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a corporation of Delaware
Continuation-in-part of application Ser. No.
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| [54] | IMAGE MONITORING AND CONTROL SYSTEM | |
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95/94; 350/96 |
| [51] | Int. Cl. | G03d 3/06 |
| [50] | Field of Search | 95/89, 94;
350/96 |

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ABSTRACT: An automatic replenishment system for a film processor comprises an optical sensor and associated circuit for monitoring and integrating the optical densities developed in sheets of image bearing photosensitive material, to control the feeding of replenishment chemicals to the film processor. An improved sensor is employed wherein scanning occurs at constant speed to permit use of an integrator having a fixed integration time; and the integrator is activated as a function of the distance that an image-bearing photosensitive sheet has been transported past the sensor. A rebalancing zeroing circuit automatically adjusting the monitoring system for each scan is added to improve overall accuracy without requiring regulated power supplies.

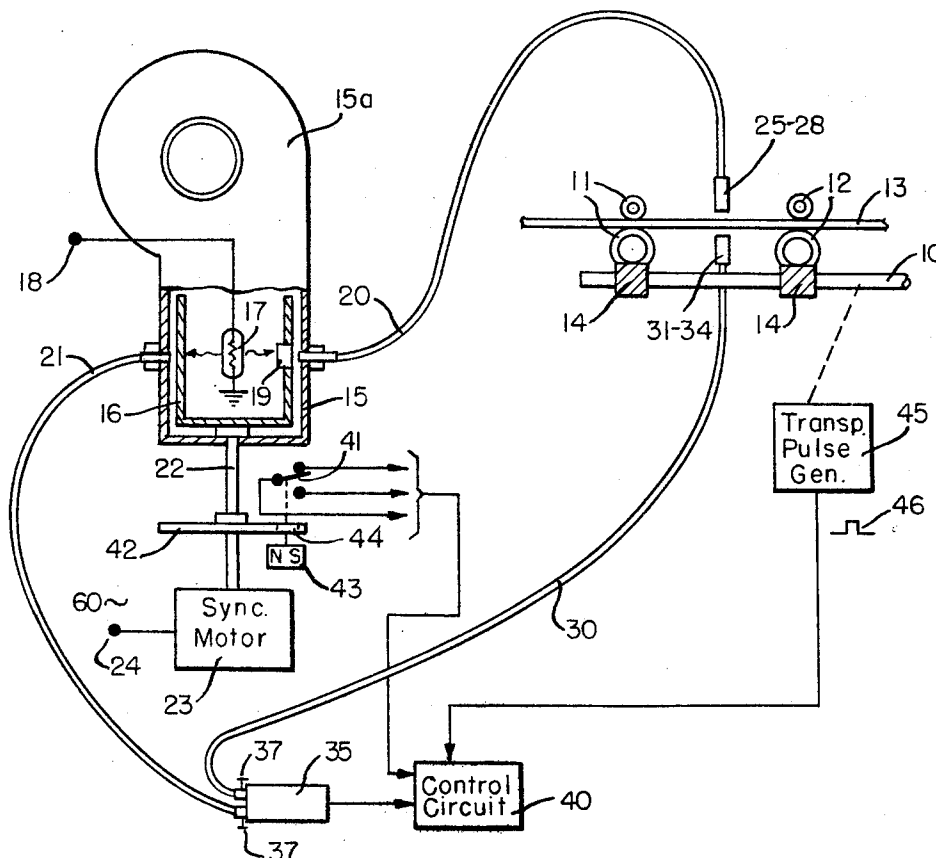


FIG. 1.

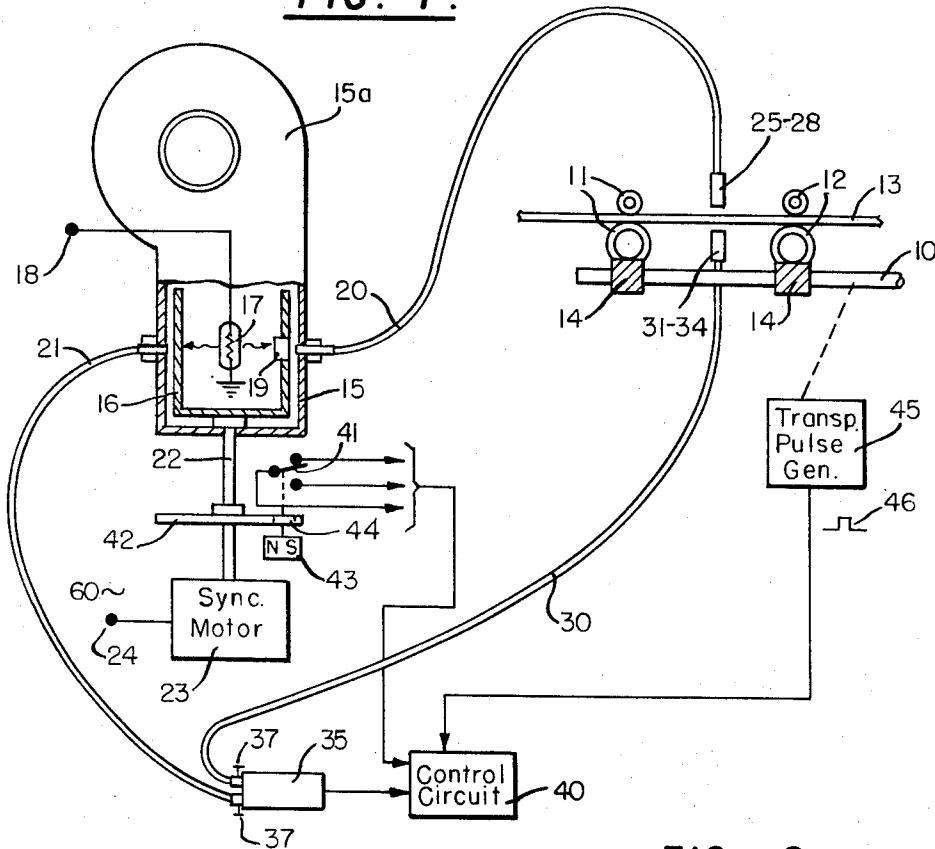
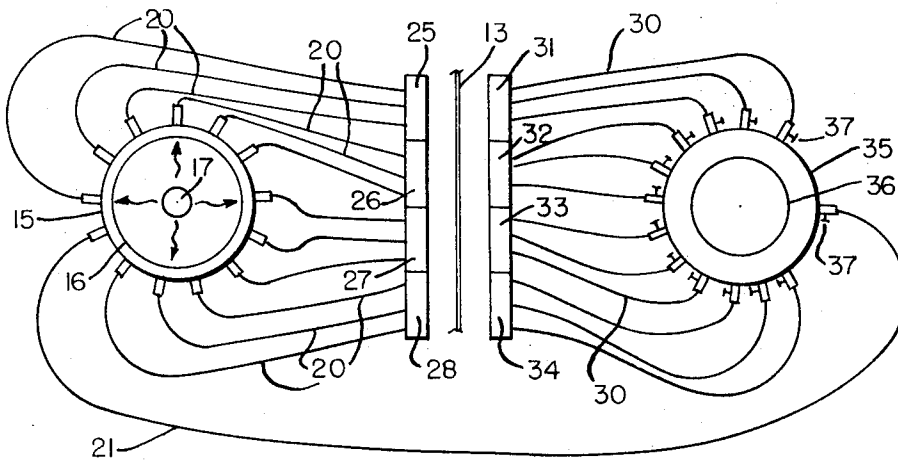


FIG. 2.



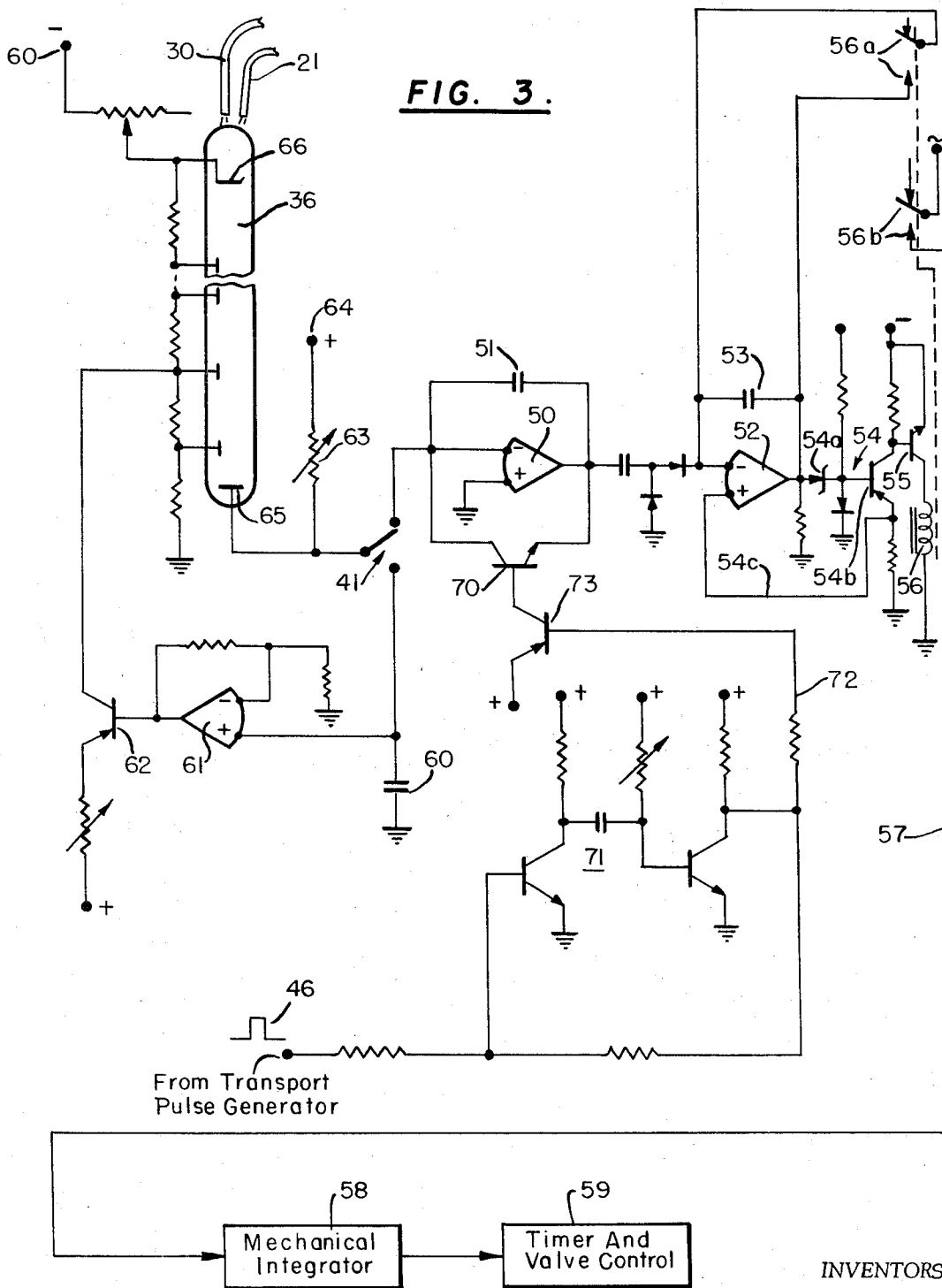
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IMAGE MONITORING AND CONTROL SYSTEM

CROSS-REFERENCE TO RELATED APPLICATION

The present application comprises a continuation in part of John N. Street application Ser. No. 734,297 filed Jun. 4, 1968, for "Image Monitoring and Control System".

BACKGROUND OF THE INVENTION

Various forms of automatic processors adapted to develop, fix, wash and dry sheets of photosensitive material are already known to those skilled in the art. In such processors, a sheet of photosensitive material to be processed is fed in sequence from one processor tank to the next; and the developed, fixed and washed material is then automatically passed through a drier and collected. In the normal operation of such processors, the chemicals employed for processing the photosensitive material tend to become depleted as sheets of such material are processed; and unless some form of chemical replenishment is effected during continued operation of the processor, there will be a severe degradation in the image quality of the films being developed.

It has been customary in the past to include some form of controllable replenishment facility in automatic film processors, intended to maintain chemical concentrations in the processor tanks at desired values, or within desired limits. A variety of techniques and apparatuses attempted in the past for this general purpose have been discussed in the aforementioned prior copending application Ser. No. 734,297; and this discussion, as well as the overall disclosure of said prior copending application, is incorporated herein by reference. In general, prior manual and so-called automatic replenishment systems exhibited various disadvantages and inaccuracies which prevented attainment of proper replenishment and maintenance of proper chemical balance.

A highly improved and far more accurate film processor replenishment system has been disclosed in prior copending application Ser. No. 734,297. In the system of this earlier application, a film processor is provided with a sensor apparatus adapted to monitor the image density throughout the complete area of a film sheet after it has been developed, and integrator means are provided for generating an electronic signal commensurate with the monitored image density in such film sheets. (The term "sheet" encompasses both continuous and cut lengths of material, and the term "film" encompasses any suitable type of material requiring processing.) The complete area image density variations of the film sheet (or a plurality of such sheets), thus monitored, provide a highly accurate measure of the degradation of the developer and fixer solutions of the processor; and a signal generated as a result of the monitoring operation is employed to control proper replenishment of said solutions.

The system of application Ser. No. 734,297 employs an optical scanner comprising an array of optical fibers which are illuminated in sequence by a light source, and which cause an elongated narrow beam of light to scan repetitively the complete width of a sheet of film transported past the scanner after the sheet has been developed and fixed. Light passing through the developed film is detected by a further array of optical fibers located on the opposite side of the film; and the detected light is then transmitted via said further array to a photocell, photomultiplier tube, or like means. The photocell is coupled to a first or "fast" integrator adapted to produce a signal commensurate with the developed areas sensed on the film during a single scan of the film sheet by the sensor, and the output of this first integrator is sampled after each lateral scan of the film. The sampled output of the fast integrator is transferred to a second or "slow" integrator arranged to store and aggregate information corresponding to a plurality of lateral scans of the film sheet. The output of the second integrator is in turn applied to a level detector and, when the output of the second integrator reaches a preselected level, the accumulated information in the second integrator is transferred to a mechanical for further accumulation. When a

predetermined level of information has been accumulated in the mechanical integrator, a timer and replenishment solenoid valve system are energized to transfer replenishment chemicals from storage tanks to the processor tanks for a fixed interval of time and at preselected flow rates.

The general system described above incorporates light commutator and reed switching assemblies which are basically simple in concept, but complex in execution. The light commutator or scanner is driven directly from the transport system of the film processor so that the sensor achieves its optical scanning at a rate related to the speed of transport of the sheet through the processor; and this operates to produce a constant number of scans per linear inch regardless of transport speed. In addition, however, this arrangement presents the requirement for a variable integration time in the fast integrator, and the system of the prior application accordingly employs a fast integrator which incorporates a plurality of capacitors which are individually selected for use in the integrator for various major transport speed increments to compensate for the variable velocity scan.

This use of plural integrating capacitors represents a complexity in the system and, also, a source of possible inaccuracy since any one capacitor can, at best, merely approximate the desired integration time except at one particular speed. As will appear, this possible source of error has been eliminated in the present invention through use of a new optical scanner which operates at a constant scanning velocity; and the fast integrator is controlled to take fixed time-interval samples of the film density information, with the commencement of each sampling time-interval being determined by the distance which a sheet of film has been transported past the sensor, rather than by its speed of transport. These considerations permit the employment of a single integrating capacitor in the fast integrator, and cause it to exhibit a fixed integration time, regardless of possible variations in transport speed thereby reducing the complexity of the system and avoiding a possible source of error.

The system of prior application Ser. No. 734, 297 also employs a plurality of fiber optics bundles distributed over a 120° arc in the light scanner; and these plural fiber optics bundles are scanned by a light source and associated rotary shutter having three equally-spaced identical apertures. This arrangement necessitates relatively high cost precision machining procedures, and requires that extreme care be taken in fabrication of the scanner. An improved scanner is employed in the present invention which obviates these cost and assembly difficulties.

To assure accuracy, the system of the prior application contemplates the use of regulated power supplies for energizing the lamp of the scanner, as well as for energizing the photomultiplier tube of the reading sensor. The need, and attendant cost, of such regulated supplies are eliminated in the present invention by the use of a novel zeroing arrangement operative to transmit a quantity of reference light to the photomultiplier tube at the end of each active scan, and associated with a control circuit incorporating a dynode voltage feedback loop operative to maintain the photomultiplier tube anode current, and therefore its light sensitivity, at a constant value.

The system of the earlier application, moreover, contemplates the use of three rotating magnets to obtain identical actuation of two reed switches for effecting various control functions during the monitoring and information accumulation steps. These mechanical considerations have been found to present major problems during production, involving the accurate balancing of magnets, plural reed switches, etc. In the present invention, an improved electronic circuit is employed which eliminates the use of one reed switch and all rotating magnets. To achieve a more reliable and predictable operation of the remaining switch, a different means of switch actuation has been adopted, involving the use of a stationary magnet which has its field interrupted by a shunt-type rotating aperture plate.

SUMMARY OF THE INVENTION

The system of the present invention is generally similar to the arrangement discussed above and disclosed in prior copending application Ser. No. 734,297. While the general organization and theory of operation of the system is the same as that described in said earlier application, a number of significant changes have been made.

In the system of the present invention scanning of the developed film occurs at a constant speed to provide a constant scan time. The line scanning rate is maintained at a fixed value, irrespective of the film transport speed, by means of a constant-velocity mechanical scanner driven by a motor having its speed of rotation synchronized by a power source of stable frequency, e.g., the power-line frequency.

The fast integrator of the present invention is revised to employ only a single capacitor of fixed value, whereby the fast integrator exhibits a predetermined and constant integration characteristic. The fast integrator is turned "on" for a time period equal to one scan line (approximately 100 milliseconds for a scanner rotational speed of 600 r.p.m. once every 0.1 inch of linear film travel through the sensing station. This control of the fast integrator is achieved by means of a one-shot multivibrator and an associated reading gate which are triggered by a transport pulse generator operated by the processor transport system. The fast integrator is thus caused to accumulate information corresponding to a single scan, as in the earlier system, but it does so without the complexity of plural reed switches and rotating magnets, and without the inaccuracies which are certain to arise through use of a variable integration time.

The improved system of the present invention incorporates, moreover, a rebalancing (or zeroing) circuit which employs an extra fiber optics bundle extending between the scanning light source and the photomultiplier tube, but located outside of the film path, for exposing the photomultiplier tube to a reference light level during a portion of each scan. The difference between the output current of the photomultiplier tube and that of a stable reference current source is coupled, during the zeroing time interval, to a sampling amplifier which controls a feedback circuit operative to adjust the photomultiplier tube dynode potential immediately prior to the commencement of each active line scan. As a result, the system operates to maintain a constant value of photomultiplier tube anode current and a predetermined optical sensitivity, irrespective of line voltage variations and/or lamp brightness changes. This permits the system to dispense with costly and complex regulated power supplies without affecting the accuracy of the overall monitoring and integration operations.

A number of additional improvements are made to reduce the cost of the overall system, to reduce maintenance requirements, and to make the system more easy to manufacture, set up, and operate. As discussed earlier, one of the reed switches and all of the rotating magnets employed in the arrangement of the earlier application have been eliminated, and a different means of actuation is employed for the remaining switch, comprising a stationary magnet associated with a shunt-type rotating magnetic-aperture plate. The separate level detector of the earlier circuit has been simplified, and is partially combined with the slow integrator. In addition, the sensor is now constructed to exhibit a new distribution of fiber optic bundles, relative to the light source, to simplify fabrication of the scanner; and the sensor bundles themselves are constructed in a modular form at the transmitter and receiver sensor portions of the system to facilitate sensor installation and replacement of faulty optical bundles.

By the various changes discussed above, the overall system has been simplified and reduced in cost, and, at the same time, its stability and reliability have been improved.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an illustrative view of an improved scanner and zeroing arrangement constructed in accordance with the present invention;

FIG. 2 is another view of the scanner and zeroing arrangement of FIG. 1; and

FIG. 3 is a circuit diagram of an improved control system constructed in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As is discussed in prior copending application Ser. No. 734,297, identified earlier, the description of which is incorporated herein by reference for completeness, an automatic film processor employing the improved automatic replenishment control of the present invention may comprise a plurality of processor tanks including at least one developing tank, at least one fixing tank, and at least one wash tank. Exposed sensitized material to be developed is fed in sequence through the several tanks by means of an appropriate transport system; and the transport drive shaft for such a system has been designated 10 in FIG. 1. Squeegee roller pairs 11 and 12 may be located downstream of the wash tank in the processor; and the developed film 13 is caused to pass through said squeegee roller pairs by means of a worm drive 14 carried by shaft 10, to achieve surface moisture removal from film 13 before it is finally dried and collected.

As is discussed in prior copending application Ser. No. 734,297, sensor arrangement is provided adjacent the squeegees to inspect or monitor each sheet of film 13 throughout both its width and length thereby to determine the optical image densities developed in the film by the processor action. This provides information constituting a measure of the amount of chemical which has been used in the course of the development process, and this information is accumulated during the monitoring operation and used to control chemical replenishment in the processor. An improved sensor is used in the present invention; and a preferred embodiment is shown in FIGS. 1 and 2.

The sensor of the present invention employs an improved scanner comprising a stationary light-tight lamp housing 15 provided, on its interior, with a concentric drumlike shutter member 16. A lamp 17 is supported within drum 16; and lamp 17 may comprise, for example, a 50 watt lamp energized by a 12 volt DC source 18. Lamp 17 may emit white light, or may have other spectral characteristics e.g. red light), or may be associated with any appropriate light filter. As will appear subsequently, source 18 need not be a regulated source. A blower 15a is attached to housing 15 for cooling purposes.

In the scanner employed in prior application Ser. No. 734,297, ten light commutating stations were distributed over a 120° arc, and were scanned by three equally-spaced identical apertures provided in a drum analogous to drum 16. This arrangement necessitated high-cost precision machining procedures. In the improved arrangement of FIG. 1, drum 16 is provided with only a single aperture 19, and light from lamp 17 passing through aperture 19 is caused to impinge upon successive ones of a plurality of 13 light-commutating stations which are equally spaced through 360° about housing 15. More particularly, the 13 light-commutating stations comprise 12 light-transmitting fiber optics bundles 20 which constitute portions of the transmitting sensor, and a thirteenth bundle 21 constituting a zeroing bundle the function of which will become apparent subsequently.

The 13 bundles 20 and 21 each have one end thereof plugged into housing 15 in a circular array (see FIG. 2) and in a plane passing through shutter aperture 19. Drum 16 is mounted for rotation within housing 15, and is driven by a shaft 22 connected, for example, to a 600 r.p.m. synchronous motor 23 which is energized and synchronized, for example, by a 60 Hz source 24. By this arrangement, drum 16 is caused to rotate at a constant speed; and light passing from lamp 17 through aperture 19 is caused to impinge in succession and at a constant repetition rate on the ends of bundles 20 and 21 which are plugged into housing 15.

The 12 bundles 20 have their other ends connected, in groups of three to four transmitter sensor modules 25, 26, 27

and 28 disposed in side by side relation to one another on one side of the path of travel of film 13. The several modules 25 through 28 are individually replaceable; and each such module may be 6 inches in length so that the four modules cooperate with one another to transmit light through film 13 over a total width of 24 inches. The fibers in each individual bundle are, within the body of each module, fanned out to form a line; and as light from lamp 17 impinges on each of the bundles 20 in succession, a narrow rectangle of light is directed onto the sheet of film 13, and scans across said sheet at a constant speed determined by the speed of rotation of drum 16.

The system also includes a reading sensor comprising 12 fiber optics bundles 30 constructed to form four reading sensor modules 31-34 disposed in aligned relation to one another below film 13 and below the transmitter sensor modules 25-28. The several modules 31-34 are, again, individually replaceable, and each such module comprises a group of three fiber optics light receiving bundles 30 the fibers of which are fanned out linearly.

The ends of bundles 30, remote from film 13, are individually plugged into a light-tight housing 35 containing a photomultiplier tube 36, or any other appropriate light sensing element. The light which passes through film 13 from each segment of transmitter sensor modules 25-28 is collected by a corresponding segment in receiver modules 31-34 and then passed via fiber optics bundles 30 to photomultiplier tube 36. By this general arrangement, and as described in greater detail in prior application Ser. No. 734,297, a measure of the image density in film 13, encountered during each individual scan of the film, can be obtained.

The zeroing bundle 21, one end of which is plugged into housing 15 of the scanning light source, has its other end plugged into housing 35 of photomultiplier tube 36 in a manner similar to that employed for plugging the analogous such ends of bundles 30 into housing 35. More particularly, each bundle 21 and 30 plugs into the photomultiplier tube housing 35 by means of a fitting provided with an adjustment screw diagrammatically illustrated at 37. Each such adjustment screw has a free end which is variably positionable relative to the emitting end of its associated bundle; and by rotation of each screw 37, it is possible to selectively attenuate the light received by photomultiplier tube 36 from a given bundle. The several screws 37 are initially adjusted so that the light emitted from all of bundles 30, and from zeroing bundle 21, will have the same identical value in the absence of film sheet 13, and this initial adjustment of the light received by tube 36 from the several bundles 21 and 30 assures that zeroing bundle 21 will always provide an appropriate magnitude of reference light from the scanning light source 15-19, for zeroing the overall system.

The output of the photomultiplier tube arrangement 35, 36 is coupled to a control circuit 40, which will be described in greater detail subsequently in reference to FIG. 3. Circuit 40 includes a switch 41 which may comprise a reed switch; and switch 41 is actuated magnetically. In accordance with the improvement of the present invention, drive shaft 22 of the scanning light source carries a disc 42 fabricated of a magnetic material. A permanent magnet 43 is located on one side of disc 42, and switch 41 is located on the other side of said disc 42. Disc 42 is provided with an aperture 44. When aperture 44 is, during rotation of disc 42, disposed between switch 41 and stationary magnet 43, the field of magnet 43 can actuate switch 41. For other positions of disc 42, however, the magnetic material of said disc acts as a magnetic shunt to prevent the field of magnet 43 from actuating switch 41. By this arrangement, therefore, switch 41 is actuated once during each revolution of drum 16. As will appear hereinafter, the time at which switch 41 is actuated corresponds very precisely to the time during which light is being projected onto zeroing bundle 21.

In accordance with the improvement of the present invention, film sheet 13 is scanned at a fixed rate as already

described; and the system of the present invention is caused to take fixed time-interval samples periodically, with the commencement time for each sample being determined by the distance a sheet has been transported through the processor (or past sensor 25-28, 31-34) rather than being determined by the speed of transport. In order to monitor the distance each sheet has been transported past the sensor, a transport pulse generator 45 is provided. Generator 45 is actuated from transport drive shaft 10 of the system and operates to produce a triggering pulse 46 once every 0.1 inch of linear film travel through the sensing station. Transport pulse generator 45 can, of course, take various forms. In one possible arrangement, generator 45 may comprise a stationary reed switch, a stationary magnet, and a rotary magnetic shunt disposed between the two and driven by the transport system so that the reed switch is actuated every one-tenth of an inch of film travel by an operation entirely similar to that of elements 41-44 already described. Pulse 46, when it occurs, is coupled to control circuit 40 and, as will be described, is used to trigger a one-shot multivibrator which in turn controls a reading gate associated with the fast integrator of the system.

FIG. 3 illustrates control circuit 40 in some detail, and shows the relationship of that control circuit to photomultiplier tube 36. The general operation of the FIG. 3 circuit corresponds to that already described in prior copending application Ser. No. 734,297 and will therefore not be repeated in detail. Structurally, the arrangement includes photomultiplier tube 36 which is exposed to light from receiving sensor bundles 30 and zeroing bundle 21 in sequence; and the output from photomultiplier tube 36 is selectively coupled to a fast integrator comprising an operational amplifier 50 connected as shown to a capacitor 51. The output of fast integrator 50-51 is coupled to a slow integrator comprising operational amplifier 52 and a capacitor 53; and the output of slow integrator 52-53 is coupled to a level detector 54, comprising a Zener diode 54a and transistor 54b plus associated components, which ultimately controls energization of a transistor 55 operating as a driver for a relay 56. Relay 56, when energized, operates inter alia to transfer information from the slow integrator 52-53 via a line 57 to the input of a mechanical integrator 58; and mechanical integrator 58 in turn controls the operation of a timer and valve control mechanism 59 which achieves replenishment in the automatic film processor.

Since the main scanner lamp 17 is energized by an unregulated power supply, the lamp output will vary with variations in line voltage. These output light variations, and other similar variations resulting from the accumulation of foreign matter on the lamp surfaces, manifest themselves as variations in the light output at each of the 12 transmitter sensor bundles 20, as well as a similar light output variation at the thirteenth zeroing bundle 21. Photomultiplier tube 36 is energized by an unregulated source 60 (e.g. -1kv); and variations in energization of tube 36 have a major effect on the output of said tube 36. These effects could be minimized, of course, through use of regulated power supply; but it is preferred, if possible, to use unregulated supplied to simplify the overall system, and reduce its cost. The use of such unregulated power supplies becomes feasible by means of the zeroing system which is incorporated into the present invention.

The zeroing operation employs, as described, an extra bundle of fiber optics 21 which extends from the scanning light source 15-19 to the photomultiplier tube 36. Zeroing bundle 21 can be entirely separate from the film sensor structure or, in the alternative, can comprise a portion of the film sensor structure wherein the optical path of the zeroing bundle is located outside of the film path. The zeroing system is intended to compensate the entire system against possible errors resulting from line voltage variations, and from any other effects which may be present and which may tend to change the output of the photomultiplier tube 36. In essence, the zeroing system operates to fix the value of output anode current from tube 36 at a preselected constant value at the time that the tube is receiving light from the zeroing bundle 21; and the

zeroing adjustment is maintained intermediate successive receptions of light from the zeroing station 21 due to the relatively long time constant of the overall system achieved by a capacitor 60.

In general, the zeroing system incorporates a sample and store capacitor 60, a zeroing amplifier 61, and a dynode shunt regulator employing a driver transistor 62. Amplifier 61 selectively modifies the photomultiplier tube dynode potential via the shunt voltage regulator arranged in a negative feedback loop so as to electronically rebalance the lamp-photomultiplier tube sensing system immediately prior to the commencement of each active scanning line, thereby to maintain a constant value of photomultiplier tube anode current and optical sensitivity irrespective of line voltage variations and/or lamp brightness changes. When the overall system is first placed into operation, the desired anode output reference current of tube 36 is initially established by adjusting a variable resistor 63 extending between source 64 and the anode 65 of tube 36. Resistor 63 comprises a compensation current balance control, and can be set so that the effective output supplied to the blade of switch 41 is zero, or any other predetermined reference value; and the zeroing system then operates to assure that this preselected value of current is produced at anode 65 and switch 41 in response to exposure of tube 36 to a predetermined quantity of light.

The zeroing operation occurs as follows: when the light scanner applies light from lamp 17 onto the zeroing bundle 21, light transmitted via bundle 21 is directed onto the cathode 66 of tube 36. During this same interval of time, when light is being received from the zeroing bundle 21, the reed switch 41 is magnetically actuated so that its blade is in the lower position, and compensated anode current is accordingly coupled from tube 36 to capacitor 60 to charge that capacitor. The movable blade of switch 41 transfers to its upper position immediately after the zeroing bundle has been scanned, and this operates to transfer the output of the photomultiplier tube 36 to the fast integrator 50—51 for normal operation during the remainder of the scan operation.

If the actual current applied to the blade of switch 41 during the zeroing operation corresponds to the preadjusted output achieved earlier by means of compensation current balance control 63, there will be no effective change in the charge maintained in sample-and-store capacitor 60, and zeroing amplifier 61 will have no effect on the dynode voltage of tube 36. Let us assume, however, that something has occurred which has caused the output of the photomultiplier tube 36 to increase. During the zeroing operation, the increased output of tube 36 causes an increase in the charge maintained in capacitor 60; and this in turn increases the output of zeroing amplifier 61 to increase the output of driver transistor 62 in the dynode shunt regulator. The increased conduction of transistor 62 reduces the effective dynode voltage of tube 36, and thereby reduces the output reference-level current of the photomultiplier tube to its desired value. Conversely, if the light output from the photomultiplier tube should decrease, the dynode voltage is effectively increased to similarly restore the reference-level anode current to its desired value.

By this type of feedback regulation, the dynode voltage of tube 36 is adjusted during each zeroing interval of the system to assure that the anode current of the photomultiplier tube is at a desired reference value during the subsequent scan, and the output then varies from that reference value in accordance with the detected density of film 13 during said subsequent scan. Inasmuch as the system is rebalanced at the beginning of each active scan, there is no need for elaborate and expensive regulated power supplies.

After zeroing operation, the blade of reed switch 41 transfers to the position shown in FIG. 3 to couple the adjusted output of photomultiplier tube 36 to the input of the fast integrator 50—51. In the improved arrangement of the present invention, integrator 50—51 has a fixed integration time determined by the single capacitor 51, thereby avoiding the approximations and possible errors which attended the use of a varia-

ble integration time in the arrangement of prior application Ser. No. 73,297.

Operational amplifier 50 is shunted by a normally-conducting transistor 70 which prevents the fast integrator from accumulating any charge across capacitor 51. Transistor 70 comprises a reading gate, and is selectively cut off for a fixed time period at intervals corresponding to each 0.1 inch of film travel past the sensor. More particularly, each pulse 46 produced by the transport pulse generator 45 triggers a one-shot multivibrator 71 having a period of 100 milliseconds. When monostable multivibrator 71 produces an output at 72 during its "on" time, normally-conductive transistor 73 is rendered nonconductive; and this in turn cuts off reading gate transistor 70 and permits the accumulation of a charge across fast integrator capacitor 51 during the next succeeding 100 milliseconds. The 100 milliseconds during which fast integrator capacitor 51 accumulates a charge actually corresponds to the time needed to complete one active scanning line; and therefore fast integrator 50—51 accumulates information corresponding to a single scan, just as in the earlier system of Ser. No. 734,297, but without the complexity of plural reed switches, etc.

It should be noted that because of the constant velocity of the light scan, and the possible variations in speed of film transport, the actual sampling period for any one line of information does not necessarily commence at the beginning of that line but can, indeed, commence at almost any part of the line and at different parts of the line as the transport speed varies. Nevertheless the total information accumulated between the beginning and end of each sample always corresponds to a single line of information regardless of the precise point on that line at which the sample commences. Thus the present invention, by scanning at a constant velocity, and by using an integrator having a fixed integration characteristic, assures that information is accumulated more accurately despite possible variations in film transport speed past the sensor.

Slow integrator 52—53 of the present invention is also revised somewhat from that described in earlier application Ser. No. 734,297, but the operation is still effectively the same. In the earlier circuit, a separate operational amplifier was used as a level detector. The arrangement shown in FIG. 3 utilizes a revised transistor circuit which partially combines the separate level detector with the slow integrator to form a regenerative trigger circuit which performs the same function as the earlier circuit. When the output of the slow integrator stage 52—53 reaches a potential level determined by the level detector Zener diode 54a, transistor 54b, which is normally nonconductive, is rendered conductive; and transistor 55, which is normally nonconductive, is similarly rendered conductive to energize the coil of relay 56. At the same time that transistor 54b is rendered conductive, i.e., at the time that the desired potential level has been reached at the output of slow integrator 52, a signal is fed back via line 54c to the inverting input of integrator 52 to drive the integrator to its maximum output value. It would remain at this value except for the fact that, when relay 56 is energized, relay contacts 56a are closed to short circuit capacitor 53 and to restore the slow integrator to its starting condition. At the same time, upon energization of relay 56, relay contacts 56b generate a pulse which is fed to the input of the mechanical integrator 58 which accumulates information in the manner already described in earlier application Ser. No. 734,297.

The general operation of mechanical integrator 58, and of timer and valve control mechanism 59, and one possible circuit which can be used for these components, is set forth in prior application Ser. No. 734,297, which is incorporated herein by reference.

While we have thus described a preferred embodiment of the present invention, many variations will be suggested to those skilled in the art. It must therefore be emphasized that the foregoing description is intended to be illustrative only and not limitative of the present invention; and all such variations and modifications as are in accord with the principles

described are meant to fall within the scope of the appended claims.

We claim:

1. A chemical replenishment system for a film processor, comprising sensor means adjacent said processor for monitoring the image density in sheets of image-bearing material developed in said processor, means for transporting each such developed sheet past said sensor means, said sensor means including means for optically scanning each sheet repetitively and at a fixed speed, accumulating means coupled to said sensor means for accumulating information related to the image density of each such sheet and to the aggregate densities of a plurality of such sheets, said accumulating means including means for periodically sampling the output of said sensor means as a function of the distance each such sheet is transported past said sensor means, and control means responsive to said accumulated information for selectively controlling the feeding of replenishment chemical to said processor.

2. The system of claim 1 wherein said sensor includes a photomultiplier tube, and means for automatically adjusting the output of said tube during each of said repetitive scans.

3. The system of claim 1 wherein said accumulating means includes a normally inoperative electronic integrator circuit, said sampling means including triggering means for rendering said circuit operative to store information.

4. The system of claim 3 wherein said integrator circuit includes capacitor means, a normally conductive transistor shunting said capacitor means for rendering said integrator circuit inoperative, said triggering means including pulse generator means controlled by said transporting means for producing a triggering pulse upon occurrence of a preselected increment of travel of said sheet past said sensor means, and means responsive to occurrence of each such triggering pulse for rendering said transistor non-conductive for a predetermined time interval.

5. The system of claim 4 wherein said last-named means comprises a monostable multivibrator.

6. The system of claim 1 wherein said sensor means comprises a light source, a first plurality of bundles of optical fibers having one end of each such first bundle disposed adjacent said light source, scanning means for directing said light source in sequence and at a constant speed onto said one ends of said first bundles, the other ends of said first bundles being disposed adjacent one side of the path of travel of each such sheet past said sensor, a second plurality of bundles of optical fibers having one end of each such second bundle disposed adjacent the other side of said path of travel of said sheet, the other ends of said second plurality of bundles being disposed adjacent a photosensitive element, and means coupling the output of said photosensitive element to the input of said accumulating means.

7. The system of claim 6 including a further bundle of optical fibers positioned outside the path of travel of said sheet and extending between said light source and said photosensitive element for periodically exposing said photosensitive element to reference light from said light source, and control means operative during the time interval of said reference light exposure for adjusting the output current of said photosensitive element to a preselected value.

8. The system of claim 7 wherein said photosensitive element comprises a photomultiplier tube, said control means including means for varying the dynode voltage of said photomultiplier tube.

9. The system of claim 7 wherein said one ends of said first bundles and one end of said further bundle are regularly spaced from one another in a circular array about said light source, said scanning means comprising a rotary motor-driven, apertured shutter disposed between said array and said light source.

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