, the film 10 is threaded around adjustable spools 18 and spools 20 using external film drive means, and returned

through an exit slot 22 in the film seal fully developed. A removable glass cover 24 provides easy access to the upper portion 16 of the developer for initial threading of a film leader around the spools. Four clamps 26 fasten the glass cover against a rubber seal 28 on the rim of the upper portion of the developer. The glass cover allows visual inspection of the film developing process as it occurs enabling an operator to make those adjustments necessary for the most efficient operation of the system and provides for thermodynamic properties required by the basic cycle.

The upper portion 16 of the developer is divided by a vertical dam 30 into a first chamber 32 and a second chamber 34. In the first chamber 32 the film is subject to a cycled air mixture containing water vapor cooled to the dew point and an ammonia vapor which act to develop the film. In the second chamber 34 the film is subjected to the preheated air mixture which dries the film and scavenges any excess ammonia from the previous developing process. The dam 30 forms a partial barrier to the flow of the mixture of air and water vapor from the second chamber 34 to the first chamber 32 forcing the flow upward and between the top of the dam 30 and the surface of the glass cover as indicated by the flow arrows shown in FIGS. 1 and 2, and in particular, FIG. 5.

When the air mixture flows through the narrow passage between the dam and glass cover it is cooled to approximately its dew point as it enters the first chamber 32.

The upper portion of the developer is separated from the lower portion 36 by a floor plate 34 which supports the adjustable spools, spools and dam.

Located in a row on the floor plate in the second chamber are circulation holes 42 which allow the air mixture to be cycled from the lower portion to the upper portion of the developer. Similarly, circulation holes 44 in the first chamber allow the air mixture to be cycled from the upper portion to the lower portion. These circulation holes permit the cycled air mixture to continuously flow from the second chamber to the first chamber.

Ammonia vapor is introduced to the first chamber from an anhydrous ammonia reservoir 46 contained in a remote container and enters through an ammonia vent 48 in the floor plate. The venting is regulated by a control valve 50 as illustrated in FIG. 5. The ammonia vent 48 releases ammonia vapor initially into an ammonia tunnel 52 through which the film passes to insure that the film is subjected to an adequate ammonia supply. From the ammonia tunnel 52 the majority of the ammonia is emitted to the first chamber where it is continually absorbed by the water condensate that has been deposited on the film by the cooled air mixture until an equilibrium state is reached. As water and ammonia mixture is absorbed into the film surface the film is developed.

The cyclical flow of the air mixture is most clearly shown in FIG. 5. A pump or blower 54 draws the air mixture from the first chamber 32 through the circulation holes 44 in the floor plate 38 across a temperature sensor 60 to a third chamber 56 containing a water reservoir 58. Here the air mixture picks up additional water vapor to approach saturation before it is forced by the pressure from the blower 54 through a heater

62. The heater 62 is regulated by the temperature sensor 60 to control the degree to which the air mixture is raised above the dew point. Knowing the degree to which the air mixture is cooled when passing from the second chamber to the first, the temperature sensor 60 ultimately controls the temperature of the air mixture in the first chamber. After the air mixture is passed through the heater it flows up an air passage 64 and through the circulation holes 42 in the floor plate 38 to the second chamber 34 to scavenge any ammonia and water from the film.

It can be readily perceived that the film developing process is closed to the outside atmosphere except at the point the film enters and exits the developer. To inhibit escape of noxious ammonia vapors from the developer, a special film seal 14 has been constructed.

As noted hereinbefore the film as shown in FIG. 1 enters a slot 12 in the film seal 14 and exits an identical slot 22 parallel to the entrance slot. The internal construction of the film seal 14 is most clearly illustrated in the exploded view of FIG. 3 and the section view of FIG. 4.

A pair of contoured side pieces 66 are fixed to opposite sides of a contoured center piece 68 that is mounted against the upper portion 16 of the film developer.

The side pieces are cut with a wide groove on their contoured face 70 to form the entrance and exit slots, 12 and 22, when the side pieces are clamped to the center piece 68 by a spring clamp 72 as shown in FIGS. 1 and 2. Scratching of the film is prevented by the adjustable spools 18 which transport the film through the slot without the film coming in contact with the walls of the slot.

Also cut into the face 70 of the contoured side pieces, 66, are two interlocking, U-shaped channels, 74*a* and 76*a*, respectively. The channels match oppositely disposed U-shaped channels, 74*b* and 76*b* on each contoured face 78 of the center piece 68. The matching sets of channels are interconnected by separate internal conduits, 74*c* and 76*c*, in the center piece and are respectively joined to a pressure supply line 74*d* and a vacuum supply line 76*d* as shown in FIG. 3.

As the film enters and exits the developer, it encounters two sets of alternating pressure — vacuum channels transversely disposed in the entrance and exit slots of the developer. As apparent from FIGS. 3 and 4, the channel most internally disposed in each slot is a pressure channel. Air is forced through the pressure line 74*d* to the pressure channel to create a back pressure in the entrance and exit slots forming an air cushion to counteract the moderate pressures that build up in the developer during operation. Adjacent to the pressure channel is the vacuum channel 76*a* and 76*b* wherein air circulation scrubs the film and draws off excess air from the pressure channel 74*a* and 74*b*. The vacuum channel also removes any of the internal atmosphere of the developer which permeates the air cushion. The second pressure channel is a back up which in combination with the final vacuum channel disposed adjacent to the slot entrance insures that escape of any of the ammonia laden atmosphere in the developer is kept at an absolute minimum. Additionally, the film seal provides a final air scrubbing for the ammonia developed film as it leaves the developer through the exit slot.

FIG. 6 and FIG. 7 schematically illustrate two alternate methods of operating the film seal 14. In FIG. 6 the film seal is operated essentially as a closed loop. The vacuum line 76*d* draws air and any escaping ammonia from the vacuum channels to an ammonia absorber 80 which removes all of the air-mixed ammonia. An air pump 82, which draws the air from the seal returns the scrubbed air through flow control valve 84, and pressure line 74*d* to the film seal 14. Since air from the external atmosphere and excess ammonia are entrained in small quantities by the vacuum channels, 76*a* and 76*b*, a bleeder line with a bleeder valve 88 is included to vent this excess air to the atmosphere.

In FIG. 7 an open system is provided for the seal 14. An air pump 90 draws air and any contained ammonia from the vacuum channels through vacuum line 76*d* and forces the air-ammonia mixture through flow control valve 84, thence through the ammonia absorber 80 which removes the ammonia before the air is vented to the atmosphere. The separately operated pressure line 74*d* draws air from the atmosphere and forces the air into the pressure channels by a separate air pump 92 through flow control valve 84. Either system equally insures that ammonia vapors do not escape from the developer into the atmosphere. Since the developing process does not require venting to the outside atmosphere, the developer may be operated in a closed room.

OPERATION OF THE DEVELOPER

Roll-type film having a diazo containing emulsion is transported through the developer. During the brief time that a segment of film is within the developer it is subjected to the following enumerated processes:

1. Condensation of water onto the film emulsion.
2. Diffusion of water into the emulsion to form a liquid medium for the coupling reaction.
3. Absorption of ammonia into the water on the emulsion.
4. Diffusion of ammonia into the emulsion to neutralize the acid present and provide an alkaline medium for reaction.
5. Coupling of the diazo salt and the coupler.
6. Removal of excess water and ammonia.

Each of these steps can be considered separately, but due to the heterogeneous nature of the chemical system, there are no doubt some points in the process where all of them are proceeding simultaneously in different parts of the film.

For example, the coupling of step 5 will occur on the surface after condensation of steps 1 and 3 but it can proceed deeper in the emulsion only after steps 2 and 4. Similarly, the concentration of water and ammonia deep in the emulsion may still be increasing when evaporation of ammonia and water begins from the surface. Thus, a description of the overall process as a composite of the individual steps is complex. Nevertheless, consideration of the individual steps is useful in order to define the several operating requirements.

When the film passes through the film seal it enters the first chamber at ambient temperature (about 25° C). The temperature of the air mixture in the chamber at this point is maintained at approximately 53° C, but

may vary between 45° C and 55° C depending on location. The dew point in the chamber is operated between 45° and 50° C. As the comparatively cool film enters the chamber two processes act upon it. It is warmed by convective transfer of heat from the surroundings, and at the same time water condenses on the surface causing the film to be also warmed by the heat of condensation. This condensation provides the water needed for proper reaction. Thus, if the chamber temperature is too high and/or the dew point too low, the film will be warmed above the dew point before an adequate amount of water has condensed. Conversely, if the dew point is too high and/or the chamber temperature too low, too much water will condense and cause "water spotting" of the film. With the operating temperature of the chamber stated, an overall desired condensation of approximately 0.1 microns thickness will occur.

The surface coating of diazo film comprises an emulsion about 0.0003 inches thick and contains the diazo salt, coupler and other stabilizing chemicals. Diffusion of water in this layer is rapid and accomplished in less than a second.

Ammonia in the vapor phase is rapidly absorbed by the water condensed on the film until equilibrium is reached between the concentration in solution on the film and that in the vapor. For adequate development of the film the ammonia concentration should be sufficient to create a pH of 11 in the solution on the film. This corresponds to a minimum partial pressure of ammonia vapor in the air mixture of approximately 5×10^{-4} atmospheres, or 500 parts per million by volume if the chamber is at atmospheric pressure. Adjustment of the ammonia level in the vapor may be regulated by the control valve to the ammonia reservoir. A locally higher concentration in the ammonia tunnel will promote and accelerate the absorption process. The proper concentration is adjusted by the ammonia vapor level throughout the chamber.

The ammonia absorbed at the surface must diffuse throughout the coating emulsion in sufficient quantity to neutralize all the acid medium present in the film coating and then provide an alkaline medium of pH at least 11. In this medium coupling of the diazo salt and coupler will occur.

The average film segments spend approximately three seconds transporting through the first chamber for the development process before looping through the second chamber.

In the second chamber, the film segment is subjected to a higher temperature air mixture for approximately 2 seconds which is to remove excess water and scavenge any remaining ammonia, and to return the film to a dry condition on exiting the chamber. The film segment is subjected to a final air scrubbing by the film seal before leaving the developer.

While film is threading through the developer, air is cycling around inside the developer in a continuous flow from chamber to chamber. The process cycle for the air mixture starting at the blower is summarized as follows:

1. Air mixture picks up water vapor to approach saturation.
2. Air mixture is heated raising its temperature farther above dew point.
3. Warmed air mixture passes over film prior to film egress, scavenging water and ammonia from the film. This scavenging reduces the potential to develop a surface haze on the film.
4. Air mixture passes between dam and glass, dropping temperature near or to dew point temperature.
5. Air mixture which is near or at dew point temperature comes in contact with the incoming film which is below dew point temperature causing moisture to condense on the film surface. Water readily absorbs ammonia which causes development.

From a consideration of either the film path through the developer or the air mixture cycle, it is clear that the thermodynamic conditions prescribed must be maintained in the developer for proper film development.

If for any reason the gaseous mixture temperature is not above the temperature of the incoming film, development will not proceed properly. If the air mixture is too far above the dew point temperature too little condensate results. If a wide temperature differential between the film and the air mixture exists with the air mixture close to or at the dew point temperature excessive condensation will cause water spotting, a phenomena which is undesirable, but does not affect film development.

When properly operated the developer herein disclosed is extremely efficient from the standpoint of both developing time and material consumed. The improved efficiency also results in drier film leaving the chamber improving image quality because of reduced "weeping" or blushing of the diazo dyes.

We claim:

1. A film developer for diazo film comprising:
   a. means defining a film processing zone having a film entrance and a film exit with
      1. a developing area, and
      2. a drying area,
   b. transport means for moving film through said zone from said entrance through said developing area hence through said drying area and then through said exit,
   c. air circulation means for moving air in counterflow relation to said film into said drying area and hence through said developing area,
   d. temperature control means for heating air to maintain the air in said drying area hotter than the air in said developing area, and
   e. supply means for supplying water and ammonia to air circulated by said circulating means to provide an air-water-ammonia mixture near the dew point thereof in said developing area.

2. The developer of claim 1 in which said temperature control means comprises means for heating air entering said drying area and means for cooling air passing from said drying area to said developing area.

3. The developer of claim 2 in which said air circulation means comprises a pump connected between said developing area and said drying area for pumping air from said developing area to said drying area.

4. The developer of claim 3 in which said pump is connected to said supply means for introducing water into said developer outside said processing zone.

5. The apparatus of claim 4 in which said means for heating air is connected between said pump and said drying area to heat circulating air above its dew point after said air contacts said supply means and before said air enters said drying area.

6. The developer of claim 4 in which said means for cooling air comprises a wall portion of said developer and guide means for guiding circulating air against said wall portion.

7. The developer of claim 1 in which said film exit comprises:

a. a housing having a wall with a passageway therethrough connected to said drying chamber,
b. a first recess in the wall of said passageway,
c. a second recess in the wall of said passageway between said first recess and said drying chamber,
d. ammonia absorbing means,
e. means for pumping air from said first recess, through said ammonia absorbing means and into said second recess.

8. A film exit for transporting diazo film from the drying chamber of a developing machine comprising:

a. a housing having a wall with a passageway therethrough extending out of said developer from said drying chamber,
b. a first recess in the wall of said passageway,
c. a second recess in the wall of said passageway between said first recess and said drying chamber,
d. ammonia absorbing means,
e. means for pumping air from said first recess, through said ammonia absorbing means and into said second recess.

9. A film seal for transporting film from a processing unit comprising:

a. a passageway into the processing unit having a passageway wall
b. a first recess in the wall of said passageway
c. a second inner recess in the wall of said passageway
d. air scrubbing means
e. means for pumping air from said first recess through said air scrubbing means and into said second recess.

10. The film seal of claim 9 further comprising guide means to transport the film through the passageway without contacting the walls of the passageway.

11. The method of developing diazo film which comprises:

a. continuously moving said film along a path in a predetermined direction,
b. circulating air along a closed path from a first area out of the film path to a second area contacting the film path to a third area contacting the film path upstream of the film path from the second area and hence back to said first area,
c. maintaining a mixture of water and ammonia in said circulating air in said third area adjacent to the dew point thereof,
d. heating said circulating air between said first and second areas, and
e. cooling said circulating air between said second and third areas.

12. The method of claim 11 in which said step of maintaining a mixture of water and ammonia is performed by introducing into said closed air path water in said first area and ammonia in said third area.

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