May 10, 1960 H. L. BAUMBACH ET AL 2,935,923

AUTOMATIC CONTROL SYSTEM FOR FILM PRINTING MACHINES AND THE LIKE

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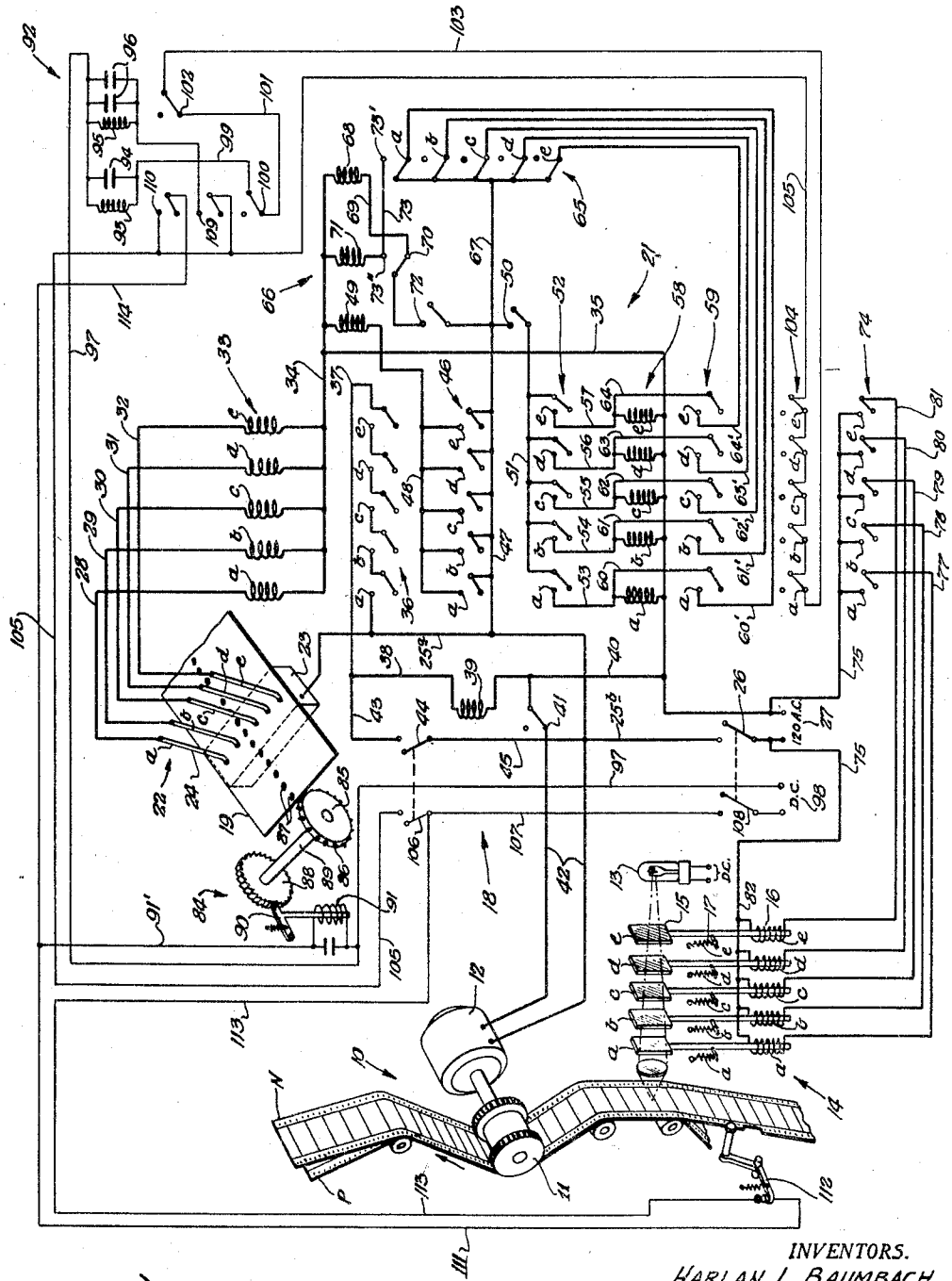


Fig. 1

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Fig. 2

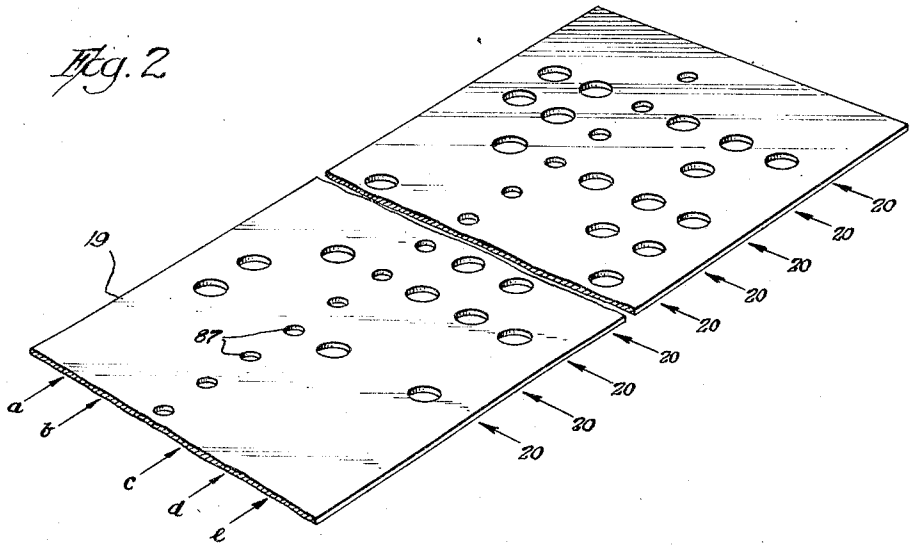
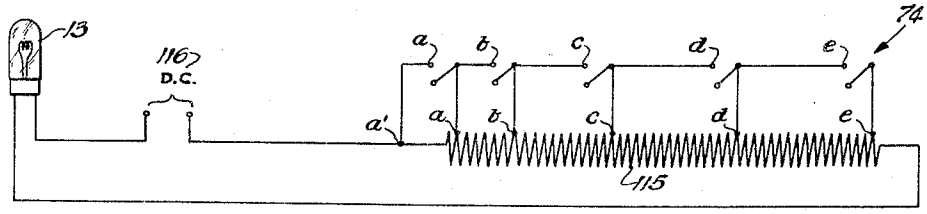



Fig. 3




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# AUTOMATIC CONTROL SYSTEM FOR FILM PRINTING MACHINES AND THE LIKE

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Application September 1, 1955, Serial No. 531,879

9 Claims. (Cl. 95—75)

This invention relates to photographic printing machines, and more particularly to a new and improved automatic light change system for film printing machines.

This invention is related to the invention disclosed in our copending divisional application Serial No. 737,964 filed May 26, 1958, and entitled Automatic Control System.

It is well known in the art of cinematography that the average light density of the several scenes in a developed motion picture film to be printed will vary between relatively wide limits because of the impossibility or impracticality of accurately and continuously compensating or controlling, during filming, the numerous factors, such as lighting, changes in background scenery, and lens opening, which effect the density of the developed film. Accordingly, it becomes necessary to periodically correct, that is vary the intensity of the printing light, during the printing of the developed film on positive film stock, to obtain the desired density of the several scenes in the final print. Also, various dramatic effects are often achieved through control of the printing light intensity.

Because of the high speed at which film printing machines operate, especially those machines employed in printing film for use in the television industry, changes in printing light intensity during printing operations are accomplished automatically.

Numerous automatic printing light correction devices have been devised for film printers, such devices generally embodying various means for presetting predetermined light changes into the printer. The light correction devices are cued by notches in the developed film, for example, to effect and respond to each such cuing notch by automatically adjusting the printing light to a new, preselected intensity.

One general type of existing light change device, for example, comprises, in substance, a control panel or board embodying a series of light change means each of which can be preset to correspond to a predetermined printing light intensity. During operation of the printer these light change means are sequentially rendered operative, in response to the passage of succeeding cuing notches in the developed film past a given point, to adjust the printing light to the corresponding intensity. Such presettable control panel arrangements are not, however, completely satisfactory owing mainly to their complexity, the limited number of light changes and light intensities that may be pre-established in the system, and the difficulty of initially presetting the light changes into the panel.

To obviate the above deficiencies of such presettable control panel arrangements, various types of light change systems have been devised which utilize a control member, such as a punched tape, for controlling a series of light change devices. The tape in such light change systems is prepunched with sets of perforations which are sequentially placed in operative relation to a perforation sensing device, in response to the cuing notches in the



film, the printing light intensity being varied in accordance with the perforations present in each perforation set.

While this latter type of light change system overcomes many of the noted disadvantages of the preset panel arrangements, the various punched tape systems which are presently in use have certain deficiencies which are obviated by the instant invention.

Thus, in certain of the existing punched tape systems the actual light change devices are directly connected to the sensing means for selective operation of the devices by closure of contacts, in the sensing means, corresponding to the perforations present in a given perforation set. An obvious disadvantage of such an arrangement is that if any one or more of the closed contacts fail after initial closure thereof, as frequently occurs, and, more important, during advancing of the tape to aline a following set of perforations with the sensing means, in which transit interval all the contacts of the sensing means will be open, the operation of the light change devices is interrupted so that the corresponding portions of the positive film will not be properly exposed.

It is desirable, therefore, that the light change system embody some type of "memory arrangement" which is operative, during this transit period as well as in the event of accidental opening of a contact, to maintain the previous light intensity until the latter becomes changed by alining of the following perforation set within the sensing means.

To this end, there have been developed certain punched tape light control systems which incorporate capacitor or magnetic type memory circuits. The "memory period" of these circuits is, however, relatively short whereas it is often desirable or necessary, as where a given contact fails at the beginning of a relatively long scene or where a relatively slow tape advance speed is employed, that the memory circuit be operative for long or indefinite periods of time.

A further deficiency of the existing light change systems stems from the fact that the control tape is generally provided with a relatively long leader portion and it has, heretofore, been necessary to initially manually advance this leader portion through the sensing means, or tape reader, to aline the first set of light change perforations therewith. This, obviously, is a time consuming and troublesome operation. Moreover, it is desirable that a printing machine, once placed into operation, will shut itself off automatically at the completion of a printing operation.

Briefly, then, the illustrative embodiment of the invention provides a punched tape system for automatic control of a film printing machine and its printing light intensity which system embodies the features of a memory circuit capable of "remembering" a given set of tape perforations for an indefinite period of time, means for automatically advancing the tape past a tape reader to aline a first set of perforations with the latter, and means for automatically shutting down the printer at the completion of a printing operation.

A broad object of this invention is the provision of an automatic light change system for photographic printing apparatus which obviates the preliminary noted deficiencies of existing light change systems.

Another object of the invention is the provision of a light change system of the class described which is fully automatic in its operation and capable of use with relatively high speed film printing apparatus.

Yet another object is the provision of an automatic light change system by which an unlimited number of light changes may be pre-established in a film printer.

A further object of the invention is the provision of an automatic light change system for film printers which embodies a memory circuit, having a memory period of

indefinite length, for maintaining each printing light setting until a new printing light setting is established by operation of the light change system.

A still further object of the invention is to provide an automatic light change system of the character described in which the control tape is automatically advanced to the first bit of control information thereon and the system is automatically shut down after the last bit of information.

In the illustrated embodiment of the invention, a control tape, prepunched with sets of light change perforations in accordance with the varying density in the several scenes of a negative film, is intermittently advanced past a tape reader, in response to cueing notches in the film, to sequentially aline said perforation sets with the reader. An electrical circuit, associated with the reader, incorporates a series of light change means which are selectively operated, in accordance with the perforations present in any given set of perforations, for establishing predetermined light intensities in a film printing machine.

This circuit embodies means for initially continuously advancing the tape past the reader to aline a first set of perforations with the latter as well as means for stopping the printer automatically when the tape is advanced to a position wherein the alined perforation set contains a predetermined number of perforations.

A highly important and advantageous feature of the invention resides in the provision, in said circuit, of a memory system which has a memory period of indefinite length and which is operative to maintain a given printing light intensity, after establishment thereof by alining of one set of light change perforations with the reader, even though the reader contacts subsequently fail and also during advancing of the tape to aline a following perforation set with the reader.

A better understanding of the invention may be had from the following detailed description taken in conjunction with the annexed drawings wherein:

Fig. 1 is a schematic circuit diagram of the invention;

Fig. 2 is an enlarged showing of the control tape used in the invention; and

Fig. 3 schematically illustrates a modified form of light change device.

Referring first to Fig. 1, diagrammatically illustrating one form of the present light change system, the numeral **10** denotes the film feed mechanism of a film printer including a sprocket wheel **11** and drive motor **12** therefor for advancing a negative film strip N and a positive film strip P through a beam of light from a source **13**. The beam of light passes through the negative film strip and impinges on the positive film strip so as to produce on the latter latent positive images of the negative images contained on the negative film strip N.

In the form of the invention illustrated in Fig. 1, the intensity of the beam of light from source **13** at the film strips P and N is controlled by a variable density light filter arrangement **14** including a series, shown as five in number, of varying density light filter elements **15**, separately designated as *a, b, c, d, e,* which are normally disposed in the path of said beam, between source **13** and the film strips P and N, and adapted to be selectively removed therefrom either singly or in combination. Each of the filter elements **15** is of different predetermined light density so that by such selective individual or combined removal of the filters, different light intensities may be provided at the film strips, as will presently be more fully explained.

Associated with each of the filter elements **15** is a solenoid actuating element **16** which when energized will move its respective filter element out of the path of the printing light beam. The filter elements are normally retained in a position in such path, for example, by means of biasing springs **17** on the solenoids **16**.

Automatic selective energization of the solenoids **16** to achieve predetermined light changes during the operation of the printer **10** is accomplished by operation of the present light change system, generally denoted at **18**. This light change system includes a presettable information storage member or control member **19** (see also Fig. 2), which may be a tape punched with sets **20** of light change perforations. The light change system also includes an electrical circuit **21** including a tape reader or sensing device **22** for sensing the perforations or other information in each of the sets **20** in the control tape **19** and effecting selective energization of the light filter solenoids **16** in accordance with the perforations present in any given one of the perforation sets **20**.



As shown in Fig. 2, each of the perforation sets **20** has five positions, designated as *a, b, c, d, e,* in which a perforation may be formed, each of said positions being identified with the correspondingly lettered one of light filter solenoids **16**. As will presently be more fully described, the arrangement of circuit **21** is such that with a given set **20** of perforations operatively alined with reader **22**, a perforation in position "*a*" will result in energization of filter solenoid **16***a*, a perforation in position "*b*" will result in energization of filter solenoids **16***b*, and so forth.

While each of the perforation sets **20** have been illustrated as containing a maximum of five perforations for the selective control of five light change filters, it will be apparent that the maximum number of perforations in each of the sets **20** may be varied according to the number of means to be controlled. For example, in addition to the light filter elements, additional devices, as for example, a dissolve mechanism, may be operably controlled by the tape. To this end certain ones of the perforation sets might contain additional perforations for the control of such mechanism. Thus, the disclosure of a maximum of five perforations in each perforation set is only illustrative in nature and more or fewer perforations may be employed depending on the type and number of elements to be controlled.

Circuit **21** will now be described in greater detail. Where a punched tape is utilized as the control member **19**, as shown, sensing device **22** may comprise any conventional punched tape reader. For the purpose of illustration, the reader **22** is shown as comprising a metallic platen **23** and five flexible contact brushes **24** individually designated as *a, b, c, d, e,* arranged to normally contact the platen. As will be seen, tape **19** is, during operation of the system, fed between platen **23** and brushes **24** so that contact will be established between any given one of the brushes and the platen only in the presence of a corresponding perforation in the tape.

Platen **23** is connected, through leads **25***a* and **25***b*, the latter including a series connected switch **26**, to one terminal of an A.C. supply **27**. Brushes **24***a* through **24***e*, are connected, respectively, through leads **28, 29, 30, 31,** and **32** to one of the terminals of a series of five relay coils **33**, individually designated as *a, b, c, d, e.* The other terminals of the coils **33** are connected through a common lead **34** and a lead **35** to the other terminal of the A.C. supply **27**.

It will be apparent from the foregoing description that when switch **26** is closed, relay coils **33** will be energized whenever their respective brushes **24** in the sensing device **22** contact the platen **23**.

Relays **33** comprise a first set of normally open, series connected contacts **36**, individually designated as *a, b, c, d, e,* which, when all are closed by simultaneous energizing of the five relays **33**, complete a circuit from lead **25***a* extending to one terminal of A.C. supply **27**, through lead **37**, including the series contacts **36**, lead **38**, a relay coil **39**, and lead **40** to the other terminal of supply **27**. Thus, when switch **26** and all of the contacts **36** are closed, relay **39** energizes to open its normally closed contacts **41**. These contacts are series connected in the energizing circuit **42** for film feed motor **12** so that energization of the relay **39** results in stop-

page of the feeding of the film strips N and P through the printer **10**. Arranged in shunt with the relay contacts **36** is a circuit comprising a lead **43**, extending from lead **38** for relay **39**, to one terminal of a switch **44** and a lead **45** extending from the other terminal of switch **44** to A.C. supply lead **25***b*. It will be seen that when switch **44** is closed, relay contacts **36** are bypassed and relay **39** energizes. This switch **44** is momentarily closed at the outset of a printing operation to prevent the printer motor **12** from starting, for reasons to be presently described.

Relays **33** comprise a second set of normally open, parallel connected contacts **46**, designated as *a, b, c, d, e*. Closing of any one of these contacts by energization of its respective relay coil **33**, will complete a circuit from lead **25***a*, connected via lead **25***b* to one terminal of A.C. supply **27**, through lead **47**, contacts **46**, lead **48**, a relay coil **49**, and thence through leads **34** and **35** back to the A.C. supply **27** to cause energization of the relay **49**.

Relay **49** comprises a first set of normally open contacts **50** which when closed by energizing of coil **49**, connect lead **47** to a lead **51** extending to a third set of normally open parallel arranged contacts **52**, individually designated as *a, b, c, d, e*, of the relays **33**. These latter relay contacts **51** are connected, through leads **53**, **54**, **55**, **56** and **57**, respectively, to one of the terminals of a second set of five relay coils **58**, designated as *a, b, c, d*, e, the other terminals of which are connected to lead **35** extending to the A.C. supply. Thus, it will be evident that energization of any one of the first set of five relays **33** results in the energization of the corresponding one of the second set of five relays **58** by completing of the circuit extending from one terminal of the A.C. supply **27**, through leads **25***b*, **25***a*, **47**, contacts **50** closed, as above described upon energization of any one of the relays **33**, lead **51**, the one of the contacts **52** corresponding to the energized one of the relays **33**, relay coils **58**, and thence to the other terminal of A.C. supply **27** through lead **35**.

A series of normally open lock-in contacts **59***a*–**59***e* are associated with the second set of five relays **58** for maintaining the latter in an energized state once they are energized by energization of the corresponding relays **33** for reasons to be presently seen. To this end the lock-in contacts **59***a*–**59***e* have one terminal connected via leads **60**, **61**, **62**, **63** and **64**, respectively, to the upper ends of their associated relay coils **58***a*–**58***c* and have their other terminals connected through leads **60′**, **61′**, **62′**, **63′**, **64′**, respectively, to a series of five normally closed, parallel arranged contacts **65***a*–**65***e*, in an A.C. pulse circuit **66**. Contacts **65** are connected through leads **67**, **47**, **25***a* and **25***b* to one terminal of A.C. power supply **27**. Thus, with the lower ends of coils **58** connected to the other terminal of supply **27** and with the contacts **65** closed, closing of any one of the lock-in contacts **59** by energizing of the corresponding one of the relays **58** operates to lock such corresponding relay in its energized condition. As will presently be more fully described, the lock-in contacts **59** and their associated leads comprise the previously mentioned memory circuit which constitutes a highly important feature of the invention. Thus, during advancing of tape **19** from a position wherein one set **20** of perforations is alined with the reader brushes **24** to a position wherein the next following perforation set **20** is alined with said brushes, contact between all of the latter and the platen **23** will be momentarily broken. In the absence of the present memory circuit, therefore, all of the filters **15** would be momentarily disposed in their normal positions in the path of the printing beam so that that during this period, the positive film P would be improperly exposed.

The lock-in contacts **59**, however, act to maintain those of the filter solenoids **16**, corresponding to the perforations in a preceding perforation set, energized during this advancing of the tape **19** to the next set of perforations so that during this transit the filters **15**, associated with said energized solenoids will remain out of the path of the beam and the positive film will be properly exposed. Moreover, these lock-in contacts act to maintain the predetermined printing beam intensity, corresponding to a given set of perforations in the control tape **19** even though the contacts **24** of the tape reader fail after initial contact with the platen **23**.

It will be seen that the lock-in contacts **59** will remain operative to their intended purpose so long as they are supplied with energizing current. Thus, the present memory circuit may be considered to have a memory period of indefinite length. This prolonged memory period may be important, for example, where relatively slow or widely varying tape advance speeds are used under various conditions or where a given reader contact fails at the beginning of printing a relatively long scene wherein no light changes occur. Also the printer may be stopped and the reader rendered inoperative for prolonged periods of time and subsequently their operation continued without interruption of the memory circuit.

The A.C. pulse circuit **66** provides for the opening of the lock-in contacts **59** under certain, hereafter described conditions. To this end the contacts **65** comprise a relay whose coil **68** has one terminal connected to the A.C. supply lead **34** and the other terminal connected through a lead **69** including a set of normally closed relay contacts **70** associated with a relay coil **71**, and a second set of normally open contacts **72** of the relay **49** to lead **47**. One terminal of relay coil **71** is connected to the A.C. supply connected lead **34** while its other terminal is connected through a lead **73** to normally open contact points **73′** and **73″** associated with normally closed contacts **65** and **70** so that contacts **73″** close upon opening of contacts **70**, by energizing of coil **71**, and contacts **73′** close upon opening of contacts **65** by energization of relay **68**. Operation of this lock-in-releasing A.C. pulse circuit will be described presently.

Associated with the relay coils **58** are a second set of normally open contacts **74**, individually denoted by the letters *a–e*. The upper terminals, as viewed in the drawing, of these contacts are connected through a common lead **75** to one terminal of A.C. power supply **27** while the lower terminals of the contacts **74** are connected through leads **77**, **78**, **79**, **80** and **81** to the lower ends of light change solenoids **16**. The upper ends of these latter solenoids are connected to the other terminal of supply **27** through a common lead **82**. Printing light **13** may be energized from a D.C. supply as indicated.

As will be more fully described, contacts **74** control the actual light intensity changes in the present system. Thus, closing of any one of the contacts **74** by energizing of the associated one of the relays **58** completes a circuit from the supply **27** to the corresponding one of the light filter solenoids **16** to energize the latter and move its associated filter **15** out of the path of the light beam from source **13**.

Indicated generally at **84** is any conventional mechanism for advancing tape **19** past reader **22** during operation of the system. This mechanism is schematically illustrated as comprising a sprocket wheel **85** formed with teeth **86** for meshing engagement with sprocket holes **87** in the tape. Wheel **85** is coupled to a ratchet wheel **88** by a shaft **89** so that rotation of wheel **88** will impart rotation to wheel **85**.

A spring biased pawl **90** is arranged to engage the teeth of ratchet wheel **88** and is operated by a solenoid **91**, the arrangement being such that each time solenoid **91** is energized, pawl **90** will be operated downwardly to step ratchet wheel **88** and cause advancing of tape **19** through a predetermined distance. This distance is made equal to the spacing between the sets **20** of perforations in the tape so that the latter, during operation of the sys-

tem, may be advanced to sequentially aline said perforation sets with brushes 24.

Solenoid 91 is controlled through a D.C. energizing circuit, whose conductors are, in the interest of clarity, illustrated by relatively fine lines as compared to the conductors of the A.C. circuit heretofore described.

This D.C. energizing circuit comprises a D.C. "pulse" circuit, generally indicated at 92, which is operative, in the absence of any perforations in tape 19, to supply to the tape advance mechanism solenoids 91, a series of pulses for continuously advancing the tape past the tape reader 22 to aline the first set of perforations with the reader. To this end, the D.C. pulse circuit 92 comprises a first coil 93 shunted by a first condenser 94 and a second coil 95 shunted by a pair of condensers 96.

These coils and condenser 93–96 have one terminal connected through a common lead 97 to one terminal of a D.C. supply 98. First coil and condenser 93 and 94 have their other terminal connected to the other terminal of the D.C. supply 98 through a circuit which may be traced through lead 99, a set of normally closed contacts 100 associated with the first coil 93, lead 101, a set of normally closed contacts 102 associated with the second coil 95, lead 103, a third set of series connected, normally closed, contacts 104*a*–104*e* of the relays 58*a*–58*e*, lead 105, switch 106, lead 107, and switch 108 to said other terminal of the D.C. supply 98. Switches 44 and 106 and switches 26 and 108 are tied together for simultaneous operation thereof, as indicated.

The other terminal of the shunt connected coil and condenser assembly 95 and 96 is adapted to be connected to D.C. supply connected lead 105 by closing of a second set of normally open contacts 109 operated by first coil 93 while a third set of normally open contacts 110 associated with this latter coil, when closed, connect said lead 105 to a lead 11 extending to one terminal of a film-operated switch 112. The other terminal of this latter switch is connected, via a lead 113 to lead 107, extending to the D.C. supply 98. The tape advance solenoid 91 is series connected in a lead 91′ tied at opposite ends to leads 111 and 97.

*Operation*

Negative film N will have been initially viewed in its entirety by an operator who will form in the film, at each point where a change in printing light intensity is to occur, a notch 114. Simultaneously he will form in the control tape 19, associated sets 20 of perforations wherein the perforations will be present in one or more of the previously mentioned positions *a*–*e* depending on which of the filters 15 must be removed from the path of the printing light beam to yield the desired light intensity at the film.

The leading end of this prepunched tape is inserted into reader 22 to engage sprocket holes 87 with the sprocket wheel 85, the tape passing between the platen 23 and brushes 24 so that the latter will not contact the platen unless the tape contains a perforation in the position corresponding to a given brush. Normally the first set 20 of light change perforations will be spaced some distance from the leading end of the tape so that the latter must be initially advanced a substantial distance through the reader to aline said first set of perforations with the reader brushes 24.

To effect this initial advancing of the tape, switches 44 and 106 are moved to their right hand, closed position, and switches 26 and 108 are closed to connect the D.C. power supply 98 to energize the control circuit for the tape advancing mechanism 84. A.C. supply 27 will thereby also be connected to the control circuit for the light filter solenoids 16 and film feed motor 12. However, since tape 19 will separate brushes 24 from platen 23, relays 33 and 58 will remain unenergized. Moreover, closing of the switch 44, as previously described, completes a circuit through the motor control relay 39, so that when switch 26 is closed, relay 39 energizes to open contacts 41 for film feed motor 12. The printer 10, therefore, remains inoperative.

Since relays 58 are unenergized, contacts 104 thereof will be closed so that a circuit may be traced from the right hand terminal of D.C. supply 98, through lead 97, coil 93, lead 99, contacts 100, lead 101, contacts 102, lead 103, contacts 104, lead 105, switch 106, lead 107, switch 108 back to the other terminal of the D.C. supply. Coil 93 is thereby energized to close its normally open contacts 109 and 110 and open its normally closed contacts 100.

Closing of contacts 110 completes a circuit from D.C. supply 98 through switch 108, lead 107, switch 106, lead 105, contacts 110, lead 111, lead 91′, tape advance coil 91, and thence back to the other terminal of supply 98 through lead 97. Coil 91 thus energizes to actuate the tape advance mechanism 84 and cause advancing of the tape 19 a distance equal to the spacing between adjacent sprocket holes 87.

Simultaneously with the closing of contacts 110, contacts 100 open to break the circuit between coil 93 and D.C. supply 98 and contacts 109 close to complete a circuit from D.C. supply connected lead 97 through coil 95 to D.C. supply connected lead 105. Coil 95 will, therefore, energize and its normally closed contacts 102 will be opened.

Although the energizing circuit to coil 93 will be broken by opening of its contacts 100, discharge of condenser 94 through said coil maintains the latter energized sufficiently long to deliver a D.C. pulse to tape advance coil 91 and to effect opening of contacts 102 of coil 95.

After condenser 94 has become discharged, through coil 93, to a given value, its contacts 109 and 110 reopen and its contacts 100 reclose. Reopening of said contacts 109 breaks the energizing circuit to coil 95, but the latter will remain energized for a brief period of time sufficient to allow the advance mechanism to return to its normal position under the action of the biasing spring therein.

Accordingly, reclosure of contacts 100 does not instantaneously result in energization of coil 93 inasmuch as contacts 102 will be held open by this prolonged energization of the coil 95.

After condensers 96 have become discharged, through their associated coil 95, to a predetermined value, contacts 102 reclose and coil 93 will be reenergized to repeat the above described cycle. Thus, it may be seen that the D.C. pulse circuit 92 operates to deliver a series of D.C. pulses to the tape advance coil 91 and the tape 19 will be continuously intermittently advanced past the reader 22.

This intermittent advancing of the tape continues until the first of the sets 20 of light change perforations become alined with the reader brushes 24 whereupon one or more of the brushes 24, depending on the perforations present in the first set, will contact the platen 23 through such perforations. As will now be described, this contact of any one of the brushes with the platen results in energizing of the corresponding one of the relays 58 and opening of its contacts 104. Opening of any one of the contacts 104 breaks the energizing circuit to the coil 93 in D.C. pulse circuit 92 and the latter will cease to operate. Thus, the tape will stop when said first set of perforations becomes alined with the reader brushes 24.

This initial contact between one or more of the reader brushes 24 and platen 23 also establishes an initial printing light intensity at the film strip N in the following manner. Assuming that the first perforation set 20 on the tape 19 contains only a perforation in position *a* so that only brush 24*a* contacts the platen, relay coil 33*a*, as heretofore described, becomes energized and its normally open contacts 36*a*, 46*a*, and 52*a* close.

Closure of contacts 46*a* places the A.C. supply 27 across relay coil 49 so as to energize the latter and close its normally open contacts 50. Closure of contacts 50

and 52*a* completes a circuit from A.C. supply 27 through relay coil 58*a* to energize the latter and close its normally open contacts 59*a* and 74*a* and open its normally closed contacts 104*a*. As described above, opening of contacts 104*a* results in interruption of the D.C. pulse circuit 92.

Contacts 59*a*, as previously described, act to lock-in relay coil 58*a*, for the reasons heretofore set forth, so that the latter remains energized and its contacts 74*a* remain closed. These latter contacts 74*a* complete a circuit from the right hand terminal of A.C. supply 27 through lead 75, contacts 74*a*, lead 77, light filter solenoids 16*a*, and lead 82 to the other terminal of source 27. Solenoid 16*a* is thus energized with a resultant downward movement of light filter 15*a* to a position out of the beam from light source 13.

Similarly, if the first of the perforation sets 20 contains perforations in any of the other positions *b*–*e*, the corresponding ones of the filter elements 15*b*–15*e* will be removed from said beam.

Thus, the intensity of the light impinging on the film will be increased in accordance with the light density of a single filter, where only one filter is removed, or in accordance with the combined light density of several filters where more than one filter is removed from the light beam.

Printing light 13 is now energized and simultaneously switches 44 and 106 are operated to their open position. Opening of switch 44 results in breaking of the previously described energizing circuit for motor relay 39 whereupon its normally closed contacts 41 reclose to complete a circuit from the left hand terminal of A.C. supply 27, through now closed switch 26, leads 25*b* and 42, the latter including film feed motor 12, contacts 41, and lead 40 to the right hand terminal of supply 27.

The positive and negative film strips P and N are now fed, by operation of motor 12, in the direction indicated to successively expose the frames of the negative film to the beam from source 13, such beam being of the proper intensity, due to the aforementioned selective removal of the light filters 15*a*–15*e* corresponding to the perforations present in the first perforation set to achieve the desired exposure of the positive film P.

The negative film N, as heretofore described, will have been formed with notches 114, in one edge thereof, at those positions along its length whereat it is desired to effect a change in the intensity of the printing light beam either for the purpose of compensating for a change in the light density of the negative film or to achieve certain dramatic effects in the positive film.

As the first one of the notches passes the interrupter switch 112, the latter is momentarily closed, by movement of the roller carried on the switch rocker arm into the notch, and a circuit is momentarily established from the left hand terminal of D.C. supply 98, through now closed switch 108, leads 107 and 113, switch 112, leads 111 and 91′, tape advance solenoid 91 and lead 97 to the right hand terminal of the D.C. supply.

Tape 19 is thereby advanced to aline the second set of perforations 20 with the reader brushes 24. Contact with platen 23 of those of the brushes 24*a*–24*e* corresponding to perforations present in said second set of perforations results in the energization of the corresponding ones of the light filter solenoids 16*a*–16*e* and removal of the associated filter elements 15*a*–15*e* from the path of the printing light beam to achieve the proper beam intensity for the following length of negative film.

If a perforation in one set of perforations is absent from the next following set, A.C. pulse circuit 66 becomes operative to release the lock-in contacts 59 associated with that perforation so as to permit return of the corresponding filter element 15 to its normal position.

Thus, for example, assuming that the first perforation set contained a perforation in position *a* and that the second perforation set contained a perforation only in position *b*, relays 33*b* and 58*b* energize due to contact of brush 24*b* with platen 23. Resultant closing of contacts 46*b* of relay 33*b* energizes relay 49 to close its normally open contacts 72 whereupon a circuit may be traced from lead 47, extending to the left hand terminal of A.C. supply 27, through contacts 72, normally closed contacts 70, lead 69, relay coil 68 to lead 34 extending to the other terminal of the supply 27. Relay 68 will thereby be energized and its normally closed contacts 65*a*–65*e* will open, thus breaking the energizing circuit through lock-in contacts 59*a* for relay 58*a*. This latter relay now becomes deenergized and its contacts 74*a* and lock-in contacts 59*a* open allowing light filter 15*a* to be reinserted under the action of the associated biasing spring 17. Relay 58*a* will, therefore, remain deenergized until subsequent contact is established between brush 24*a* and platen 23 due to the presence of a perforation being present in position *a* in a succeeding set of perforations.

Relay 58*b* will, however, remain energized by virtue of the contact between brush 24*b* and platen 23. Simultaneously with the opening of contacts 65*a* by energizing of coil 68, normally open contacts 73′, associated with that coil, close to complete a circuit from lead 67, extending to the left hand terminal of A.C. supply 27, through contacts 73′, lead 73, relay coil 71 to lead 34 extending to the right hand terminal of the supply 27.

Relay coil 71 is thereby energized and its normally closed contacts 70 open to break the energizing circuit to relay 68 and allow its contacts 65*a*–65*e* to return to their normal closed condition whereupon the lock-in contact 59*b* associated with relay coil 58*b* becomes operative to maintain the latter coil energized during subsequent advancing of the tape and even though the contact between brush 24*b* and platen 23 subsequently fail.

Contacts 73″ of relay coil 71 close simultaneous with the opening of its contacts 70 so that coil 71 will be locked in energized condition as long as contacts 72 are retained closed by energization of relay 49. This latter relay is momentarily deenergized during advancing of tape 19 from one set of light change holes 20 to the next, since during this transit none of the brushes 24 will contact the platen and accordingly all of the contacts 46 open momentarily. This momentary deenergizing of coil 49 opens contacts 72 and deenergizes coil 71. This allows contacts 73″ of relay 71 to reopen and contacts 70 to reclose so as to condition the A.C. pulse circuit for repetition of the above described operation when the next set of light change holes in tape 19 become alined with the brushes 24.

Tape 19 will continue to be advanced to sequentially aline the sets 20 of light change holes in the tape with the brushes 24 each time one of the cuing notches 114 in the film passes interrupter switch 112. As each of said sets of holes 20 become alined with the brushes, the system operates in the manner described above to remove from between the printing light source 13 and the film one or more of the light filters 15 in accordance with the perforations present in each set.

The system will continue to operate in this manner until the tape is advanced to a position wherein the set of perforations alined with the reader 22 contains a perforation in each of the positions *a*–*e*. This condition of all five perforations being present results in all five relays 33 being simultaneously energized and, accordingly, in all five of its contacts 36*a*–36*e* being simultaneously closed. A circuit is then completed, as heretofore described, from A.C. supply 27 through motor relay 39. The latter will energize, therefore, to open its normally closed contacts 41 and stop film feed motor 12.

Tape 19 will be deliberately punched with all five perforations to stop the printer at the completion of a printing operation.

The present invention may also embody a variable resistance printing light change in lieu of the variable density filter arrangement just described. In this variable

resistance arrangement, shown in Fig. 3, contacts 74*a*–74*e* of relays 58 operate to remove varying amounts of resistance in series with the printing lamp 13. In Fig. 3, only the contacts 74, resistance element 115, lamp 13, and a D.C. supply 116 have been illustrated, in the interest of clarity, it being understood that the remainder of the light change system would be identical to that described.

As shown in Fig. 3, with all of the contacts 74*a*—74*c* open, which position they will occupy when all of the relays 33 and 58 are unenergized due to no light change perforations being present in the tape 19, a circuit may be traced from the left hand terminal of supply 116, lamp 13, and resistance element 115 to the right hand terminal of said supply. The intensity of the light emitted from the lamp will, therefore, have a minimum value.

As shown, the contacts 74*a*–74*e* are series connected and are tapped to the resistance element 115 at five points designated as *a*–*e*, the first contacts 74*a* having one terminal tapped at *a'* to the lead extending to supply 116. The distance between taps gradually increases so that, for example, the resistance value between taps *a* and *b* will be a multiple of the resistance value between taps *a'* and *a*, the resistance value between taps *b* and *c* will be a multiple of that between taps *a* and *b*, and so forth.

The arrangement is such that when contacts 74*a* are closed, the resistance between taps *a'* and *a* is shunted, when contacts 74*b* are closed the resistance between taps *a* and *b* is shunted, and so on. Thus, successive closing of the contacts 74*a*–74*e*, in that order, will produce incremental increases in the printing light intensity, which intensity may be further increased by closing two or more of the contacts in desired combination.

The operation of the system when incorporating the above described resistance change is the same as that previously set forth with respect to the system utilizing variable density light filter elements. No further description thereof is, therefore, deemed necessary.

While the invention has been described with reference to a system utilizing means for automatically advancing the tape 19 to the first set of light change perforations 20, a reader may be employed which permits manual alinement of said first perforation set with the reader brushes 24. In such a case, the D.C. pulse circuit 92 would be eliminated.

While certain preferred embodiments of the invention have been described, they are only illustrative in nature, it being understood that numerous modifications in instrumentalities, design, and arrangement of parts are possible within the spirit and scope of the following claims.

We claim:

1. In a photographic film printing machine, means for directing a printing light beam through a developed film to raw film stock therebehind, beam modulating means including a plurality of first relays adapted to be selectively energized to establish different predetermined printing light conditions at the developed film, an energizing circuit for each relay including a second relay having a set of first normally open contacts in series with the respective first relay, each first relay being energized in response to closure of its respective set of contacts by energizing of the respective second relay, intermittently operable, presettable control means for intermittently effecting preselected energizing of said second relays, holding circuits for said first relays including a second set of normally open contacts in each first relay and a third set of normally closed contacts in series with said second sets of contacts, each holding circuit being completed by simultaneous closure of its respective second set of contacts and said third set of contacts, each second relay including a fourth set of normally open contacts which are closed in response to energizing of the respective second relay, and means in circuit with said fourth sets of contacts for momentarily opening said third set of contacts to momentarily break said holding circuits in response to closure of any one of said fourth sets of contacts.

2. In a photographic film printing machine, means for directing a printing light beam through a developed film to raw film stock therebehind, beam modulating means including a plurality of selectively energizable means adapted to be selectively energized to establish different predetermined printing light conditions at the developed film, a first relay for controlling the energizing of each selectively energizable means, each latter means being energized by energizing of its respective relay, a second relay for controlling the energizing of each first relay, each first relay being energized in response to energizing of its respective second relay, selectively operable, presettable control means for intermittently effecting preselected energizing of said second relays, holding circuits for said first relays including a first set of normally open contacts in each first relay which are closed in response to energization of the latter and a second set of normally closed contacts in series with said first sets of contacts, each holding circuit being completed by simultaneous closure of its respective first set of contacts and said second set of contacts, relay means operative in response to each energization thereof to momentarily open said second set of contacts and thereby momentarily break all of said holding circuits, and means including a third set of normally open contacts in each second relay for effecting energizing of said relay means in response to energizing of any one of said second relays.

3. In a photographic film printing machine, means for directing a printing light beam through a developed film to raw film stock therebehind, feed means for feeding said developed film and raw film stock through said beam, selectively energizable beam modulating means adapted to be selectively energized to establish different predetermined printing light conditions at the developed film, a plurality of first relays for controlling the energization of said selectively energizable means, said relays being adapted to be selectively energized to effect selective energization of said selectively energizable means, a second relay associated with each first relay including a first set of contacts in circuit with and for effecting energizing of the respective first relay in response to energizing of the second relay, selectively operable, presettable control means for intermittently effecting preselected energizing of said second relays in synchronism with movement of the developed film through said printing beam, a holding circuit for each first relay including a second set of contacts in each first relay closed by energization of the respective first relay, means including a third set of normally closed contacts in each holding circuit in series with the respective second set of contacts, each holding circuit being completed by simultaneous closure of the second and third sets of contacts therein, means including a fourth set of contacts in each second relay for operating said relay means to momentarily open all of said third set of contacts and thereby momentarily deactivate said holding circuits in response to energizing of any one of said second relays by said control means, and means including a fifth set of contacts in each second relay for deactivating said feed means in response to simultaneous energizing of all of said second relays.

4. The subject matter of claim 3 wherein said presettable control means comprises a control member adapted to be preformed with a series of coded control groups each coded to correspond to a preselected one of said predetermined light conditions, sensing means for individually sensing said control groups, means for intermittently relatively advancing said control member and sensing means past one another to successively align said control groups with said sensing means, and circuit means operatively connecting said sensing means and second relays for selective energization of the latter in accordance

with the coding of each control group to establish the preselected light condition corresponding to each control group.

5. The subject matter of claim 4 wherein said advancing means comprises electrical means operative in response to each energization thereof to cause predetermined relative advancing of said control member and sensing means past one another, pulse circuit means for causing continued intermittent operation of said advancing means to align a first control group with said sensing means, said pulse circuit means comprising an energizing circuit including a sixth set of normally closed contacts in each of said first relays, said sixth set of contacts being connected in series in said latter circuit and said latter circuit being deactivated to deactivate said pulse circuit means and terminate relative advancing of said control member and sensing means in response to opening of any one of said sixth set of contacts by energization of its respective first relay.

6. In a photographic film printing machine, means for directing a printing light beam through a developed film to raw film stock therebehind, beam modulating means including a plurality of relays adapted to be selectively energized to establish different predetermined printing light conditions at the developed film, a control member including a blank leader portion and a trailing portion adapted to be preset with coded control groups each coded to correspond to a preselected printing light condition, a device for sensing the coding of the individual control groups, means connecting said sensing device and relays for selectively energizing the latter to establish the predetermined printing light condition corresponding to the coding of each control group, electrically operated feed means for advancing said control member past said sensing device, all of said relays being retained in one condition of energization when said blank leader portion of the control member is aligned with the sensing device and at least one relay being placed in another condition of energization upon sensing of the first control group by the sensing device, each relay including a set of contacts which occupy one position in said one condition of the respective relay and another position in said other condition of the relay, a circuit having said sets of contacts connected in series therein for energizing said feed means to cause continuous operation of the latter when all of said sets of contacts occupy said one position whereby to continuously advance said leader portion of the control member through the sensing device, said circuit being deactivated to terminate advancing of the control member by operation of at least one set of said contacts to said other position in response to sensing of the first control group, and means for thereafter periodically energizing said feed means to step said control member from one control group to the next.

7. The subject matter of claim 6 including a motor for feeding the developed film and raw film stock through said beam, each relay having a second set of contacts which occupy one position in said one condition of the respective relay and another position in said other condition of the relay, and a circuit having said second sets of contacts connected in series therein for retaining said motor energized when at least one of said second sets of contacts is in said one position thereof and deenergizing said motor when all of said latter sets of contacts are in said other position thereof.

8. In a photographic printing machine, means for directing a printing light beam through a developed film to raw film stock therebehind, a motor for feeding the developed film and raw film stock through the beam, beam modulating means including a plurality of relays adapted to be selectively energized to establish different predetermined printing light conditions at the developed film, a control member adapted to be preset with coded control groups each coded to correspond to a preselected printing light condition, a device for sensing the coding of the individual control groups, means connecting said sensing device and relays for selectively energizing the latter to establish the predetermined printing light condition corresponding to the coding of each control group, means for intermittently advancing said control member past said sensing device to successively align the control groups with the sensing device, an energizing circuit for said motor including a motor relay, and a circuit having a group of contacts of said first-mentioned relays connected in series therein for retaining said motor relay in one condition of energization wherein said motor is energized when at least one of the first-mentioned relays is in a different condition of energization than the remainder of the latter relays and effecting operation of said motor relay to deenergize said motor when all of said first-mentioned relays are in a predetermined condition of energization.

9. In a photographic film printing machine, means for directing a printing light beam through a developed film to raw film stock therebehind, beam modulating means including a plurality of relays adapted to be selectively energized to establish different predetermined printing light conditions at the developed film, a control member including a blank leader portion and a trailing portion adapted to be preset with coded control groups each coded to correspond to a preselected printing light condition, a device for sensing the coding of the individual control groups, means connecting said sensing device and relays for selectively energizing the latter to establish the predetermined printing light condition corresponding to the coding of each control group, solenoid operated feed means for advancing said control member past said sensing device, all of said relays being retained in one condition of energization when said blank leader portion of the control member is aligned with the sensing device and at least one relay being placed in another condition of energization upon sensing of the first control group by the sensing device, each relay including a set of contacts which occupy one position in said one condition of the respective relay and another position in said other condition of the relay, a pulse generating circuit connected to said solenoid operated means and having said sets of contacts connected in series therein for feeding a continuous series of electrical impulses to said solenoid operated means to cause continuous operation of the latter when all of said sets of contacts occupy said one position whereby to continuously advance said leader portion of the control member through the sensing device, said circuit being deactivated to terminate advancing of the control member by operation of at least one set of said contacts to said other position in response to sensing of the first control group, and means for thereafter periodically pulsing said solenoid operated means to step said control member from one control group to the next.

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