United States Patent

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[54] **INTEGRATION-CONTROLLED APPARATUS**
7 Claims, 3 Drawing Figs.

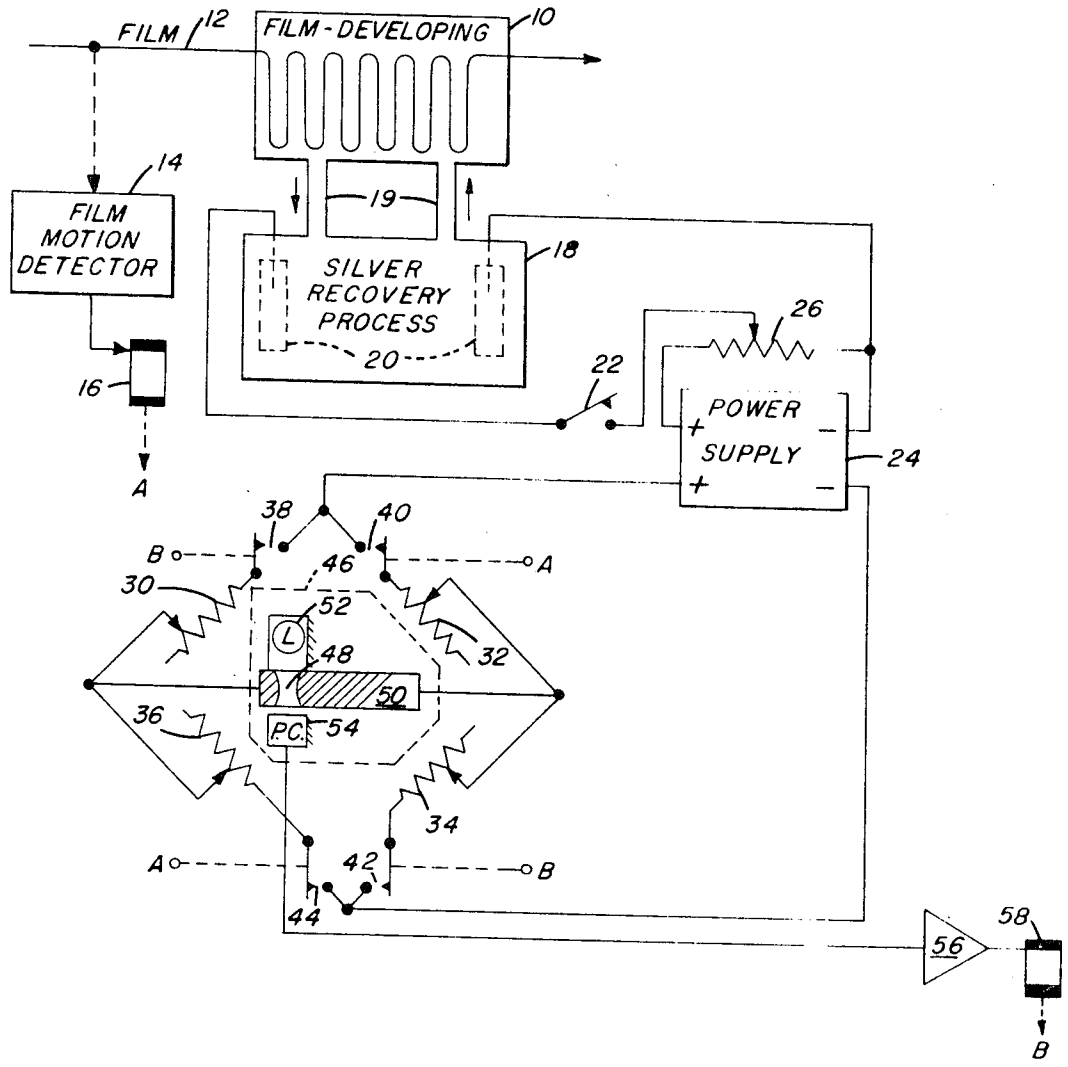
[52] **U.S. Cl.** **204/228,** 204/109
[51] **Int. Cl.** **B01k 3/00,** C22d 1/12
[50] **Field of Search** ..... 204/228, 109; 323/75 N; 250/229; 356/249

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ABSTRACT: Photographic developing solutions dissolve silver during film processing. Processing occurs during a normal workday. Electrolytic recovery of silver may occur during, and after, the workday. The electrolyzing current is (preferably) set in proportion to a quiescent silver content of the developing solution; and the duration for applying the current is regulated in accordance with the integral of the difference between the rates of input and recovery silver. Other applications of the disclosed invention are possible.



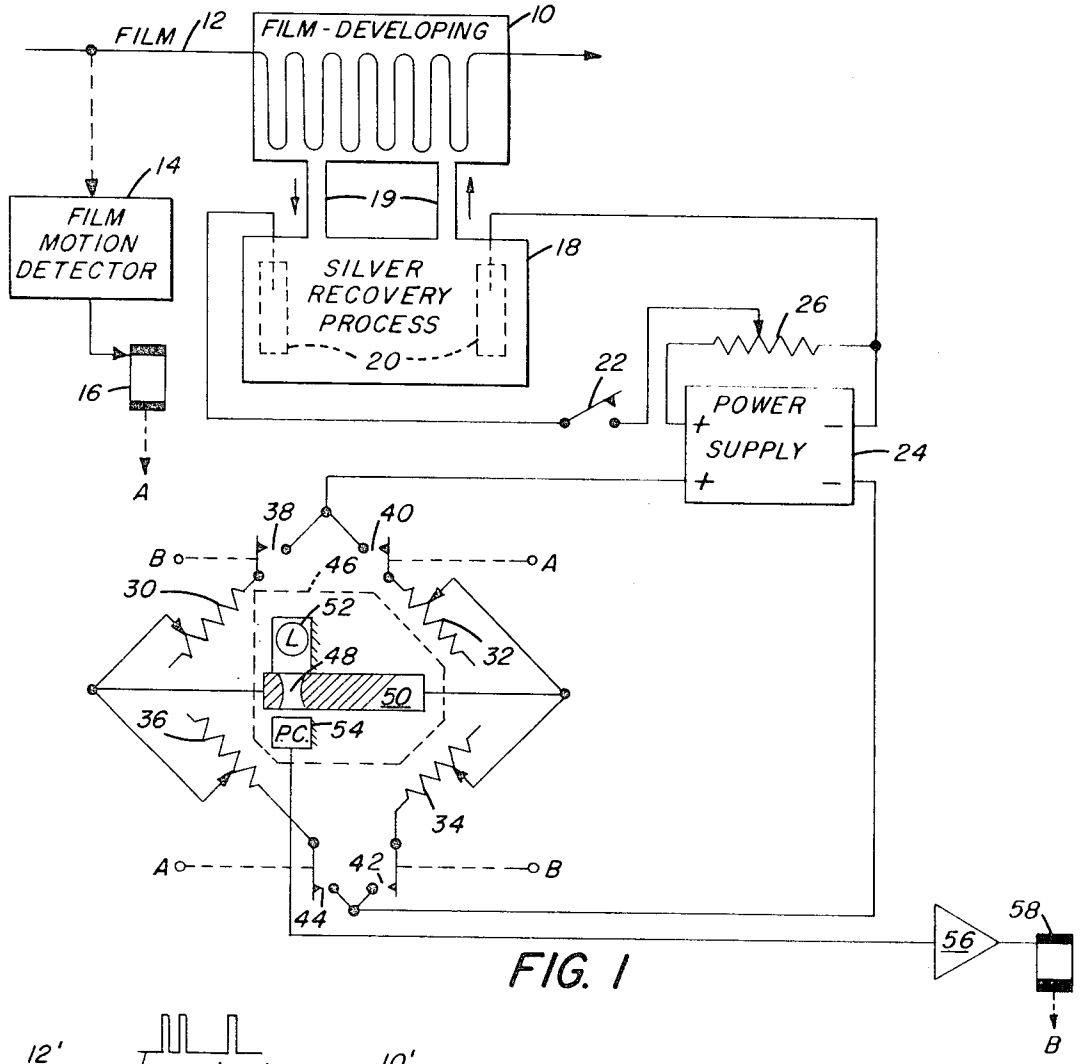


FIG. 1

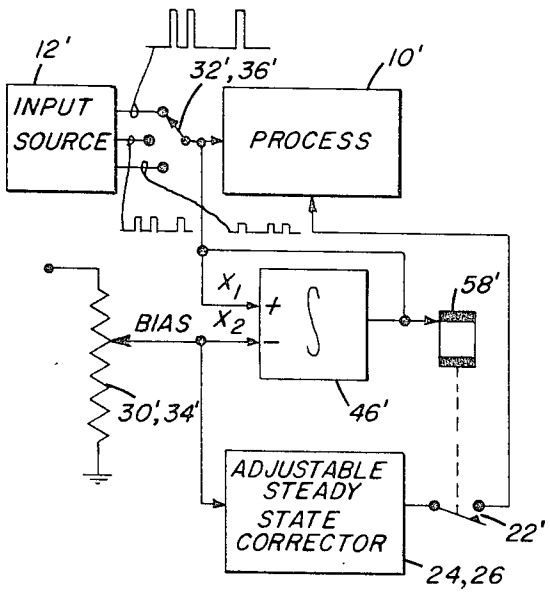


FIG. 3

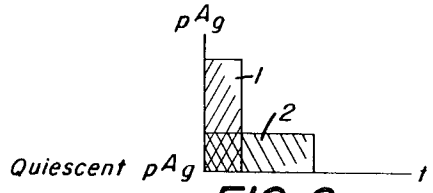


FIG. 2

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INTEGRATION-CONTROLLED APPARATUS

BACKGROUND OF THE INVENTION

1. Field of The Invention

While the invention may find many and various applications, it is herein cast in a silver recovery process which is cooperative with photographic developing apparatus adapted to receive, at discrete intervals, various quantities of film.

2. Description Relative to the Prior Art

In large film-developing operations, the preferred practice of recovering silver from photographic developing solutions, e.g. fixing solution, is to remove such silver electrolytically from solution by means of an electric current which is proportional to the quantity of silver in solution. This technique is efficient; and it permits the fixing solution to be reclaimed for subsequent use. Current levels which are too high for a given silver concentration not only attack the fixing solution, but cause the silver reclaiming electrodes to sulfide; current levels which are too low inherently require too much time for efficient recovery of silver. In the past, it had been the practice manually to control continually the electrolyzing current in accordance with silver concentration as determined by the colorimetry techniques etc.; but this general technique has recently been automatized.

Film-developing apparatus through which film is processed at irregular periods of time during a given time period are also known. These apparatus are ordinarily operated to receive film during a normal 8hour workday; and are equipped with respective silver recovery cells. Each silver recovery cell may be operated for a time longer than a normal workday. See British Pat. No. 1,065,547, published Mar. 20, 1968. The silver recovery cell and its complementary developing apparatus are arranged to interchange their respective solutions. In the past, it had been the practice to employ silver recovery electrolyzing currents which were sufficiently low to assure against the above-mentioned sulfiding. Attendently, since the quantity of silver washed into solution during a normal workday could be in excess of what might be reclaimed during the silver recovery period (say a full 24hour day), the silver concentration of the (interchanged) developing solution could gradually build up; and eventually such solution would become less than adequate for its intended purpose, and would usually have to be replaced.

SUMMARY OF THE INVENTION

The invention takes into account that if a silver recovery electrolyzing current, compatible with a certain quiescent developing solution silver concentration, is employed for a duration sufficient to equate the silver which is added to such solution during one time period and the silver reclaimed from such solution during a second (longer) time period, then the developing solution will not degrade, and the maximum recovery of silver will obtain. Since the silver input to developing solution can vary depending, say, on the type of film being processed, the "quiescent" current, as suggested by the invention, is adjustable to assure that input and output silver can be made equal; and to assure that such equating of input and output silver does in fact occur, the invention proposes an adjustable integrator to control the duration for application of "quiescent" current to the silver recovery cell. A first signal is integrated in accordance with the rate of input silver; a second signal is integrated in accordance with the rate of recovery silver; and current is applied for silver recovery purposes for a time equal to the time that it takes for the integral of the output rate for silver to equal the integral of the input rate for silver. Therefore, whatever silver is added to developing solution is assuredly reclaimed. (This technique has other application and may, for example, be used to control the flow of replenisher solution into a photographic developing process. Such use of the invention, and others, will be considered later. For now it is believed that the invention is best appreciated cast strictly in the environment of a silver recovery process.)

The silver added to a developing solution during film processing (8hour workday) is approximated by an electrical analog signal of the film area. Such analog signal is gradually and steadily canceled during silver recovery (24hour day) by means of a bias signal representative of the "quiescent" current employed for silver recovery: and recovery current is applied until signal cancellation occurs. The invention employs an adjustable bridge circuit cooperative with an integrator element for signal cancellation purposes. As film is inserted into developing solution, a film motion detector causes the bridge circuit to excite the integrator element in a first direction in proportion to the quantity of silver added to solution. At the instant the integrator starts to operate, the bridge circuit reverse biases the integrator element in proportion to the "quiescent" current applied for silver recovery purposes. Since silver is recovered at a rate which is slower than the rate at which it is added to developing solution, the integrator element keeps the "quiescent" silver recovery current flowing, after film ceases to be applied to the developing solution, for a time proportional to the integral of the difference between the silver input and recovery rates. Attendantly, the developing solution maintains a quiescent silver content; which is to say that silver recovery maximizes, and the developing solution does not degrade.

An object of the invention is to provide means for maintaining a process in a prescribed quiescent operating condition.

Another object of the invention is to maintain the long term condition of photographic developing solution substantially invariant, short term variations in the consistency of such solution being corrected for by substantially steadily modifying such solution at a certain quiescent rate.

Another object of the invention is to provide apparatus for electrolytically recovering silver from used photographic developing solution, the operation of which apparatus is based on (1) recovering all silver added to the solution during developing while (2) maintaining a certain quiescent silver content of solution by means of a steady electrolyzing current which is applied so long as the actual silver content of the solution is greater than such quiescent content.

Another object of the invention is to recover silver from photographic developing solution in proportion to the area of film processed through such solution.

The invention is described with reference to the figures wherein:

FIG. 1 is a schematic diagram of a presently preferred adaptation of the invention,

FIG. 2 is a diagram useful in describing the invention, and

FIG. 3 is a block diagram illustrating apparatus according to the invention.

With reference to FIG. 1, film-developing apparatus **10** is adapted to process film **12** at irregular intervals. Motion of such film **12** into the developing apparatus is sensed by means of a detector **14**, e.g. in the manner noted in British Pat. No. 1,106,547. The detector **14** actuates a relay **16** so long as film is being processed. Since the film **12** (usually) has a certain width, the duration that the relay **16** pulls in is representative of the area of film that is fed to the developing apparatus **10**.

An electrolytic silver recovery cell **18** cooperates with the developing apparatus **10** by means of conduits **19**; and the cell **18** is equipped with electrodes **20** which are electrically excitable, via a switch **22**, by means of a power supply **24** and cooperating potentiometer **26**. The potentiometer **26** permits the electrolyzing current in the cell **18** to be set, for example, so that it flows at a level compatible with a certain quiescent silver content within the recovery cell **18**. Therefore, if such quiescent silver level is to be maintained, the current applied through the recovery cell is to be for a duration in accordance with the silver content of the film being processed.

Actuation of the relay **16** initiates operation of an adjustable bridge circuit integrator element combination. The bridge circuit is excited by the power supply **24**, and comprises four potentiometers **30, 32, 34, 36** in its respective legs; each leg includes a respective normally open switch **28, 40, 42, 44**. The

integrator element 46, in this form of the invention, is of the type indicated in U.S. Pat. Nos. 3,045,178 and 3,255,413; i.e. a window 48 in a column of mercury 50 is coulometrically positioned, with time, along the mercury column as a function of the voltage across the column, thereby cutting off the light from a lamp 52 to a photocell 54 whenever the window 48 is not at its reference position. The photocell 54, in cooperation with an appropriate circuit 56, actuates a relay 58 and pulls the relay in so long as the light to the photocell 54 is blanked.

With the potentiometers 26 set so that the steady current to be applied to the silver recovery cell 18 will, for example, be commensurate with a certain silver content of the solution within the recovery cell 18, the insertion of film into the film-developing apparatus 10 causes the relay 16 to close switches 36, 40 for a time proportional to the length (area) of such film. This places a potential, of one sense, across the mercury column 50, causing its window 48 to start to migrate at a certain high rate to the right (looking at FIG. 1), thereby blanking the photocell 54. As soon as the photocell 54 is blanked, the relay 58 pulls in to close the switches 38, 42. By setting the potentiometers 32, 36 in accordance with the rate of silver input, and by setting the potentiometers 30, 34 in accordance with the steady silver recovery rate (potentiometer 26) the voltage across the mercury column 50 when the relay 58 pulls in causes the window 48 to be steadily displaced rightwardly in proportion to the time that is necessary to maintain the electrolyzing current (potentiometer 26) after the film 12, into the developing apparatus 10, stops. When the film 12 ceases to be applied to the developing apparatus 10, the relay 16 drops out, thereby opening the switches 44, 40 to remove the dominant silver input bias which causes the window 48 to move rightwardly. Instead, the sense of the potential across the mercury column 50 reverses, thereby causing the window 48 to migrate back to its reference position at a rate in accordance with the steady application of electrolyzing current to the cell 18. At the instant the window 48 reaches its reference position, the switches 38, 42, 22 all open, causing movement of the window 48 to stop, and power to the silver recovery cell 18 to cease, thereby leaving the silver content of the solution in the cell 18 at a quiescent level. See FIG. 2 which indicates by means of area 1 the "high-rate, short duration" silver into the silver recovery cell 18 from the film 12; and by means of area 2 the "low-rate, long duration" silver recovered in such cell 18 by means of the steady application of "quiescent" current.

Where the invention improves over the art is in prescribing (1) an adjustable electrolyzing current which may be made compatible with any quiescent concentration of silver in developing solution, (2) the use of adjustable analogs for the rates of input and recovery silver, and (3) the application of such electrolyzing current to a silver recovery cell for a time dependent on the ratio of the rates of input to recovery silver.

It has been indicated that the above principles are applicable to other processes. See FIG. 3 which suggests broad implications of the invention; corresponding elements of FIGS. 1 and 3 are similarly designated, but primes are used in FIG. 3. As used to control the addition of replenisher solution to a photographic developing process, consider the following: Input source 12' of photographic film intermittently applies film to a film developing process 10'. The film, as indicated, may contain any of the three quantities of impurities (e.g. silver). Depending on which level of impurity obtains, a corrector 24', 26', e.g. a valve, is set to add a steady flow of replenisher solution to the process 10'. The duration for adding replenisher solution to the process 10' is directly controlled by a relay-type device 58'; and actuation of the relay-type device 58' is either by means of an integrator 46', or by means of the film as it enters the process. An analog of the steady flow of replenisher solution is provided by an adjustable bias source 30', 34', and such analog is algebraically balanced against an intermittent analog representing one of the three quantities of film impurities, thereby producing a resultant signal. The integrator 46', which may be like the integrator element 46 of FIG. 1, integrates the resultant signal, and actuates the relay-type device 58' so long as the integrator output signal is positive. Thus, replenisher solution is steadily applied to the process 10' for a time to maintain a quiescent quality for the developing solution employed within the process 10'.

The invention has been described in detail with particular reference to a preferred embodiment thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention.

We claim:

1. In combination with a system (10) subject to short duration, high-intensity disturbances during a first time period, adjustable means (26), (18) for substantially steadily correcting for such disturbances during a second longer time period, actuable means (58) for coupling said adjustable means (26) to said system, and means (30), (32), (46) for actuating the said actuable means comprising:
   a. first means (32) settable in proportion to and disposed to produce a first signal representing the rate at which high-intensity disturbances influence said system,
   b. second means (30) settable in proportion to and disposed to produce a second signal representing the rate at which said adjustable means steadily corrects for such disturbances, and
   c. integration means (46) cooperative with said signal producing first and second means to integrate their respective signals and in response thereto to maintain the actuation of the said actuable means for so long as the time integral of the first signal is greater than the time integral of the second signal.

2. The system of claim 1 wherein said integration means (46) produces a signal representing the time integral of the algebraic difference between its two input signals, and said actuable means is responsive to both the said means for actuating and to said short duration disturbances as well.

3. A photographic film-developing system having a processing portion (10) adapted to receive and be influenced by film, and a control portion adapted to maintain the said processing portion in a substantially quiescent operating condition, said control portion comprising
   a. first adjustable (26), (18) for substantially steadily modifying the condition of the processing portion,
   b. second adjustable means (32) for producing a first analog of the rate at which said film influences the condition of said processing portion,
   c. third adjustable means (30) for producing a second analog of the rate at which said first adjustable means modifies the condition of the processing portion, and
   d. integration means (46) responsive to said analogs to couple said first adjustable means to said processing portion so long as the time integral of the first analog is greater than that of the second.

4. The system of claim 3 wherein the first adjustable means is the combination of silver recovery means (18) and a regulatable power supply (24), (26) therefor, said silver recovery means being cooperative with said processing portion to interchange their respective solutions.

5. The system of claim 4 including means, in addition to said integration means and responsive to the application of film to the processing portion of said system, for coupling the combination of silver recovery means and power supply to said processing portion, whereby silver recovery occurs while said film is being applied to said processing portion and for a duration thereafter which is proportional to the integral of the difference between the rates at which silver is dissolved into and recovered from processing solution.

6. The system of claim 4 wherein the said power supply is so regulatable that the current through the silver recovery means may be made compatible with the silver content of solution within that means.

7. The system of claim 5 wherein said second and third adjustable means are potentiometric means, wherein said integration is a reversible integrator element respectively op-

positely excitable by means of said potentiometric means, and wherein the said integrator element has a reference condition at which it does not influence the coupling between the first adjustable means and the said processing portion.

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