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CONTROL FOR RAPID FILM PROCESSING

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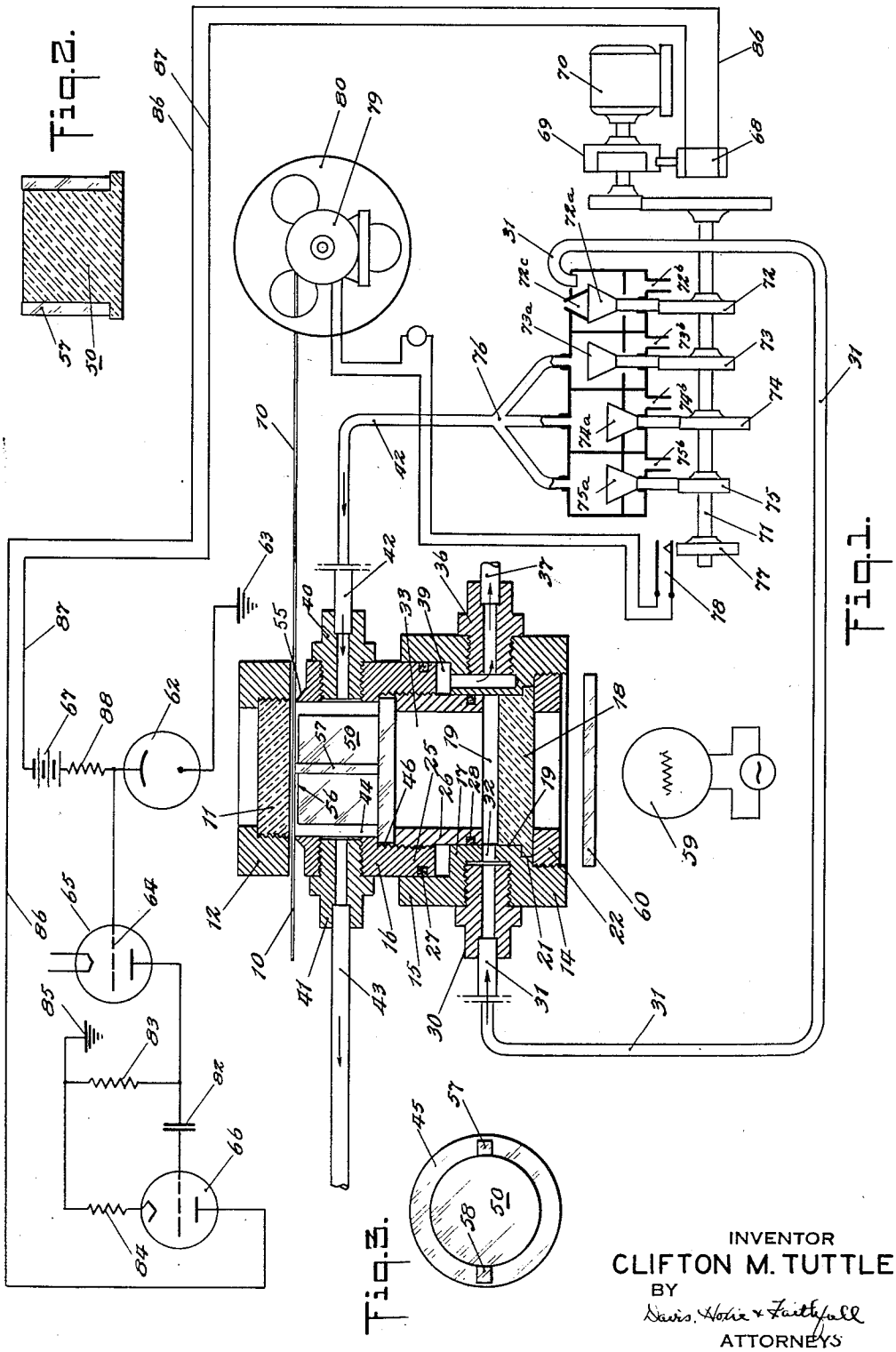


Fig. 1.

Fig. 2.

Fig. 3.

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CONTROL FOR RAPID FILM PROCESSING

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5 Claims. (Cl. 95—89)

1

This invention has to do with apparatus for rapidly processing photographic film which has been exposed. It is an improvement upon apparatus which was developed for rapid processing of photographs of the cathode-ray tube face of a radar system. This apparatus for radar use, including a camera, a processing unit and a projector, came to be known as "P4I" and is described in the Journal of the Franklin Institute, vol. 242, No. 3, September 1946, at pages 203 et seq.

In P4I, a strip of film is pulled intermittently along a track within a light-tight housing past a station where the image is produced and where the exposed film is processed, and thence past a station outside the housing where the image is projected, one image being formed and processed while the one previously formed and processed is being projected. The film has its emulsion side uppermost and the exposure is made through the film base by focusing the tube face, located below, through an aperture in the track. The processing cycle may be as short as five seconds.

This rapid action is accomplished by delivering hot chemicals in sequence to an open plastic cup in the form of two concentric cylinders arranged to drop onto the film at the processing station so that the film forms the bottom of the cup and a seal is effected by the lip or rim of the outer cylinder. After each hot chemical (e. g., the developer, fixer or wash) has been delivered to the space within the inner cylinder and has had its effect on the emulsion, suction is applied at the space between the cylinders to remove the chemical and to draw air rapidly over the film surface to dry it; whereupon through action of the controlling cams the delivery of the next chemical to the cup is initiated. The whole operation, including film movement and delivery and exhaust of the chemicals and drying air, is controlled by a bank of switches operated by a bank of cams on a single shaft which makes one full turn in the total cycle of about 15 seconds.

The present improvement deals with the control of the supply of processing fluids to the processing unit. It is not limited to use in the P4I system or to systems of the same purpose, but may be used in various systems and for various purposes where processing fluids are delivered in sequence to a processing unit.

The combination of this invention preferably employs a processing unit having certain new features which are the subject of Clifton M. Tuttle et al., Patent No. 2,582,182, granted January 8, 1952, for improvements in Apparatus for Rapid Processing of Film. The same preferred

2

form of processing unit is described here to illustrate that part of the combination, along with the associated parts which complete the control system. The whole is described with reference to the annexed drawing in which the system is shown diagrammatically with the processing unit in vertical section.

The basic idea of control is to project a light beam through the film undergoing processing, the processing apparatus having transparent parts in the path of the beam to permit this; and to use the variations in light value caused by the changes in opacity of the film at different stages of processing to give changes in the output of a photocell activated by the light beam. Properly amplified, the increases and decreases in photocell output are then used to effect the action of a solenoid which controls the rotation of a shaft carrying cams which operate the valves controlling the supply of processing fluids. In this way, at least some of the valve operations can be controlled to deliver different processing fluids at the proper time in the processing cycle. It is within the broad concept to use the photocell output to control the action of other means than the cam unit for actuating the valves by which the processing fluids are delivered in predetermined sequence.

For example, the latent image formed upon exposure of a film is translucent. When the film frame comes to the processing station in that condition it passes a definite and considerable amount of light to the photocell. The cell output under this condition may be caused to initiate the opening of a valve to supply developer to the processing unit. The action of the developer causes the film to become more opaque and to reduce the light value at the cell. The reduction at full development reduces the cell output to a value which may be used to cause the closing of the developer supply valve and the opening of the valve controlling the supply of fixer. The fixing solution checks development and, by dissolving the unchanged silver salts in the emulsion, increases the translucency of the film. This increases the light value at the cell to a degree sufficient to give an increased cell output which may be utilized to cause closing of the valve in the supply of fixing solution and opening of a valve controlling the supply of air to dry the film. The termination of the drying and the initiation of the pull-down may then be effected by other means, manual or automatic.

A preferred form of the invention is described below with reference to the annexed drawings, in which

Fig. 1 is a view in vertical section through the

processing unit proper, with a diagrammatic showing of a light-sensitive control for automatically delivering processing fluids to the unit.

Figs. 2 and 3 are, respectively, a plan and an elevational view of one of the components of the processing unit.

I first describe the processing unit which I prefer to use and which has the features that lend it to use in a control system of this new type.

The film 10 is preferably, but not necessarily, in a horizontal plane at the processing station. In the example shown, the film is at rest at the station; but the only essential is that it be at rest relaive to the processing unit. Here the film is shown with the emulsion face at the lower side. The film is moved intermittently by any suitable means to bring successive frames to the processing station.

At this station is a fixed backing support for the film in the form of a disc 11 of transparent plastic mounted in a fixed metal ring 12 located above the film track and close to the film. This backer presents a flat surface to the film at one side so that the film can be held flat against it during the processing.

Below the film is the unit which during the processing forms a chamber that is closed except for the inlet and outlet through which the processing fluids pass under pressure. This unit provides for a continuous flow of each processing fluid in a confined thin stream across the emulsion face of the film. It also includes means for bringing the parts which form this confined flow passage into working relation with the film, involving a peripheral sealing engagement between the film and the movable member which in conjunction with the film defines the flow space.

This lower unit consists of two main structural parts, an outer fixed element 15 and an inner movable element 16 sliding in the fixed part so that it can be brought into and out of enagement with the film. The movable element 16 comprises the parts which define the flow passage for the processing fluids. The processing unit shown here also includes pneumatic means for moving the element 16 into and out of its engagement with the film, certain parts of the fixed and movable elements being so shaped and related that they form two separate piston and cylinder units, one for advancing the inner element 16 under air pressure and the other for retracting it by a suction action. Because of these piston and cylinder features, which preferably are cylindrical, both parts of the processing unit are of cylindrical shape generally; but it will be evident that this shape is not necessary.

Considering the fixed element 15 specifically, it has a main body part 14 of hollow cylindrical shape with an inwardly projecting integral ring 17 giving a smaller internal diameter at the lower part. It has a bottom closure 18 in the form of a transparent disc of plastic material which fits within the central bore 19 and has a flange 20 held in a recess 21 by a threaded retaining ring 22.

The upper and wider part of the central bore of this fixed element 15 receives the main cylindrical part 25 of the movable element, while the smaller bore afforded by the ring 17 receives the depending skirt part 26 of the movable element. Packing rings 27 and 28 seal the joints between the interfitting parts which provide the two piston and cylinder units for actuating the movable element 16.

At one side of the fixed element 15, near its bottom, is a nipple 30 threaded into a tap in the cylinder wall. This is for connection to a compressed air line 31. From this nipple a passage 32 leads through the wall of the fixed element 15 to the central bore 19 at a point just above the bottom closure 18, thereby admitting air to the space 33 within the depending skirt 26 of the movable element. Because there is a partition 45 (described below) across the interior of the movable member, forming with the skirt 26 a piston sliding in the cylinder formed by the inward ring 17, the compressed air admitted through passage 32 to the interior space 33 acts on this piston to cause the movable element to move upward toward the film.

At the other side of the fixed element 15 is another nipple 36 similarly threaded into a tap in the wall and giving connection to a vacuum line 37. A passage 38 in the wall of the fixed element leads upward from this tap through the ring 17 to the annular space 39 beneath the main body 25 of the movable element and between the outer wall of the skirt 26 and the inner wall of the fixed element 15. Thus the suction action serves to retract the movable element 16 by its action in this annular piston and cylinder unit formed by these coacting parts.

Near its upper end the movable element 16 has two nipples 40, 41 threaded into taps extending through the wall of the main body part 25 at opposite sides. These furnish respectively the connections to the supply line 42 and the exhaust line 43 for the processing fluids, so that flow can be established through the interior chamber 44 in the movable element. This chamber 44 has a bottom closure formed by the transverse partition 45 which is a disc of transparent plastic held in a recess 46 at the lower part of the main body of the movable element by the threaded skirt 26 already mentioned. This bottom closure 45, together with the cylindrical main body part 25, form a cup shaped part the peripheral rim of which engages the film around the area to be processed to form a fluid tight joint, thereby forming the main closure for the processing chamber.

Integral with this partition 45 is a block 50 of transparent plastic which is of smaller lateral size than the interior chamber 44. This block 50 serves as a filler to reduce the free space within the cup shaped part of the movable element, and also serves to further define the flow path for fluids passing from the inlet to the outlet. It extends upward to a plane just short of the plane of the upper rim 55 of the movable element 16. When the movable element is brought into sealing engagement with the film at the peripheral rim 55, the top face 56 of the filler block 50 is slightly spaced below the emulsion face of the film, and so defines with it a shallow flow passage across the film face.

The upper rim 55 of the outer cylinder part 25 of the movable element 16 is tapered to give a narrow surface engaging the film. This gives an effective seal.

To confine the flow of processing fluids to the shallow passage at the film face, between the film and the top surface of the filler block 50, there are vertical fins 57 and 58 at the sides of the filler block 50 midway between the inlet and outlet. These extend into contact with the inner wall of the bore in the movable element and prevent flow around the side of the filler block while providing some free space in the regions of the

inlet and outlet connections to give easy flow to the shallow flow passage across the processing area.

It will be understood that the thin stream flow passage across the film face may be obtained by other forms of construction. This use of an otherwise large chamber with a filler block is, however, a good way of providing wall area sufficient for good inlet and outlet fittings while still obtaining the thin stream flow across the film face, which is a desirable feature.

It will be noted from the above that all of the tranverse parts above and below the film are transparent, that is, the backer disc 10 above the film, the filler member 50 and central partition 45 of the movable element 16, and the end closure 18 of the stationary element 15. This permits light from a source 59 below the unit to pass through the entire unit, including the thin stream of processing fluid directly under the film, and the film itself to the extent permitted by the film. An optically selective filter 60 may be interposed between the light source and the processing unit to transmit only the desired visible but photographically non-actinic light. If the light source is incorporated in the processing unit above its bottom closure, the latter of course may be opaque.

The photocell and associated control system are shown schematically since they may be incorporated in a wide variety of housing structures and I claim no present novelty in that respect.

The photocell 62 is located above the backing plate 11 in the path of the light from the source 59 which is projected through the translucent parts of the processing unit. The cell has one terminal grounded at 63 and its other terminal is connected to the grid 64 of a triode 65 forming part of an electronic control circuit including triode 66, battery 67, and a solenoid 68 which operates an escapement on a one-turn clutch 69 in the driving connection between a constant speed motor 70 and a cam shaft 71. Whenever the solenoid is energized by a pulse from the electronic circuit, it causes the clutch 69 to couple motor 70 and shaft 71 for one complete revolution of the motor shaft, which corresponds to a fraction of a revolution of shaft 71. A cam 72 on the latter shaft controls a valve 72^a for admitting compressed air from a source 72^b to the line 31 which leads to the central bore 19 of the processing unit. The supply of developer fluid, fixer solution and drying fluid is controlled by cams 73, 74 and 75, respectively, which operate valves 73^a, 74^a and 75^a in the respective supply lines 73^b, 74^b and 75^b leading to a manifold 76 which is connected to pipe 42. A fifth cam 77 controls a switch 78 connected to an electric motor 79 for winding a reel in a housing 80, so as to advance successive frames of the film to the processing unit.

The electronic circuit is so designed that (1) triode 65 is normally non-conducting but becomes conducting when the output of photocell 62 drops below a certain value owing to reduction of the light received from source 59, and (2) triode 66 will pass an electrical pulse by which solenoid 68 is energized when triode 65 becomes conducting and also when it reverts to its non-conducting state. The electronic circuit for producing these pulses is not new in itself, although this application of it in combination with a photocell and actuating device is believed to be new. Its details therefore need but summary statement.

As illustrated, the electronic valve 66 is connected in the plate circuit of triode 65 through a resistance-capacitance network including a capacitor 82 connected between the plate of triode 65 and the grid of triode 66, resistors 83 and 84 connected between the filament of triode 66 and a point between capacitor 82 and triode 65, and a ground connection 85 between the two resistors. The plate of triode 66 is connected by wire 86 to one terminal of solenoid 68, the other terminal of which is connected by wire 87 to one side of battery 67. The other side of the battery is connected through resistor 88 to the grid 64.

In operation, an exposed film frame having the latent image is drawn into the processing position between the block 50 and the part 11, this action being effected by momentary closing of contacts 78 to energize motor 79. Then the cam shaft 71 is turned (as by manually operating the clutch 69) so that cam 72 raises the valve 72^a from its seat, allowing compressed air from source 72^b to pass through pipe 31 into space 19 in the processing unit. As a result, the movable element 16 is brought into sealing engagement with the film at the rim 55. The shaft is then rotated another fraction of a revolution (as by manually operating clutch 69) to cause cam 73 to open valve 73^a, the valve 72^a being held open. Photographic developer fluid then passes under pressure from source 73^b through manifold 76 and pipe 42 and flows across the film surface and out the waste pipe 43. As the image develops, it becomes more opaque and eventually reaches a state of opacity such that the light on photocell 62 is reduced to the point where triode 65 becomes conducting. A pulse is thus originated in the electronic circuit, momentarily energizing solenoid 68 and causing shaft 71 to rotate sufficiently to close valve 73^a and open valve 74^a. This results in cutting off the supply of developer and starting the supply of fixer from source 74^b.

The fixing solution checks the development of the image as soon as it reaches the film in the processing unit, and acts to dissolve the unchanged silver halide salts in the film emulsion. This increases the transparency of the film to the point where the photocell current increases to the cut-off point of triode 65, whereby a second pulse is transmitted to solenoid 68. The cam shaft then rotates to close valve 74^a and cut off the supply of fixer, and to open valve 75^a so as to admit drying air from the source 75^b. The air flows through the processing unit in contact with the film surface, and when the latter is dried the cam shaft is again rotated (as by manual operation of clutch 69) to close valves 75^a and 72^a. When valve 72^a closes, it uncovers a vent 72^c, through which the compressed air in line 31 escapes, thereby allowing the vacuum in line 37 to lower the movable element 16 from the film surface. Switch 78 is then closed again to draw a new film frame into the processing unit, and the processing cycle is repeated.

If desired, a timing mechanism may be arranged to operate the clutch 69 from the time when the drying valve 75^a is opened until the developer valve 73^a is opened. The timer may be set into operation by opening of valve 75^a, whereby the apparatus is fully automatic.

It will be understood that the sequence cycle described above is merely a typical operation and may be modified to accommodate desired conditions.

I claim:

1. Apparatus for rapid processing of exposed photographic film, comprising a member pre-

senting a flat supporting surface to the film on one side and a member engageable with the opposite side of the film to hold the film against said surface during processing, said members also forming a chamber with inlet and outlet whereby processing fluids may be passed across the face of the film to be processed, said supporting and movable members having transparent parts forming a light path in register with a substantial part of the area of film to be processed, means for delivering said fluids sequentially to said inlet, including valve mechanism and a power source for operating said mechanism step-by-step through a predetermined cycle, to direct the flow of said fluids in predetermined sequence, a light source for transmitting light through the film by way of said light path, and a light sensitive device arranged to receive light transmitted through the film, actuating means operable by said device upon decrease in the amount of light transmitted by the film, actuating means operable by said device upon increase in the amount of said transmitted light, and an operative connection between the actuating means and said power source, whereby the actuating means operates the valve mechanism step-by-step through the power source to cut off the supply of one of the fluids to the film and initiate the supply of another fluid to the film upon said decrease in the amount of transmitted light, and to cut off the supply of said last fluid to the film upon said increase in the amount of transmitted light.

2. Apparatus in accordance with claim 1 in which said light sensitive device is a photoelectric cell and in which said actuating means operable thereby comprises an electronic circuit including a triode so arranged as to become conducting when the output of said cell exceeds a predetermined value, and a second triode so arranged as to apply an impulse to said operative connection when said first triode becomes conducting or changes to a non-conducting state upon reduction of cell output.

3. Apparatus according to claim 1, comprising also separate sources of the processing fluids including a source of developer solution, and a valve operable independently of the light-sensitive device for supplying said solution to the chamber, said fluid sources including a source of fixer solution and a source of drying fluid, said valve mechanism being operable from said device to cut off the supply of developer solution and initiate the supply of fixer solution when the photographic film image attains a predetermined opacity under the action of the developer solution, and to cut-off the supply of fixer solution and initiate the supply of drying fluid when the film attains a predetermined transparency under the action of the fixer solution.

4. In apparatus for rapid processing of exposed photographic film, in which the film is contacted successively with developer and fixer fluids operable to vary the light-transmitting capacity of the film during the processing, the improvement which comprises valve mechanism for delivering the fluids one by one to the film to make the successive contacts of the film with said fluids, means for directing light of predetermined intensity upon the film during each of said contacts, a light-sensitive device positioned to receive light transmitted by the film from the light-directing means during each of said contacts, and an operative connection between the light-sensitive device and said valve mechanism for controlling the duration of the respective contacts in accordance with variations in the intensity of light received by said device, said operative connection including means operable by said device upon decrease in the amount of light transmitted by the film to said device, to actuate the valve mechanism for cutting off the supply of developer fluid to the film and initiating the supply of fixer fluid to the film, and means responsive to increase in the amount of said transmitted light for actuating the valve mechanism to cut off the supply of said fixer fluid to the film.

5. The improvement according to claim 4, in which said connection includes means for operating said mechanism to terminate the developer contact and initiate the fixer contact when the intensity of light upon said device decreases to a predetermined value, and to terminate the fixer contact when said intensity increases to a predetermined value.

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