

United States Patent

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[54] AUTOMATIC FILM PROCESSING DEVICE

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1963, abandoned.

[52] U.S. Cl. **95/89**

[51] Int. Cl. **G03d 3/06**

[58] Field of Search **95/14, 89, 94**

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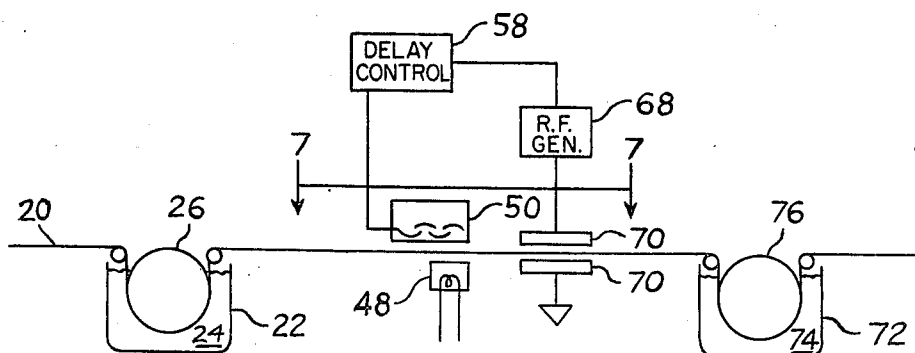
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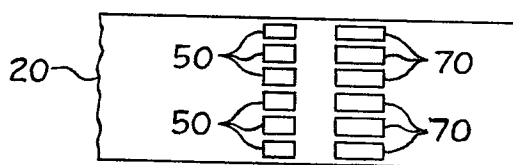
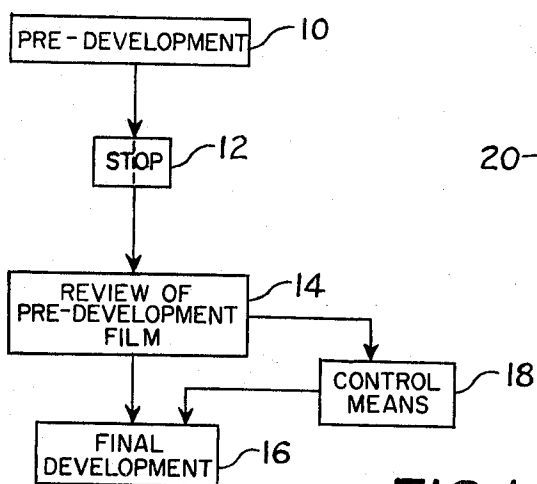
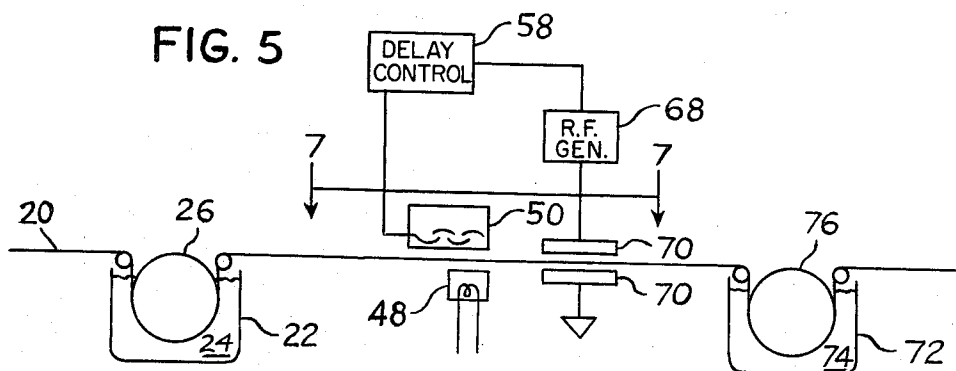
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ABSTRACT

This disclosure relates to a method and apparatus for selectively processing silver halide photographic film or the like by partially developing the latent image on the film in a standard developing solution, scanning the film with infrared radiation, sensing the density of discrete areas of the film by sensing the amount of infrared radiation reflected or transmitted through the partially exposed film by utilizing a photoelectric sensing device, and automatically controlling the temperature of processing of discrete areas of the film in response to signals developed by the photoelectric sensing device and thereafter finishing the developing process in a conventional developing bath.

12 Claims, 6 Drawing Figures





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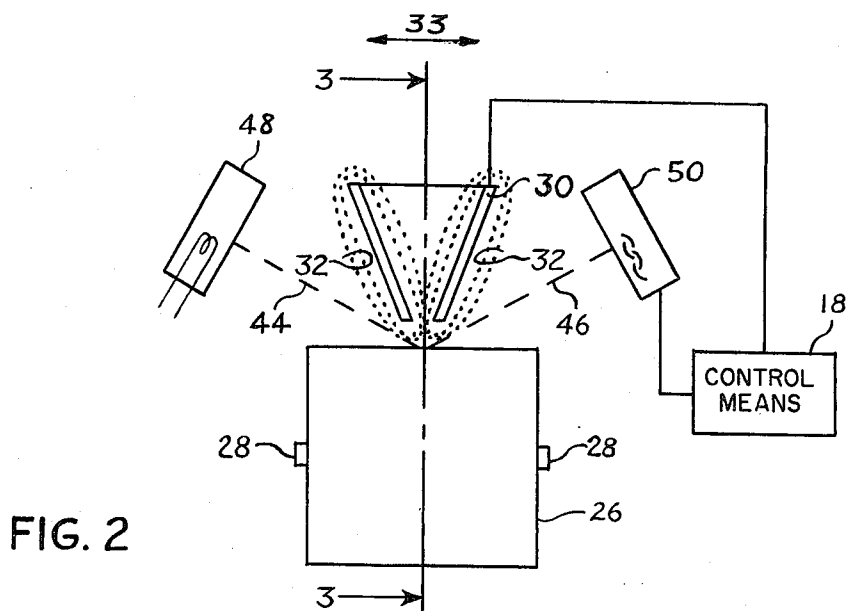


FIG. 2

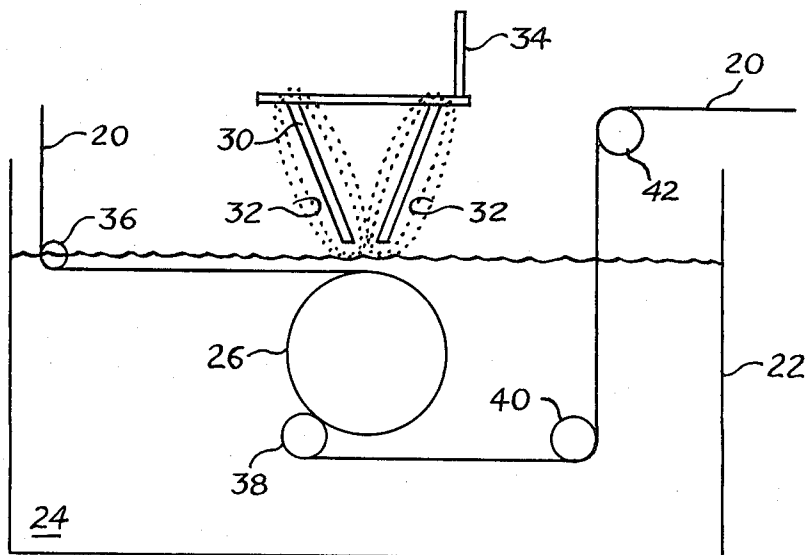


FIG. 3

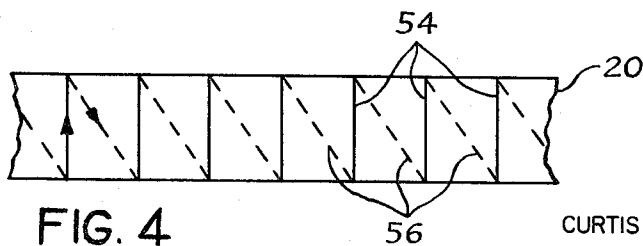


FIG. 4

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AUTOMATIC FILM PROCESSING DEVICE

CROSS-REFERENCE

This application is a continuing application of application Ser. No. 285,421 filed June 4, 1963 for AUTOMATIC FILM PROCESSING DEVICE now abandoned.

SUMMARY OF THE INVENTION

This invention relates to film processing devices and more particularly to an automatic accurately controlled developing device.

While the following description will be directed to the processing of aerial reconnaissance film, it is not intended that the broad concept be so limited since it will be obvious to those skilled in the art that what is herein disclosed is applicable to any type of film processing.

Resolution of fine detail, a factor of paramount importance in reconnaissance, severely restricts the choice of exposure latitude principally because the degree of detail recorded (resolution) is at least partially dependent upon obtaining an optimum negative density of the scene recorded on the film. Controlled processing, which in effect has the capability of extending the range of exposure for a given level of resolution is therefore an extremely important and critical means of increasing the amount of information that can be extracted from a given photographic exposure.

The prior art, during the course of processing and retrieving the latent image placed on the film, has many techniques available to vary the contrast and/or density of the image. One of these techniques is to vary the temperature of the developing solution. This has rather obvious defects in that when one portion of a negative is being developed at a given solution temperature and a given time, these parameters may not be applicable to the next succeeding portion of the film. As a result a compromise had to be achieved and it became possible for the compromise to be unsatisfactory for major portions of the film.

Still another method available to the prior art was one which involved increasing the agitation or activity of the solution over various parts of the film. This, too, had obvious disadvantages in that the increased activity could only be viewed at a considerably later period of time and it was possible to increase the activity at an area where decreased activity was in fact called for.

Our invention overcomes the difficulties of the prior art by providing a means of increased solution activity at selectable portions on a film strip where the amount and the duration of activity can be accurately controlled over smaller portions of the film than has previously been practicable.

It is, therefore, an important object of the instant invention to provide an improved film processing method and device.

Another important object of the instant invention to provide an improved film processing method and device.

Still another important object of the instant invention is to provide an automatic film processing method and device wherein the contrast and/or density of the film may be selectively controlled.

DESCRIPTION OF THE DRAWING

The features of our invention which we believe to be novel are set forth with particularity in the appended claims. Our invention itself, however, both as to its organization and method of operation together with further objects and advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a flow chart of our processing device;

FIG. 2 is one embodiment of our invention utilizing a shaped radio frequency field;

FIG. 3 is a side view of FIG. 2 taken along lines 3—3;

FIG. 4 is a plane view of the film of FIGS. 2 and 3 to indicate the scanning process of this embodiment;

FIG. 5 is another embodiment of our invention utilizing a dielectric heating generator; and

FIG. 6 is a view of the capacitor plates and the placement thereof relative to the film strip of FIG. 6.

DETAILED DESCRIPTION

Although the particular embodiments of the invention discussed hereinafter disclose the use of conventional developing fluids for use with particular silver halide films, it is to be fully understood that the invention is not so limited but that such embodiments merely are illustrative of particular manners of practicing the invention and as shown as such should in no way be read as limiting the inventive concept beyond the limitations expressly set forth in the appended claims. For example, infrared radiation is disclosed as the source of scanning the film for density measurements. If as the art progresses other forms of radiation will not expose areas of the film, other forms of radiation may be used to measure the sensitivity of the silver halide film. The invention is in no way limited to silver halide film but is broad enough to encompass any chemically processed photosensitive material that may be scanned for density measurement without further exposing the material.

Referring now to FIG. 1 there is depicted the basic concept of our invention in flow chart form indicating a predevelopment stage 10, a stage previewing, the predeveloped film 14, and a final development stage 16. The previewing of the predeveloped film determines the extent of control applied in response to information given to control means 18 to the final development stage 16 to produce the desired result. In addition, there is shown a stop bath 12 between the predevelopment stage 10 and the review of predeveloped film or preview stage 14. The stop stage 12 may be necessary in some instances and has been shown to include a dotted line extending between predevelopment stage 10 and preview stage 14. The optional stop stage 12 is necessary in those instances where sufficient time elapses between predevelopment stage 10 and preview stage 14 to cause excessive development and merely serves to inhibit such development. However, when very little, if any, time elapses between stages 10 and 14, stop stage 12 will be unnecessary and unwanted.

Referring now to FIGS. 2 and 3, there is depicted one embodiment of our controlled processing system. In this embodiment, film 20 is driven through tank 22 by

an appropriate film advancing means (not shown). Tank 22 contains a suitable developer solution 24 for predeveloping film 20 to a density level significantly lower than the final or required density level. The film 20 is drawn around idler 36 to drum 26 which rotates about its hub 28. Thereafter, the film proceeds around idlers 38, 40 and 42 after which time the development is considered to be completed and the film then brought on to a subsequent stage to appropriately fix the film.

A coil, generally designated as 30, is affixed to an arm 34. Coil 30 is arranged in such a manner that electromagnetic radiation 32 (radiofrequency) energy is produced and shaped to be concentrated at a point immediately therebelow on drum 26. The arm 34 is movable, allowing the focal point of rf energy generated by coil 30 to traverse the film. That is, the coil may move across the film on an axis parallel to the axis of rotation of drum 26. The movement of arm 34 and associated apparatus is shown in FIG. 2 by the arrows 33. The manner of movement with respect to the film 20 will be more fully explained hereinafter with reference to FIG. 4.

In this embodiment, the rf energy generated by coil 30 is concentrated on the portion of drum 26 immediately under coil 30 and serves to heat the drum locally. Since the film 20 is in intimate contact with the drum with the emulsion side facing the coil, the heat generated in the drum will be transmitted by conduction to the film base or substrate. In turn, the heated substrate will then heat the film emulsion in the discrete area of focus of the energy from the coil increasing the activity of the developer in and immediately surrounding the emulsion. The period of time that it takes the film to traverse from idler 36 to the controlled heated point immediately under coil 30 is, therefore, considered the predevelopment stage previously referred to with regard to FIG. 1.

In this instance, the preview and the final development stages occur almost simultaneously. As shown in FIG. 2, control means 18 controls the amount of rf energy generated by coil 30 and therefore the amount of heating and activity applied to the film.

Previewing of the predeveloped film is done by means of infrared generator 48 and photoelectric cell 50, preferably also mounted on arm 34 so that generator 48 and cell 50 move with coil 30. Infrared generator 48 emits the rays 44 of infrared energy which are reflected as rays 46 to be collected and detected by infrared sensitive photoelectric cell 50. At this point, there will be an appreciable amount of metallic silver due to the predevelopment. Silver halide, that is, the material in the undeveloped emulsion is a whitish-looking material having a degree of transparency of about 40 to 60 percent and a reflectance of about 60 to 40 percent depending upon the condition and type of film. Such factors as the degree of wetness, amount of predevelopment, etc. govern the relative reflectance and transmissiveness of the film to infrared radiation. Metallic silver is a blackish material and hence substantially not reflective or transmissive. Hence as the density level of the image on the film increases with increased development less infrared radiation is reflected by the film and received by photosensor 50. A decreased current output from the photoelectric cell

50 will be applied to control means 18 to decreasing the rf level of energy from coil 30. Thus the instantaneous density of the film is instantaneously detected and applied as a correction to coil 30 to heat the localized area of the drum which is in contact with that discrete area of the film, the density of which has just been measured. This may be a continuous process over the width of the film or may be intermittent. Suitable electronic control is well known in the art and need not be disclosed herein.

It should be understood that immediately after the film leaves the influence of the electromagnetic radiation 32 the processing may not be completed. There may be additional periods of development time which is determined by the length of time the film travels from the point of influence due to electromagnetic radiation 32, through the solution and into an appropriate stop bath. This further development may be minimized if the developer solution were maintained sufficiently cool or in the alternative, the system may be utilized in the present form by calculating the further development time needed to traverse this additional distance and applying a lesser development by means of coil 30.

An example of the operating parameters is the embodiment of FIGS. 2 and 3 is as follows: a film that may be used is Eastman-Kodak "Kodak Tri-X" panchromatic film. A description of the physical and chemical property of this film appears on pages 50 and 51 of the 7th Edition first 1956 printing of "Kodak Films" available from Eastman-Kodak Company, Rochester, New York. A developing bath that may be used is "Kodak Developer D-76," the chemical constituents of which are set forth on page 42 of the 5th edition (1954) first 1959 printing of "Processing Chemical and Formulas" available from Eastman-Kodak Co., Rochester, New York. Typical treatment of the film may be a predeveloped time period of 3 minutes, that is, any one point on the film would travel from roller 36 to a print directly below the coil 30 in a period of 3 minutes. Heat treatment of the film is 4 minutes. That is, a point on the film would travel for a period of 4 minutes from a point directly beneath the coil to the point at which the film leaves the drum and winds around roller 38. The final development may be five minutes, that is, the period it takes for any one point to travel from roller 38 to the stop bath solution not shown. A typical stop is Kodak SB-1a, the formulation of which is found on pages 44 and 45 of 5th edition of "Processing Chemicals and Formulas." The rf coil in this example would be activated by a current suitable to raise the temperature of the developing solution D-76, from 68° to 80°F, increasing the density of the discrete area of the film so treated from 1.2 to 1.5 and increasing gamma from 0.85 to 1.00.

It is to be fully appreciated that the times quoted hereinabove for development are limited only the use of the particular developing solution, D-76 and that high speed developers would work as well as the D-76 developer with the added feature of more rapid total time of development. For example, rather than the 12 minutes disclosed with respect to D-76, developers are marketed with developing times of a magnitude of the order of 10 seconds. It is fully understood that the invention is in no way limited by the use of D-76 developing solution but it is within the concept of the

invention to use available developing solutions and solutions which may become part of the art as advances are made.

Referring now to FIG. 4, there is shown the scanning path of the embodiment of FIGS. 2 and 3 relative to a film strip. In some instances, where the film to be processed is sufficiently wide, it is necessary for the coil 30, the infrared generator 48 and the associated detector 50 to both travel across the film thereby covering small increments of the film both in width and length. While not shown in FIGS. 2 and 3 it should be understood that the movement of coil 30 will be along lines 54 in the direction of the arrows and having traversed the width of the film 20 will be blanked and its retraced path will be that indicated by dotted lines 56. Once retracing is completed, the coil is again activated and traced along the next succeeding line 54. However, since detector cell 50 monitors the instantaneous density level, it is also possible for the developing process to continue in both directions of travel and avoid the need for "unblanking."

Referring now to FIG. 5 there is shown the film 20 passing through developer solution 24 which is contained in tank 22. The film progresses around drum 26 and is brought to the appropriate infrared generator and detector 48 and 50 respectively. Here, too, the output of detector 50 is applied as an input to the delay/control means 58. In this embodiment, plates 70 are the capacitor plates of a dielectric heating device. As the film proceeds between plates 70, the film base acts as the dielectric and the substrate is heated. Once the substrate is heated the activity of the developer embedded in the emulsion and on the emulsion surface is increased in the same manner as described with the proceeding embodiment. Similarly, the output of the delay/control means 58 is applied as an input to rf generator 68 to determine the amount of dielectric heating necessary to apply to the film to achieve the desired contrast and/or density. After leaving the influence of dielectric plates 70 the film proceeds to tank 72 which has contained therein drum 76 and developer 74 to appropriately include further development or may be utilized as a stop bath terminating any further development as previously described.

As an example of the embodiment of FIG. 5 the time periods, film type and chemical solutions may be the same as that set forth with respect to the embodiment of FIGS. 2 and 3. That is, the time that a particular print on the film would be immersed in the solution of tank 24 would be 3 minutes, the predeveloped time. The post treatment time would be 4 minutes during which the film would be subjected to heat to temperatures of 80°F as opposed to 68° F of the development bath and a post development time that is, time in bath 74 be 5 minutes.

FIG. 6 denotes the relative placement of the dielectric heating plates 70 and detector tube 50 above the film 20. In this embodiment instead of scanning there is utilized a series of adjacent capacitor plates and adjacent detector so that small increment areas of the film may be detected and appropriately heated.

While we have described what is considered particular embodiments of our invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from

the invention concept, and it is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

What is claimed is:

1. Apparatus for controlling the processing of a photosensitive medium to achieve a desired density of the developed medium including:

- a. means for partially developing the medium;
- b. means for measuring the degree of partial development of the medium;
- c. means, responsive to said measuring means, for rendering a signal proportional to the extent to which further development of the medium should be altered to yield the desired density in the developed medium, said signal having differing values depending upon the degree of partial development of the medium; and
- d. means for developing the medium to completion, including utilization means responsive to said signal for altering the extent of further development during the development to completion to achieve a desired density in the developed medium.

2. Apparatus as set forth in claim 1 wherein:

- a. said measuring means includes means for making a plurality of measurements at a plurality of areas of the photosensitive medium;
- b. said means to develop a signal develops separate signals for each of said areas; and
- c. said utilization means is responsive to said signals to alter the extent of further development at each of said areas of the photosensitive medium.

3. Apparatus as set forth in claim 2 wherein said utilization means includes means for varying the temperature of the developmental activity at each of said areas of the photosensitive medium.

4. Apparatus as set forth in claim 2 wherein the photosensitive medium is a strip of film and said measuring means includes scanning means for scanning across the width of the film strip.

5. Apparatus as set forth in claim 4 wherein said scanning means includes a scanning arm and means to move the scanning arm across the width of the film strip, and said utilization means includes a heating means attached to said scanning arm to simultaneously apply heat to the photosensitive medium according to the instantaneous output of said scanning means.

6. Apparatus as set forth in claim 5 wherein said means to develop the medium to completion includes a drum which is mounted for rotation, and the film strip rotates on said drum while being processed, and said heating means includes a coil and means to apply an alternating electric current to said coil in accordance with the output of said measuring means, whereby electromagnetic radiation produced by said coil is directed against a particular area of the drum to heat that area of the drum and thereby alter the extent of further development of the area of the film strip located on said area of the drum.

7. Apparatus as set forth in claim 1 wherein the photosensitive medium is a film strip, and the apparatus is part of a continuous flow processor wherein film is moved continuously through the processor.

8. Apparatus as set forth in claim 7 wherein:

- a. said measuring means including means for making a plurality of measurements at a plurality of areas of the film strip as the film strip moves continuously through the processor;
 - b. said means to develop a signal develops separate signals for each of said areas; and
 - c. said utilization means is responsive to said signals to separately alter the extent of further development at each of said areas of the film strip as the film strip moves continuously through the processor.
9. Apparatus as set forth in claim 8 wherein said utilization means includes means for varying the temperature of the developmental activity at each of said areas of the photosensitive medium.
10. Apparatus as set forth in claim 9 wherein said measuring means includes scanning means which scans across the width of the film strip as the film strip moves continuously through the processor.
11. Apparatus as set forth in claim 10 wherein said

scanning means includes a scanning arm, and means to move the scanning arm across the width of the film strip as the film strip moves continuously through the processor, and said utilization means includes a heating means attached to said scanning arm to simultaneously apply heat to the photosensitive medium according to the instantaneous output of said scanning means.

12. Apparatus as set forth in claim 11 wherein said means to develop the medium to completion includes a drum which is mounted for rotation, and the film strip rotates on said drum while being processed, and said heating means includes a coil and means to apply an alternating electric current to said coil in accordance with the output of said measuring means, whereby electromagnetic radiation produced by said coil is directed against a particular area of the drum to heat that area of the drum and thereby alter the extent of further development of the area of the film strip located on said area of the drum.

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