Aug. 29, 1961 C. H. TOPPING 2,998,175

AUTOMATIC DEVELOPING SYSTEM

Filed July 5, 1956 4 Sheets-Sheet 1

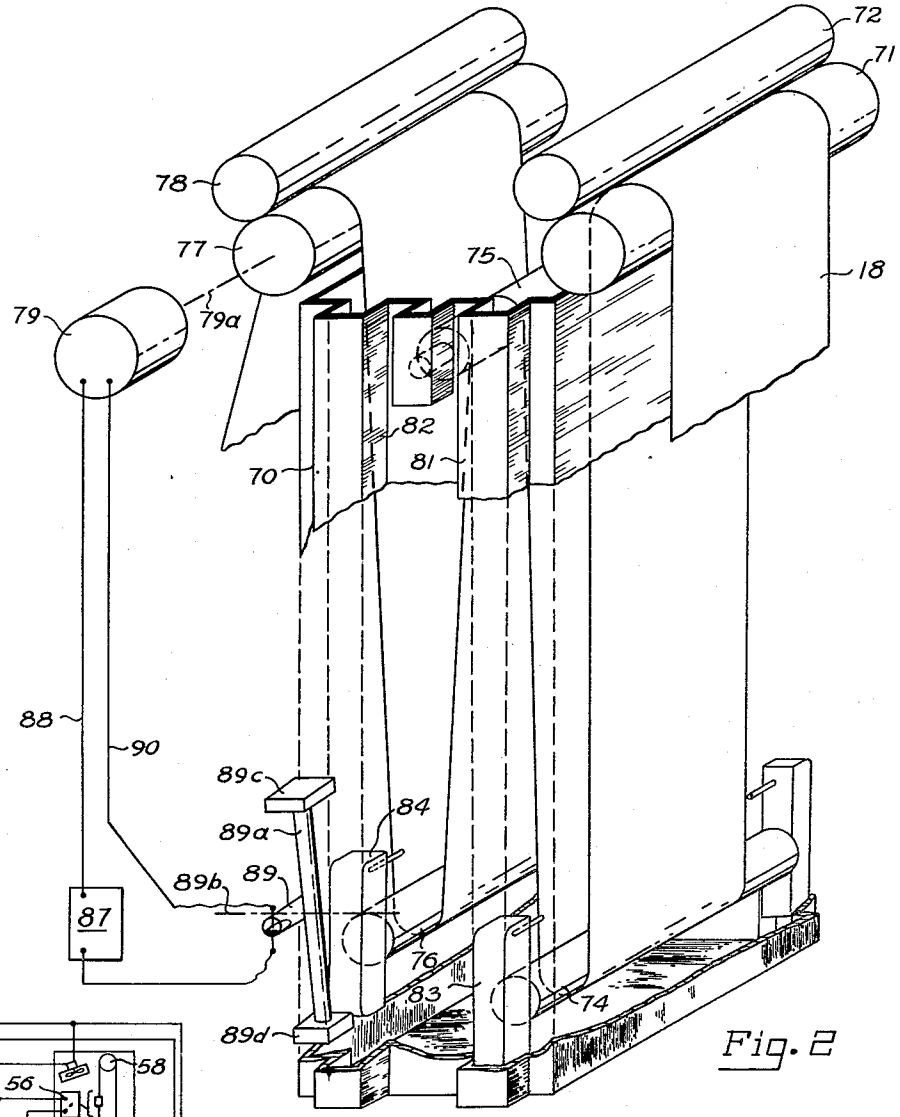


Fig. 2

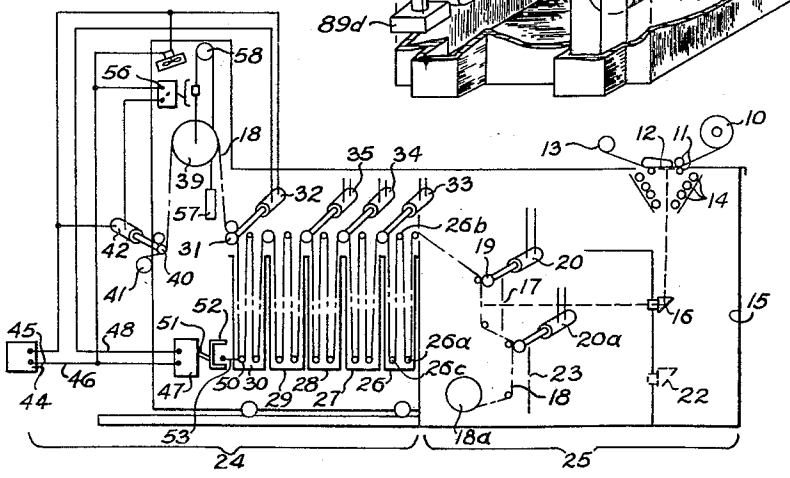


Fig. 1

Aug. 29, 1961 C. H. TOPPING 2,998,175

AUTOMATIC DEVELOPING SYSTEM

Filed July 5, 1956 4 Sheets-Sheet 2

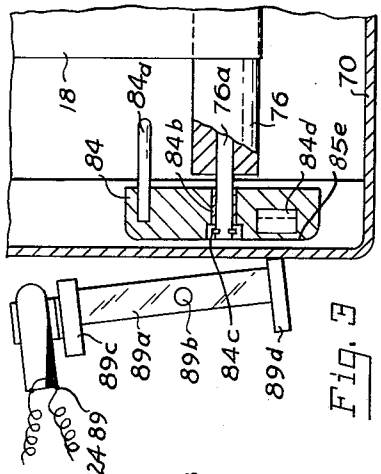


Fig. 3

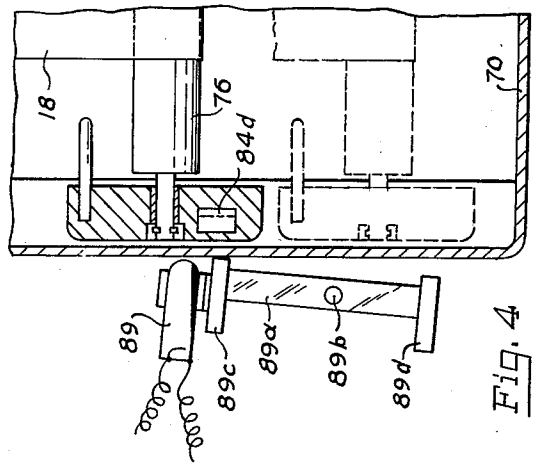


Fig. 4

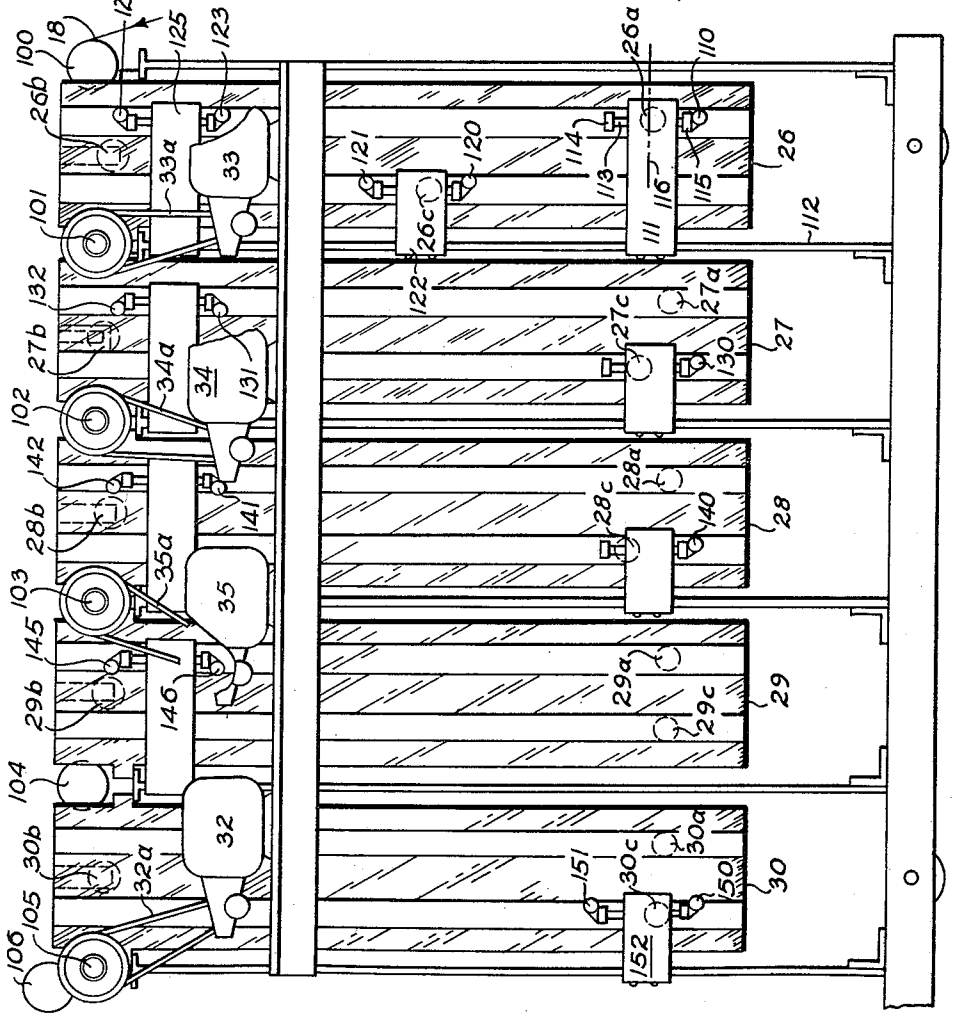


Fig. 5

AUTOMATIC DEVELOPING SYSTEM

Filed July 5, 1956 4 Sheets-Sheet 3

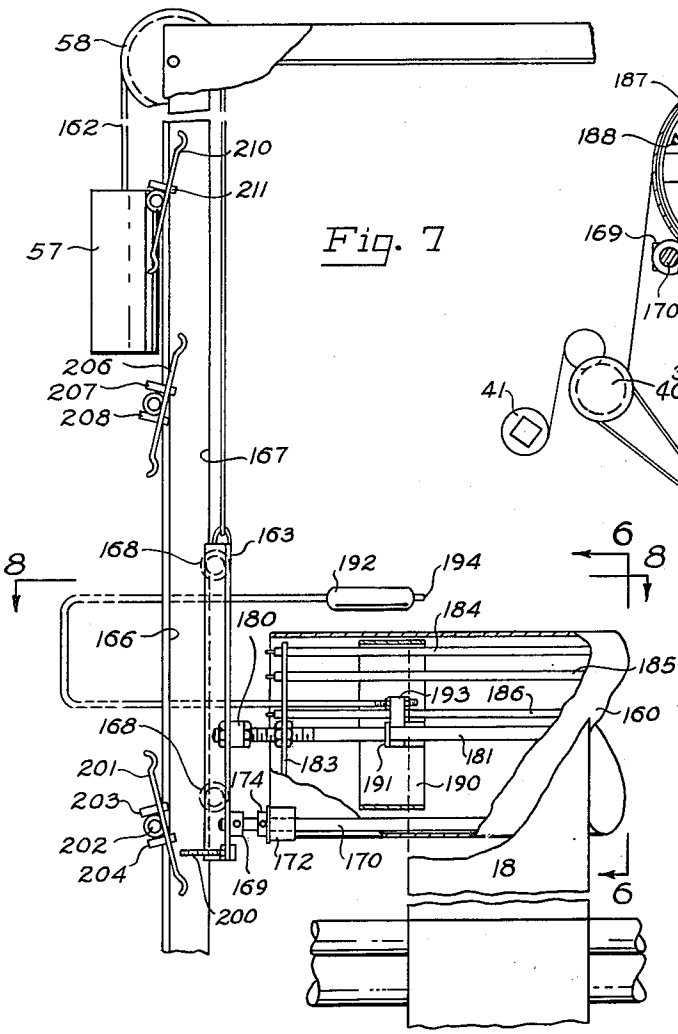


Fig. 7

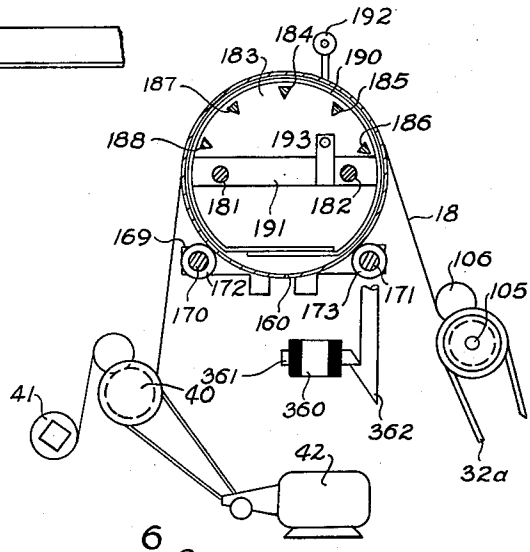


Fig. 6

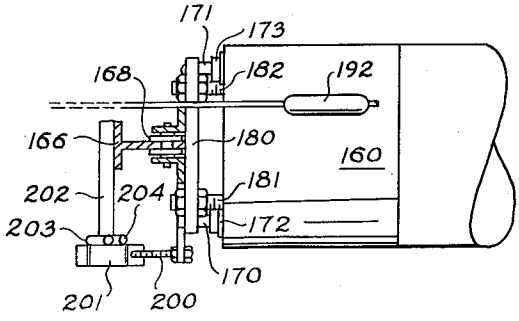


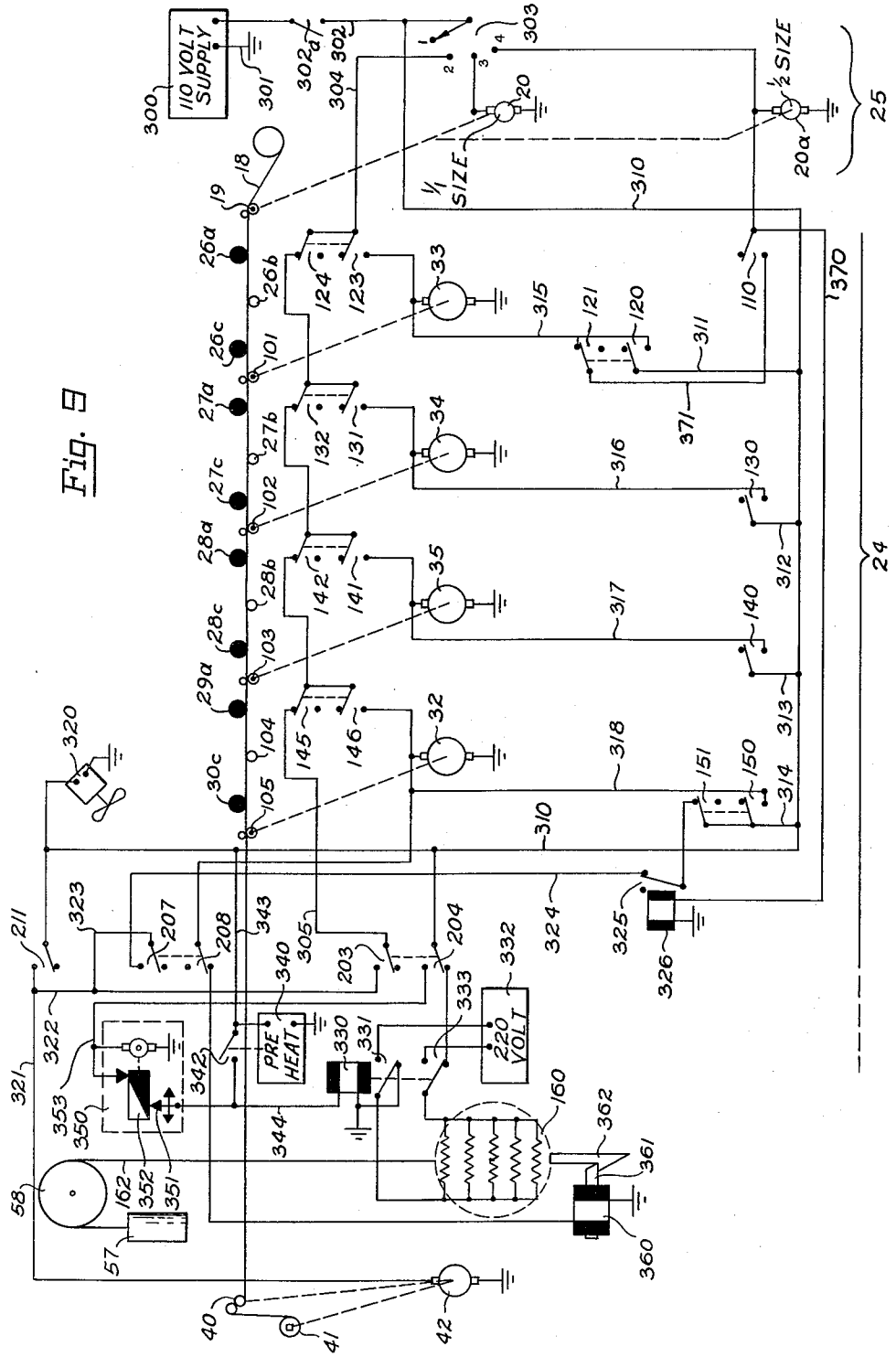
Fig. 8

Aug. 29, 1961 C. H. TOPPING 2,998,175

AUTOMATIC DEVELOPING SYSTEM

Filed July 5, 1956 4 Sheets-Sheet 4

Fig. 9



United States Patent Office 2,998,175 Patented Aug. 29, 1961

2,998,175

AUTOMATIC DEVELOPING SYSTEM

Charles H. Topping, 1831 Levee St., Dallas, Tex.

Filed July 5, 1956, Ser. No. 595,873
4 Claims. (Cl. 226—43)

This invention relates to an automatic photographic developing system and more particularly to a system in which drive means are controlled by a position-sensitive system.

In the treatment of large volumes of data and the widespread use of data converting systems, it has been found desirable to treat automatically insofar as possible the data-carrying medium. In photographic reproduction of strip charts, tables, business records and the like, it is desirable to utilize systems in which continuous production may be achieved with a minimum of supervision or control by personnel. Automatic film developing systems have been employed in the past which utilize more or less fixed guides for passing elongated film strips through tanks positioned successively along the path of travel of the film for effecting the desired developing and fixing processes. However, difficulties are encountered in prior art systems in that the film has different properties when wet than when dry. Compensation for changes in length, for example, is a necessity in many cases.

In accordance with the present invention there is provided an automatic developing system in which a film strip fed at constant speed into a developing unit automatically is controlled to accommodate variations in length of the film strip as it becomes moist, at the same time maintaining substantially uniform the period of time in which any given segment of film is in a given treating zone. Not only do the effects of the elongation when the film becomes moist require compensation, but at the conclusion of the developing treatment a drying process similarly effects dimensional changes which also must be compensated.

In accordance with the present invention there is provided an automatic treating system for a photographic strip in which independent drive means are provided for each of a plurality of treating zones with means sensitive to the position of the strip in each zone for controlling the respective drive means.

In accordance with a further aspect of the invention there is provided an automatic developer comprising an input drive for a photographic strip and an output drive therefor in which said output drive has a normal speed in excess of that of said input drive and a second speed less than the normal speed of the input drive. Means sensitive to the position of the photographic strip in said zone are provided selectively to change the speed of said output drive from one to the other of said normal and second speeds.

In accordance with still another aspect of the invention there is provided a photographic film strip drying zone in which a rotatable heating drum is positioned by said strip and drive means at the output of said zone with control means for selectively varying the position of said drum while maintaining it constantly in rotation during its operation. Further there are provided means for assuring uniform drying treatment of said strip both longitudinally and laterally.

For a further understanding of the invention and for a more complete description thereof, reference may now be had to the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a schematic drawing of the present invention including a camera system;

FIG. 2 is a detailed isometric drawing of one of the treating zones of FIG. 1;

FIG. 3 is a diagrammatic sectional view of the bottom of one of the treating tanks of FIG. 1;

FIG. 4 is a sectional view with the submerging roll of FIG. 3 in an elevated position;

FIG. 5 is a side view of a five tank developing unit;

FIG. 6 is a sectional view of the drying mechanism taken along the line 6—6 of FIG. 7;

FIG. 7 is a view of one-half of the drying mechanism;

FIG. 8 is a top view of the drying mechanism taken along the line 8—8 of FIG. 7; and

FIG. 9 is a detailed schematic diagram of the control and power system.

Referring now to FIG. 1, there is illustrated a reproducing system in which a roll 10 such as a strip chart or data containing medium is to be photographically reproduced. The chart is passed between a pair of rollers 11 past a slit 12 and thence to a take up roll 13. A plurality of lights 14 in a light-tight housing 15 illuminates the slit 12 and thus the chart 10 as it passes the slit. A camera lens system 16 projects the image appearing on slit 12 through an aperture 17 and onto a photosenstive surface such as a film strip 18 from a supply roll 18a. The drive roll 19 for the strip chart 18 is powered by a motor 20 which is so designed that the speed of the film or chart 18 will bear a predetermined relation with respect to the speed of the original chart 10.

In practice with the lens 16 in the position illustrated in FIG. 1 the chart 18 will move at the same speed as chart 10 so that a 1:1 or full size reproduction of the chart 10 will be effected. However, it will be noted that a second lens may be employed at a position 22 to project the image appearing in slit 12 onto the film through a slit or baffle 23. When this is the case, the film 18 will be driven by motor 20a at one-half the speed of film 10 to effect a one-half size reproduction of the original chart 10. In either case, however, the film ordinarily is driven from the camera section 25 to a developer unit 24 at one or the other of two speeds both of which are constant.

The film 18 is threaded over a series of rolls into each of five tanks. Tank 26 is a developing tank containing a suitable developing solution; tank 27 is a fixing tank; tank 28 contains a neutralizer solution; and tanks 29 and 30 contain wash solutions. At the output side of each of tanks 26, 27, 28 and 30 there are provided drive rolls, the final drive 31 being positioned at the output of tank 30. The drive rolls are individually powered by suitable motors such as motor 32 which is coupled to drive roll 31. More particularly, the motor 33 actuates a drive roll to remove film from tank 26. Motor 34 actuates a drive roll to remove or extract film from tank 27. Motor 35 actuates a drive roll to remove film from tank 28. An idler roll such as roll 26b is provided in each of the tanks 26—30. Submerging rolls such as rolls 26a and 26c are provided in each of the treating tanks, Thus the film or photographic strip 18 will be threaded over the guide and drive rolls with the submerging rolls such as rolls 26a and 26c supported by the film intermediate the guide and drive rolls.

The film chart 18 proceeding from drive roll 31 at the output of tank 30 is passed over a drying roll 39 to drive roll 40 and thence to a take up roll 41. Drive roll 40 like roll 31 is motor driven as by motor 42.

In accordance with the present invention the motors 33, 34, 35, 32 and 42 are so controlled that any dimensional changes in the film strip are automatically compensated. This is accomplished by suitably gearing the drive connection between the motors 33, 34, 35, 32 and 42 to their respective driving rolls such that each drive roll normally is driven at a speed slightly in excess of the speed of the roll preceding it. The motor for each such drive is then turned on and off or otherwise is speed-controlled in dependence upon the position of the submerging rolls such

as submerging rolls **26***a* and **26***c*. The principle of operation may best be understood by referring specifically to the system diagrammatically illustrated for the control of motor **32**. Power is provided from source **44** by connecting line **45** directly to motor **32**. Line **46** is connected by way of a switch **47** and conductor **48** to the second terminal of motor **32**. The switch **47** is opened and closed in dependence upon the position of the submerging roll **50**. More particularly, the switch lever **51** carries a bracket **52** which is sensitive to the position of submerging roll **50**. In the form illustrated in FIG. 1 an arm **53** attached or otherwise actuated by the submerging roll **50** is adapted to close the switch **47** in a bottom position thereby to start motor **32**. Since motor **32** normally drives roll **31** at a higher peripheral speed than the roll coupled to motor **35**, the film strip **18** will be withdrawn from tanks **29** and **30** more rapidly than it is fed thereinto and thus the submerging roll **50** will be carried upward in the loop formed by strip **18**. As submerging roll **50** rises, the arm **53** contacts the upper arm of bracket **52** to open switch **51**, thereby stopping motor **32**. As the film continues to be fed into tanks **29** and **30**, the weight of the submerging roll **50** then causes it to sink as it pulls the strip **18** over the roll system until switch **47** is again closed. Thus there is provided a proportioning action for the output drive from the tanks **29** and **30** which in normal operation will be characterized by sequential energizing and de-energizing the strip extracting apparatus.

In a similar fashion the motor **42** which pulls the film **18** over the drying roll **39** is controlled by switch **56**. The latter switch is turned on and off in response to the position of the drying roll **39** to control motor **42**. When energized, motor **42** pulls strip **18** at a higher speed than delivered to the drying section by the roll **31**.

Thus in each treating zone there is provided a proportioning action in which the position of a gravity controlled roll is sensed to control the output speed at which the film is extracted from a given treating zone. In FIG. 1 the switches **47** and **56** have been shown as controlled by a mechanical linkage between them and the gravity controlled submerging roll **50** and the drying roll **39**, respectively. Weight **57** supported by a cable threaded over a pulley **58** urges drying roll **39** upward to maintain strip **18** in tension at all times.

In positioning of the drying roll **39**, a mechanical linkage schematically represented in one form for control of switch **56** in FIG. 1 may be employed. However since fluids are involved in the treating tanks **26**—**30**, it is desirable to locate the circuit controlling components outside of such zone. It is necessary, however, to sense the rolls positioned inside the zone.

One embodiment of the invention as embodied in wet treating zones is illustrated in FIG. 2. A single treating tank **70** has been shown with a feed drive roll **71** cooperating with a squeegee roll **72** to feed a strip **18** into the tank. For the purpose of FIG. 2, the drive roll **71** will be assumed to be driven at a constant speed. The strip **18** passes downwardly into the tank where it supports a positioning roll **74**. The strip then passes over an idler roll **75** and down again into the tank where it supports a second positioning roll **76**. The strip **18** is then threaded over a roll **77** which in cooperation with a squeegee roll **78** serves to remove the strip from the treating tank **70**. The extracting roll **77** is driven by a motor **79**. It is to be noted that the developing tank **70** is provided with channels **81** and **82** for guiding end members **83** and **84** which are carried by submerging rolls **74** and **76**, respectively. A source of power **87** is connected by way of conductor **88** to motor **79** and also by way of a mercury switch **89** and conductor **90**. The circuit breaker or switch **89** is thus position sensitive in its control of motor **79**. When switch **89** is closed, motor **79** actuates rolls **77** and **78** to withdraw the strip **18** from the tank **70**. Preferably the linkage between motor **79** and the roll **77**, represented by dotted line **79***a*, will be adapted to drive roll **77** at a peripheral speed normally greater than the peripheral speed of roll **71**. The linkage **79***a* includes a gear box or speed reducer of any well known type, particular examples of preferred embodiments being hereinafter identified.

The position sensitive control for switch **89** and the actuating mechanism therefor are shiwn in greater detail in FIGS. 3 and 4. The tank **70**, FIG. 3, is partially shown in section with the submerging roll **76** positioned near the bottom of the tank and supported or cradled in a loop of the strip **18**. Tank **70** preferably is of non-magnetic material. A guide block **84** is carried by the end of the submerging roll **76** and comprises an elongated rectangular block preferably made of a non-magnetic material. A handle bar **84***a* extends inward from the upper end of member **84**. A shaft **76***a* forming a part of the roll **76** extends through a bearing **84***b* in member **84**. A clip ring or keeper **84***c* on the end of shaft **76***a* maintains the coupling to block **84**. The lower end of member **84** has a small permanent magnet **84***d* embedded therein with the poles thereof closely adjacent the face **85***e* of member **84**. Thus the poles of magnet **84***d* face the side of the tank **70**. The magnet **84***d* is utilized to sense the position of the submerging roll alternately to open and close switch **89**. The switch **89** of the mercury pool type is mounted on the upper end of an arm **89***a* which is pivoted on a shaft **89***b* for rotation about a horizontal axis which is perpendicular to the axis of shaft **76***a*. Alternatively, switch **89** may be mounted at the axis **89***b* as shown in FIG. 2. The upper end of arm **89***a* carries a permanent magnet **89***c*. Similarly, the lower end of arm **89***a* carries a permanent magnet **89***d*.

In operation the submerging roll **76** will initially be descending as strip **18** is fed into a tank and will first cooperate with the switch **89** and its supporting means in the position shown in FIG. 4. The switch **89** is open by reason of the mercury bath, being positioned at the front of the mercury switch bulb. Magnet **84***d* attracts magnet **89***c* into a position in contact with the side of tank **70**. With switch **89** open, motor **79** of FIG. 2 is deenergized so that as strip **18** is fed into the tank the submerging roll **76** constitutes its downward course. Switch **89** remains open until the submerging roll **76** reaches the position shown in FIG. 3. When the lower position is reached, magnet **84***d* attracts magnet **89***d*, rotating arm **89***a* about axis **89***b*, thereby causing the mercury in switch **89** to close the contacts thereby energizing motor **79**. Since rolls **77**, FIG. 2, driven by motor **79** extracts the strip **18** from the tank **70** more rapidly that it is fed thereto, the submerging roll **76** rises during periods switch **89** is closed until it reaches the position shown in FIG. 4 whereupon switch **89** is opened. During the operation of the system the submerging roll **76** continues to oscillate between the limits defined by the length of the arm **89***a*. The two extreme positions of the submerging roll are shown in FIG. 4, the lower one being dotted.

In one aspect therefore the present invention will now be understood as involving a feed roll and an extracting roll at the input and at the output respectively of a treating zone with the extracting roll normally driven at a speed greater than that of the feed roll. The position of a strip supported member is then sensed at the extremities of a control traverse respectively to open and close the energizing means for the extracting roll.

The foregoing description has considered only those operations involved in maintaining a continuous developing operation once it has been set into motion. In FIGS. 5–9 there is illustrated a system for automatic initiation and termination of a developing operation as well as the intermediate operations above set forth. More particularly, the system will be so constructed that strip **18** from the camera of FIG. 1 may initially be unrolled so that it extends substantially horizontally from the first roller in tank **26** to the last roll **40** in the drying section. The submerging and squeegee rolls will then be placed

in their respective positions on top of strip **18**. The application of power thereafter to the camera and developer will initiate all operations necessary to complete development and drying, including submerging of the strip **18** in each tank or zone and elevation over the drying roll. Upon removal of the power driving the strip **18** in the camera section of FIG. 1, the developing unit will continue to be operative until the strip is again substantially horizontal, with all submerging rolls removed from their respective tanks and the drying roll latched in a final position. Coincident with the latter event, all operations are automatically terminated.

Referring to FIG. 5, there is illustrated a side view of a five tank developer showing the arrangement of drive motors **32—35** and a plurality of position dependent switches which are used for controlling the drive motors. Where consistent, like parts have been given the same reference characters as in FIG. 1. Chart **18** is shown as in an intermediate stage of the developing operation and is fed over a first roll **100** into the first tank **26** and under a submerging roll **26***a*, shown dotted, thence over an idler roll **26***b* and under a second submerging roll **26***c*. It is then driven from tank **26** over a roll mounted on shaft **101** which in turn is driven by motor **33** through belt **33***a*.

In tank **27** the chart is threaded under a submerging roll **27***a*, over an idler roll **27***b* near the tank top and under a second submerging roll **27***c*. The chart is driven from tank **27** over a roller mounted on shaft **102** which is driven from motor **34** by belt **34***a*. Similarly, in tank **28** the chart passes under submerging roll **28***a*, over idler roll **28***b* and under submerging roll **28***c*. Motor **35**, through belt **35***a*, drives shaft **103** to remove the chart from tank **28**. In tank **29** the chart is threaded under submerging roll **29***a*, over idler roll **29***b* and under submerging roll **29***c*. The chart is then threaded over an idler roll **104** intermediate tanks **29** and **30** and thence under submerging roll **30***a* in tank **30**, over idler roll **30***b*, at the top of tank **30**, and under a final submerging roll **30***c*. The chart **18** is then driven from tank **30** by motor **32** which is coupled by belt **32***a* to shaft **105**. Squeegee roll **106** cooperating with the roll on shaft **105** serves to provide the necessary wiping and friction for removing the chart **18**. It will be understood that squeegee rolls such as roll **106** will be provided as to cooperate with the driving rolls on shafts **101**, **102** and **103**, though the squeegee rolls have been omitted from FIG. 5.

The control action described in connection with FIG. 2 is followed in each of the treating zones of FIG. 5. More particularly, the submerging roll **26***a* travels along a vertical path in tank **26** under the control of the chart **18**. It is provided with a suitable guide-way either formed by the side of the tank as shown in FIG. 2 or by guide strips fastened to the inside of the tank. Similar guideways are provided for each of the submerging rolls **26***c*, **27***a* and **27***c*, **28***a* and **28***c*, **29***a* and **29***c* and **30***a* and **30***c*.

A circuit breaker **110** mounted adjacent the travel path of the roll **26***a* and on the outside of tank **26**. More particularly, a bracket **111** is mounted near the bottom of tank **26** on a frame member **112** and supports a rod or pivot bar **113**. A magnet **114** is mounted on the upper end of pivot bar **113**. A similar magnet **115** is mounted on the lower end of pivot bar **113**. The bar is supported by means not shown but forming a part of the structure of bracket **111** so that the pivot bar **113** may rotate about a horizontal axis **116**.

When submerging roll **26***a* descends in tank **26** as chart **18** is fed thereinto, it carries with it a magnetic element (**84***d*, FIG. 3) which passes magnet **114**. The magnetic pull on element **114** rotates bar **113** about axis **116**. When in the latter position, the circuit breaker **110** is open. As submerging roll **26***a* descends further, past the position illustrated in FIG. 5 to a point where magnet **115** is attracted toward tank **26**, the switch **110** is closed to apply an energizing voltage to motor **33**. The particular circuits for carrying out this operation are described in connection with the schematic diagram of FIG. 9. However, the operation of the circuit controlling unit including circuit breaker **110** is as described in detail in connection with FIG. 2.

It should be noted that a second circuit controlling unit including circuit breakers **120** and **121** is supported midway along the tank by a bracket **122** to be sensitive to the position and to the motion of the submerging roll **26***c*. Additionally, circuit breakers **123** and **124** are supported by a bracket **125** to be sensitive to the position of submerging roll **26***a*, circuit breakers **123** and **124** being located near the top of tank **26**. Breakers **120—124** are provided for fully automatic operation as will be explained in connection with FIG. 9.

Tank **27** is provided with circuit breaker **130** which is responsive to the position of submerging roll **27***c* and operative near the lower end of tank **27**. Additionally, circuit breakers **131** and **132** positioned near the top of tank **27** are sensitive to the position of the submerging roll **27***a*.

Tank **28** is provided with circuit breaker **140** which is sensitive to the position of submerging roll **28***c* at the bottom of the tank. Circuit breakers **141** and **142** are supported as to be sensitive to the position of submerging roll **28***a* at the top of tank **28**.

Tank **29** is provided with two circuit breakers **145** and **146** which are supported as to be sensitive to the position of submerging roll **29***a*. The positions of submerging rolls **29***c* and **30***a* are not sensed for any control purpose in the present invention since tanks **29** and **30** are both wash tanks and comprise a single treating zone as that term is used in the present application. However, tank **30** is provided with circuit breaker **150** and circuit breaker **151** which are supported by a bracket **152** near the bottom of the tank **30** as to be sensitive to the position of the submerging roll **30***c*.

From the standpoint of operation, the system illustrated in FIG. 5 may best be understood by referring to the detailed circuit diagram of FIG. 9. However, it will be of assistance if it is noted that a circuit is opened or is closed for a control purpose whenever a submerging roll moves into such position that the magnet such as magnet **84***d*, FIG. 3, associated with a given submerging roll arrives at the elevation of the magnet associated with a particular circuit breaker.

FIGS. 6–8 illustrate the system for treatment of the chart **18** as it passes from the developer of FIG. 5 into a drying zone wherein operations are controlled in dependence upon the position of a drying cylinder so that the drying process will produce a completed film which is uniform not only photographically but also mechanically as by proper drying. The product of the entire operation will be characterized by freedom from wrinkling at the edges and otherwise will be comparable mechanically to the original stock fed to the developing or treating system.

As shown in FIG. 6, the chart **18** leaving the roll on shaft **105** and the squeegee roll **106** is passed over a heated drum or cylinder **160** and thence over the roll **40** driven by motor **42** to a take-up reel **41**. As best seen in FIG. 7 which shows one-half of the drying zone, the drying roll **160** is adapted to be moved vertically under the control of a counter weight **57** which is supported by a cable **162** threaded over pulley **58**. Cable **162** is attached at the end thereof to a guide follower **163**. The drum **160** is supported on guide follower **163** so that as shaft **105** is actuated to drive chart **18** to the drying zone the drum **160** will travel upwardly under the influence of weight **57** to maintain chart **18** in tension.

The drying unit includes an outer framework **166** which is provided with a guide flange **167**. Carriage means including the guide follower **163** is provided with rollers **168** which follow the edges of the flange **167** in the vertical path. As seen in FIGS. 6 and 7, the guide follower

163 is provided with a transverse bar 169 at the lower end thereof.

The bar 169 supports shafts 170 and 171 at its extremities. The shafts 170 and 171 support rollers 172 and 173, respectively. As shown in FIG. 7, shaft 170 is provided with a stop bushing 174. Shaft 171 similarly is provided with a stop bushing.

Roller 172 has a lip or annular extension on the end adjacent the stop 174. As shown in FIG. 6, the heating drum 160 is supported by rollers 172 and 173 and thus rotates freely thereon. The end of the drum 160 as viewed in FIG. 7 coincides with the face of the extension or lip on the roller 172 and maintains the drum in proper axial position. Thus supported, drum 160 will freely rotate under forces applied thereto by chart 18.

The guide follower 163 is provided with a second bar 180 at the axis of the cylinder 160. A pair of shafts 181 and 182 secured to the ends of bar 180 extends through the cylinder and supports two end plates one of which, the plate 183, is positioned at the cylinder end adjacent guide follower 163. Plate 183 forms a closure for the end of cylinder 160 and at the same time provides a support for electrical heating elements, three of which, the elements 184, 185 and 186, are shown in FIG. 7. Two additional elements 187 and 188 are shown in the sectional view of FIG. 6. The elements are positioned closely adjacent the surface of the cylinder 160 and when energized by a suitable heating current radiate heat to the drum 160.

A heat barrier or baffle 190 is supported inside cylinder 160 and as best seen in FIG. 6 comprises a thin annular ring which encircles the heaters 184—188. The baffle 190 is relatively short in length compared to the cylinder 160 and is mounted on shafts 181 by means of bracket 191 as to permit slide movement. More particularly, bracket 191 extends diametrically across the cylindrical baffle 190 and is provided with apertures to receive shafts 181 and 182. A handle 192 in the form of an elongated U-shaped rod is fastened to an extension 193 of bracket 191 and extends over the surface of drum 160. The tip 194 of the handle 192 is in the plane of the inner edge of the baffle 190.

The baffle 190 serves to temper the heat applied to drum 160 from elements 184—188 at the edge of the chart 18. As chart 18 is fed onto drum 160, it is wet from the treating zone. Over the middle portion of the chart the heat stored in the drum 160 is dissipated during drying substantially uniformly. However, absent the baffle 190, the heating effect at the edges of the chart 18 would be much different than at the center thereof. Non-uniform drying at the center relative to the edges of strip charts would produce wrinkling of the edges. In avoidance of such action baffle 190 is positioned so that the tip 194 overlies the edge of the chart 18 to the extent necessary to assure the uniformity in the rate of heat transfer from the drum 160 to the chart 18 over the entire width thereof.

The control of motor 42 which drives or extracts the chart 18 from the drying zone is controlled along with other control functions by a pin 200 fastened to the lower end of the guide follower 163. More particularly, a switching arm 201 is pivotally mounted on a shaft 202. Circuit breakers 203 and 204 are mounted for rotation with the arm 201. As shown in FIG. 7, if the guide follower 163 moves downwardly, the arm 201 is rotated clockwise so that the circuit breaks 203 and 204 are in a different attitude than that shown in FIG. 7, the arm 201 being tilted by pin 200 engaging the lower end thereof. Similarly, as the guide follower 163 travels upwardly, the upper end of the bar 201 engages pin 200 and is moved back to the position shown in FIG. 7. A similar mechanism including bar 206 and circuit breakers 207 and 208 are mounted at an intermediate point along the frame 166. A bar 210 carrying a single switch or circuit breaker 211 is mounted near the top of the frame 166. Switches 207, 208 and 211 all will be actuated in dependence upon the position of the guide follower 163 as it carries drum 160 the length of frame 166 all under the control of motors 32 and 42 to perform control functions to be described in connection with FIG. 9.

Having described the physical structure of the developing and drying systems shown in FIGS. 5–8, there will now be described the electrical system for controlling the automatic developing operations. Where consistent, like parts have given the same reference characters as in FIGS. 1 and 5–8.

Electrical power is provided from a suitable source which is represented by the 110 volt supply 300. One terminal of supply 300 is illustrated as connected to ground by conductor 301 for the purpose of the system of FIG. 9. It is understood, however, that in an actual embodiment of the system a continuous conductor will interconnect and thereby functionally replace all ground points. The supply 300 is connected by way of conductor 302 and switch 302*a* to a four circuit selector switch 303. The first terminal of the selector switch is an "Off" position. The second terminal is provided for "Cut-over" operation, i.e., operation when neither motor 20 or 20*a* is energized to drive film through the camera section but wherein treatment of exposed film formed in loops and immersed in the developing tanks is completed. When switch 303 is in position No. 3, motor 20 is energized to drive the film 18 from the camera section 25 into the developer section 24. When switch 303 is in position No. 4, motor 20*a* is energized to drive film 18 from the camera section of the system.

Conductor 304 leads from the second terminal of switch 303 to the arms of switches 123 and 124. The upper terminal of switch 124 is connected to the arms of switches 131 and 132. Similarly, the upper terminal of switch 132 is connected to the arms of switches 141 and 142; the upper terminal of switch 142 is connected to the arms of switches 145 and 146; and the upper terminal of switch 145 is connected by way of conductor 305 to the arm of switch 203.

The third terminal of switch 303 is connected to motor 20. Conductor 302 is connected, by way of conductors 310 and 311, to the arm of switch 120; by way of conductor 312 to the arm of switch 130; by way of conductor 313 to the arm of switch 140; and by way of conductor 314 to the arms of both switches 150 and 151 to provide energizing paths for motors 32–35.

Such energizing paths selectively will be completed by connecting the upper terminal of switch 121 and the lower terminal of switch 120, as by conductor 315, to motor 33 and to the lower terminal of switch 123. Similarly, the lower terminal of switch 130 is connected by way of conductor 316 to motor 34 and to the lower terminal of switch 131; the lower terminal of switch 140 is connected by way of conductor 317 to motor 35 and to the lower terminal of switch 141; and the lower terminal of switch 150 is connected by way of conductor 318 to motor 32, to the lower terminal of switch 146 and to the arm of switch 208.

The dashed lines leading from motors 32—35 represent mechanical connections or driving connections to the rolls which are in contact with the strip 18. The driving connection between motors 20 and 20*a* has been illustrated as a unitary coupling leading to the roll 19.

Conductor 310 extends to the motor of a fan 320 which is located in the drying section of the system and which is adapted to direct air currents downwardly onto the strip 18 as it passes over drying roll 160. Conductor 310 also is connected to the arm of a switch 211. The upper terminal of switch 211 is connected by way of conductor 321 to motor 42 which serves to drive the extracting roll 40 and a take up roll 41 at the completion of the drying process. The upper terminal of switch 211 is connected by way of conductor 322 to the upper terminal of switch 203 and by way of conductor 323 to the arm of switch 207. The upper terminal of switch 207 is

connected by way of conductor 324 to the right hand or normally closed terminal of a switch 325 which is actuated by relay coil 326. The arm of switch 325 is connected to the upper terminal of switch 151.

Current for heating the radiant elements described in FIGS. 6–8 as mounted in drum 160 is applied by way of a double pole, double throw switch controlled by a solenoid coil 330. The upper terminal of switch 331 is connected to a 220 volt or high energy source 332. The upper terminal of switch 333 is similarly connected to source 332. The lower terminal of switch 331 is connected to ground, and the lower terminal of switch 333 is connected to the lower terminal of switch 204. The arms of switches 331 and 333 are connected respectively to the terminals of the heating elements in drum 160. Switches 331 and 333 normally are in the position shown in FIG. 9 so that current applied to the heaters will be from the 110 volt source 300 by way of switch 204. When relay coil 330 is energized, current is supplied to heaters in drum 160 from the high voltage source 332.

For initial or "warm up" operation a preset control 340 is provided. Control 340 is utilized to determine the length the time interval switch 342 is to be maintained closed after it is closed initially by manual operation. The arm of switch 342 is connected by way of conductor 343 to conductor 310. The contact on switch 342 is connected to relay 330 and to a timer control mechanism by conductor 344. A proportional timer 350 is provided periodically to actuate relay 330 for controlling the proportion of the time that current may flow from source 332 to the heaters in drum 160. The contact arm 351 is variable in position relative to drum 352 which figuratively represents a proportional commutator or circuit breaker. The upper terminal of switch 204 is connected by way of conductor 353 to a timing motor in unit 350 and to the positionally fixed contact of the commutator 352.

The lower terminal of switch 208 is connected to a solenoid 360 which, when energized, actuates an armature 361 to release a latching bar 362 which mechanically is coupled to the drum 160 in the manner diagrammatically illustrated in FIG. 9, a more specific showing being provided in FIG. 6. The latch 362 normally will arrest drum 160 as to prevent travel upwards in response to tension on cable 162.

The system described thus far is involved in operations relating to the production of a 1:1 or full size replica of a positive introduced into the camera section of FIG. 1.

When the selector switch 303 is in the fourth position, power is supplied from the source 300 to motor 20*a*, to the armature of switch 110 and to the relay 326 by way of conductor 370. The lower terminal of switch 110 is connected to the armature of switch 121 by way of conductor 371. The latter elements are provided for operation with the elements of FIG. 9 previously described to produce one-half size reproductions of a postive introduced into the camera section of FIG. 1.

There will now be described the sequence of operations necessary to carry out an automatic developing process for a 1:1 or full size reproduction.

Preparatory thereto the camera of FIG. 1 will be provided with the desired positive. The film negative to be exposed, forming roll 18*a*, FIG. 1, will be threaded along a normal path shown in FIG. 9, wherein strip 18 passes over rolls 19, 26*b*, 27*b*, 28*b*, 104, as well as the drive rolls mounted on shafts 101—103 and 105. The strip 18 is threaded through the drying section, over roll 40 and onto take up reel 41 Submerging rolls 26*a*, 26*c*, 27*a*, 27*c*, 28*a*, 28*c*, 29*a* and 30*c* are placed in their guideways and rest upon strip 18 Squeegee rolls are then placed above shaft 101—103 and 105 While drum 160 has been located in FIG 9 considerably below the plane of the normal path of strip 18, as it initially is threaded through the machine, it is to be understood that the path of strip 18 actually intersects the drum 160, the periphery of which therefore will describe or form the outline of an arcuate portion or segment of the normal path of strip 18 Thus when drum 160 is released by retraction of solenoid armature 361, the drum would already be in contact with strip 18 and would not exert any undue forces thereon

With the strip 18 thus positioned, two manual operations are required to place the system in operation: (1) Switch 302*a* is closed and selector switch 303 is placed in the No. 3 position. Motor 20 is thereby energized to start movement of chart 18 over roller 19, and (2) Switch 342 manually will be closed in the heating section to apply power from conductor 310 to the relay coil 330. Thus the high voltage source is immediately connected to the heating elements to bring them up to initial temperature. The preheat control 340 after a preset time will open switch 342 to de-energize the relay 330. In the latter condition standby heating power is applied through conductor 310, switch 204 and switch 333 to the heating elements.

As strip 18 proceeds over roll 19, the submerging roll 26*a* descends into the first treating zone. As it passes switches 123 and 124 it actuates them to move their arms into contact with their lower terminals. As roll 26*a* continues to descend to the bottom of the first traveling zone and to the location of switch 110, it actuates switch 110 to close it. (Since switch 110 is energized only for half-size reproduction, no action takes place upon closure thereof.) During descent of roll 26*a*, roll 26*c* remains stationary because of friction normally present in the bearings in idler roll 26*b*. When roll 26*a* comes to rest, roll 26*c* begins to descend. As roll 26*c* reaches switches 120 and 121, it closes both switches 120 and 121 to apply power (through conductors 310, 311 and switch 120) to motor 33. Thereupon motor 33 begins to drive the roll mounted on axis 101 to extract strip 18 from the first treating zone and to feed it onto the second treating zone.

As earlier described, the speed at which strip 18 is extracted from a zone exceeds the speed it is fed thereto so that when motor 33 becomes energized the submerging roll 26*c* will begin to ascend. As it rises, it will cause both switches 120 and 121 to be moved to their upper terminals at which position motor 33 is de-energized. With extraction of strip 18 stopped, submerging roll 26*c* begins descent, operates switches 120, 121 to energize motor 33 to resume extraction of strip 18, etc. The switching action is as described in detail in connection with FIG. 2 with the traverse of submerging roll 26*c* determined by the length of bar 89*a*, FIG. 2.

In the second treating zone submerging roll 27*a* first actuates switches 131 and 132 connecting the arms to the bottom terminals thereof. Thereafter submerging roll 27*c* actuates switch 130 for selectively energizing motor 34 which in turn extracts the strip 18 from the second treating zone. Roll 27*c* then alternately opens and closes switch 130 as above described. Submerging roll 28*a* in descent moves the arms of switches 141 and 142 to their lower terminals. After roll 28*a* comes to rest at the bottom of its path, submerging roll 28*c* in its descent actuates switch 140 which energizes motor 35 to extract the photographic strip from the third treating zone.

In the final treating zone submerging roll 29*a* actuates switches 145 and 146 in its descent. After roll 29*a* reaches the bottom of its path, roll 30*c* actuates switches 150 and 151 in its descent to energize motor 32. At the same time, relay 360 is energized by way of switch 208 to unlatch element 362. Whereupon the drying cylinder ascends in contact with the photographic strip 18 and maintains strip 18 in tension. Thus as the strip 18 is fed from roll 105 into the drying zone, upward movement of the drying drum is permitted. As the drum 160 moves upwardly, it actuates switches 203 and 204

through cooperation of pin 200, FIG. 7, and arm 201. When switch 204 is connected to the upper terminal, the timer 350 is energized periodically to connect the heating elements in drum 160 to the high voltage source 332.

As the strip 18 continues to be fed to the drying zone, drum 160 continues upward movement and in its course actuates switches 207 and 208 connecting the arms thereof to their upper terminals. With switch 208 thus opened, the solenoid coil 360 is de-energized and voltage is removed from coil 360. If switch 150 is then connected to its upper terminal, as drum 160 actuates switch 207 power will be applied to motor 42 over a path including conductors 310, 314, switches 151, 325, conductor 324, switch 207, conductors 323 and 321. If switch 151 is connected to its lower terminal, conductor 324 is not energized and drum 160 will continue its upward travel until it closes switch 211 through cooperation between pin 200, FIG. 7, and bracket 210. Since the arm of switch 211 is connected to conductor 310, closure of switch 211 will apply power to motor 42.

When motor 42 is energized, roll 40 extracts strip 18 from the drying zone at a rate in excess of that fed to the drying zone by the roll on shaft 105. Thus drum 160 begins to descend and will open switch 211, thereby stopping the extraction of strip 18, and reverse direction in its travel, etc.

Fan 320 positioned above drum 160 continuously directs a blast of air downwardly over the strip 18 as it is looped over drum 160 further to effect drying action. With the operation thus far described, automatic developing and drying will continue to be carried out so long as motor 20 is energized to feed strip 18 to the system. In one embodiment for full size reproduction strip 18 was fed to the developing system at a speed of 6 feet per minute. Each of the extracting rolls in the successive zones was driven at speeds slightly in excess of the speed of the preceding roll. Similarly, the roll 40 at the output of the drying zone was adjusted for a speed slightly in excess of that of the roll on shaft 105. The developing operation, it will now be appreciated, is characterized by independent and cyclic starting and stopping of each of motors 32—35 and 42 with motor 20 continuously energized to drive the strip 18 into the system at a uniform speed.

The switches 207 and 211 were both provided to prevent the possibility of the strip 18 ever becoming stationary on drum 160. Should such a concatenation of events take place that simultaneously all of motors 32—35 become de-energized at the same time, then with motor 42 de-energized the drum 160 would be stationary and the strip 18 would possibly be damaged by over-heating as to produce a burned or scorched section. By providing the switches 207 and 211, the period of time required for actuating them is sufficient that drum 160 may continuously be in motion over a period sufficient to re-energize all of motors 32—35 should they all become stopped at the same time. The latter action obtains because conductors 324 and 310 leading to switches 207 and 211, respectively, both are connected to source 300 when motors 32—35 are de-energized.

To discontinue the operation and automatically return the system to the normal condition shown in FIG. 9, switch 303 is moved to the "Cut-Over" position (No. 2) in which case power is applied to the strip drive system by way of conductor 304 as well as by way of conductor 310. It will be remembered that the arms of all of switches 123, 124, 131, 132, 141, 142, 145 and 146 contact their respective lower terminals during the developing operation. Therefore movement of switch 303 from the third to the second position will merely de-energize motor 20 to discontinue the movement of strip 18 into the first zone in the developer. However, motor 33 is energized through switch 123. As motor 33 continues to drive the strip chart from the first treating zone, submerging roll 26c is raised from the zone to the position shown in FIG. 9. Roll 26c may pass switch 120 because of the power circuit through switch 123 to motor 33. Thereafter the first submerging roll 26a is removed and as it proceeds upward it actuates switches 123 and 124 which thereby applies power from conductor 304 to the arms of switches 131 and 132 and de-energizes motor 33. Thereafter motors 34, 35 and 32 and 42 are successively energized through conductor 304. More particularly, rolls 27c and then 27a are removed from the second treating zone whereupon switches 131 and 132 are connected to their upper terminals to de-energize motor 34. In a similar manner roll 28c and then roll 28a are extracted from the third treating zone and thereafter rolls 30c and 29a are extracted from the fourth treating zone. When roll 29a is removed, power is applied by way of the upper terminal of switch 145, conductor 305 and the switch 203 to the motor 42 so that the latter motor will operate to remove strip 18 from the drying zone. Switch 203 is closed so long as drum 160 is in a position above it. Thus motor 42 will continue to extract the roll from the drying section until drum 160 is pulled down by the motor driven strip 18 to its latched position and to such a position that pin 200, FIG. 7, cooperating with bracket 201 will move switches 203 and 204 to their lower positions. Opening switch 203 stops motor 42 and the timing mechanism 350 preventing application of power from source 332 to the heating elements in drum 160. Closure of switch 204 applies standby power from source 300 to the heating elements in drum 160 so long as the switch 302a is closed. Thus the cycle of operations is completed.

There will now be described the operations for producing one-half size reproductions insofar as that operation differs from the foregoing.

Switch 300 is placed in position No. 4 which energizes motor 20a applies power to the arm of switch 110 and energizes the closed relay 326 to open switch 325. Thus as strip 18 is driven over roll 19 at one-half speed (about 3 feet per minute) roll 26a begins to descend, actuating switches 123 and 124. As roll 26a reaches switch 110, it closes it applying power to motor 33 by way of switch 110, conductor 371, switch 121 and conductor 315. Thus the motor 33 will extract the strip 18 from the first zone (the developing zone). The time interval during which any segment of the film may remain in the developing solution is the same time interval as in the full size reproduction, compensation having been made for the differences in speed. The remaining operations are identical with those above described except that the motor 32 will not be energized through switch 207 since switch 325 is open. Switch 211 then solely controls the proportioning action of motor 42. The time intervals the motors are energized and the order of events are such that the probability is that all motors 32—35 would never be stopped simultaneously for any period of time greater than that required for travel of pin 200 over the length of bracket 210.

In one embodiment of the invention the system was provided as to accommodate reproduction of charts up to 18" or 19" in width although wider strips may be accommodated by a system of wider basic design. The heating elements 184–188 were of the type available from the Edin L. Wiegand Company, Pittsburgh, Pennsylvania, and identified as "Cromalox—Far Infra Red Elements." They were nominally of ⅜" diameter and 27¾" in length. The drum 160 was of aluminum and was about 28" in length and 8" in diameter. The guide rolls 172 and 173 of about 1⅜" diameter were mounted on ½" shafts to form a cradle for facilitating penetration of the drying roll from its normal latched position into the treating zone. The proportional timing mechanism 350 was of the type available from Zenith Electric Company, 152 W. Walton Street, Chicago 10, Illinois, and identified as No. LP–30S—Process Timer. The tanks 26—30

were approximately 28" high. The ends were approximately 5" wide and the sides had a width of approximately 20". On the ends of the tanks the guides **81** and **82** were formed as a part of the tank, the latter being of extruded plastic. Submerging rolls were of 1" diameter except for the rolls **26***a* and **26***c*, the latter being ¾" diameter for reduced weight in the first zone. Other components of the system were selected as to cooperate with the elements above more particularly described.

It will now be appreciated that modifications may be made in the system described without departing from the scope of the invention. Instead of On-Off control of motors **32**—**35** and **42**, speeds above and below the normal speed of a preceding motor may be effected to accomplish the desired proportioning action. While 1:1 or one-half size operations have been described, other ratios may be produced or full size width together with a varied length ratio may characterize the reproduction by varying the speed of the photographic negative relative to the speed of the positive in the camera section. The physical condition inherent in magnetic attraction is embodied in the switching systems above described for sensing the submerging roll position. Such means was employed because of its simplicity. However, fixed coils may be utilized in place of the elements **89***c* and **89***d* together with a suitable amplifying and switching system as to be responsive to minute voltages generated therein as the magnet in element **84**, FIG. 2, moves past each respective coil. The latter type systems are well known to those skilled in the art and are therefore not described in detail. Alternatively, other physical conditions may be employed such as low level radiant energy sources insofar as such radiation would not deleteriously affect the photographic processes. Suitably shielded radioactive sources and detector systems may thus be employed.

Uses for the system other than a photographic process may conveniently be carried out by the system of the type here described. However, it is most readily adaptable to photographic processes and has for that reason been described as applied thereto. Five heating elements have been shown in FIG. 6 but more or less than this number may be employed. Seven such elements were utilized in one embodiment of the invention. These and other modifications are intended to be covered by the appended claims.

What is claimed is:

1. An automatic developer for an elongated photographic strip which comprises a treating tank, a primary drive for introducing said strip into said tank, an auxilliary drive for extracting said strip from said tank, means for energizing said primary drive, a roller supported by said strip in said tank, control means movable in said tank with said roller, sensing means at each of three positions outside said tank adjacent the path of said control means for sensing the position of said control means and operable when said roller is at the deepest of said three positions for energizing via a first control path said auxilliary drive and for de-energizing the same at the intermediate of said three positions, separate means for energizing said auxilliary drive means via a second control path, and means responsive to arrival of said roller at the shallowest of said three positions for discontinuing energization of said auxilliary drive means via said second control path.

2. in an automatic developing system having a structure forming a treating zone, the combination which comprises a first drive for feeding a flexible elongated strip into said zone, a second drive for extracting said strip from said zone, a power source, a multi-terminal switch connected to said power source having one terminal connected to said first drive, a first control circuit leading from a second terminal of said switch to said second drive, a second control circuit extending between said source and said second drive, a roller adapted to urge said strip into said zone, switch means in said second control circuit outside said zone and adjacent the path of said roller and adapted to be closed and opened in response to movement of said roller at points within said zone, and switch means in said first control circuit outside said zone and adjacent the path of said roller and adapted to be closed in response to movement of said roller into said zone and to be opened in response to movement of said roller out of said zone.

3. In an automatic developing system, the combination which comprises a non-magnetic tank forming a treating zone, a first drive for feeding an elongated film strip into said tank, a second drive for extracting said strip from said tank, a power source, a multi-terminal switch connection to said power source having one terminal connection to said first drive, a first control circuit leading from a second terminal of said switch to said second drive, a second control circuit extending between said source and said second drive, a gravity roller supported by said strip adapted to urge said strip into said tank, magnetic means carried by said roller adjacent the side of said tank, switching means in said second circuit outside said tank and adapted to be actuated by passage of said magnetic means past spaced points adjacent the bottom of said tank for de-energizing and energizing said second drive in response to positioning of said roller at an intermediate depth and at a greater depth respectively in said tank, and switch means in said first control circuit outside said tank and adjacent the path of said magnetic means adapted to de-energize said second drive in response to positioning of said magnetic means at a shallow depth in said tank.

4. An automatic treating system for an elongated flexible strip which comprises structure which forms a treating zone, a primary drive for introducing said strip into said zone, an auxiliary drive for extracting said strip from said zone, means for energizing said primary drive, a roller supported by said strip in said zone, control means movable in said zone with said roller, sensing means in each of three positions outside said zone adjacent the path of said control means for sensing the position of said control means and operable when said roller is at the deepest of said three positions in said zone for energizing via a first control path said auxiliary drive and for de-energizing the same at the intermediate of said three positions, separate means for energizing said auxiliary drive means via a second control path, and means responsive to arrival of said roller at the shallowest of said three positions for discontinuing energization of said auxiliary drive means via said second control path.

References Cited in the file of this patent

UNITED STATES PATENTS

1,653,451	De Ybarrondo	Dec. 20, 1927
1,664,735	Capstaff	Apr. 3, 1928
1,679,239	Cassereau	July 31, 1928
1,686,907	Fairall	Oct. 9, 1928
1,759,092	Caps	May 20, 1930
1,763,629	Hopkins	June 10, 1930
1,846,075	Aller et al.	Feb. 23, 1932
2,048,182	De Ybarrondo	July 21, 1936
2,202,127	Tondreau	May 28, 1941
2,292,511	Ferm	Aug. 11, 1942
2,568,431	Congdon	Sept. 18, 1951
2,681,802	Vermeulen et al.	June 22, 1954