

Sept. 13, 1960

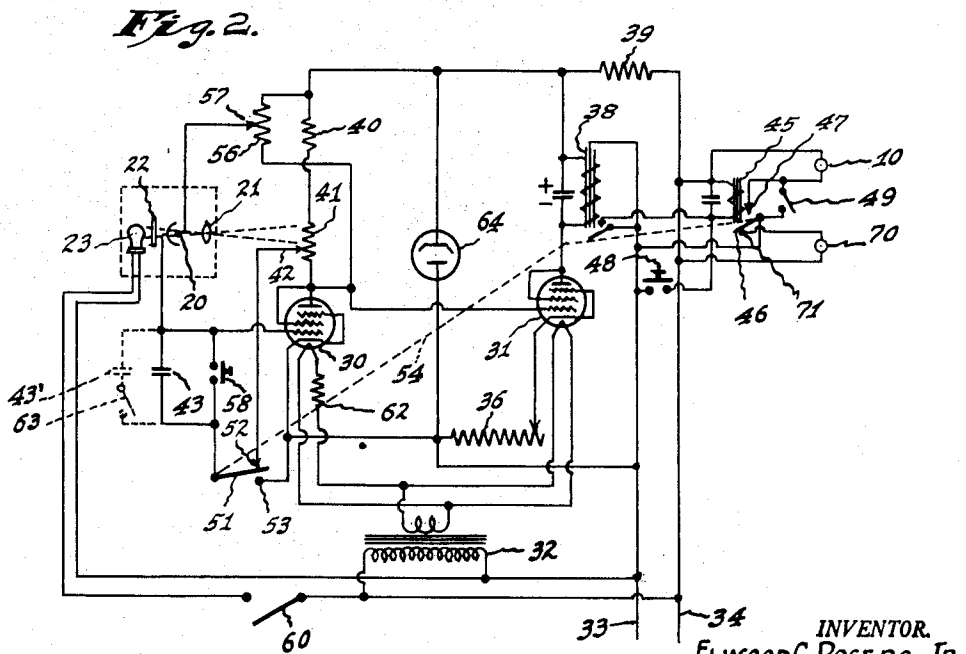
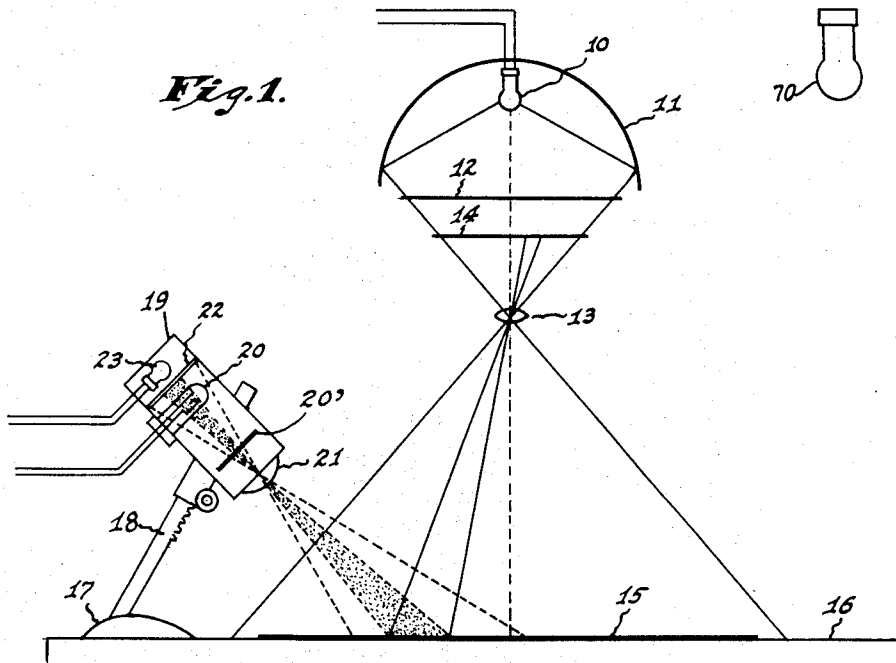
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2,952,780

PHOTOGRAPHIC PRINTING APPARATUS

Filed Jan. 8, 1954

2 Sheets-Sheet 1



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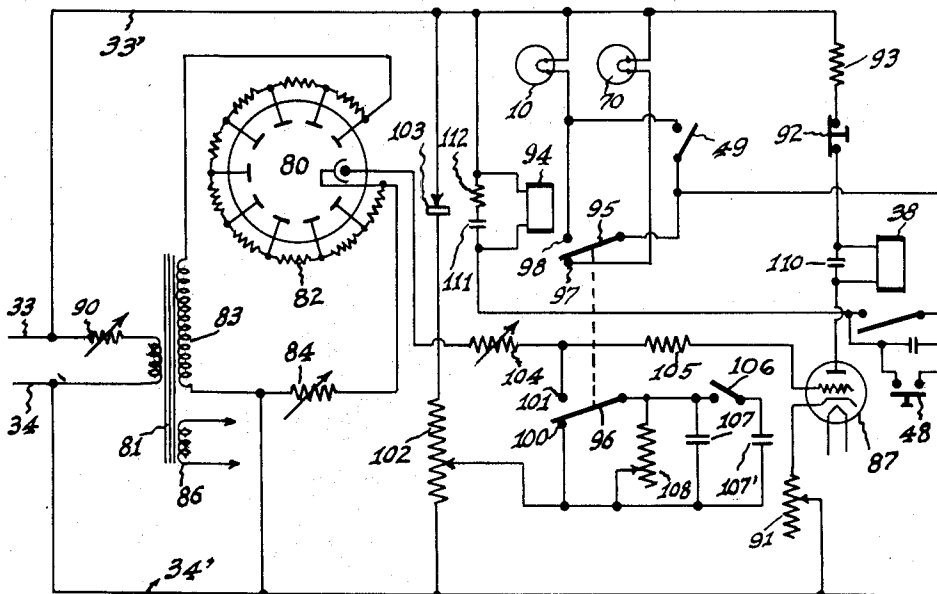
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2 Sheets-Sheet 2

2 Sheets-Sheet 2

Fig. 3.



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2,952,780

PHOTOGRAPHIC PRINTING APPARATUS

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9 Claims. (Cl. 250—214)

This invention relates to methods and apparatus for producing photographic enlargements and more particularly to an automatic means for timing an exposure in accordance with the intensity of the image projected on to the printing paper. Such automatic timing means for photo-enlarging or other photo-printing devices are not broadly new. One form of such means previously used embodies a photoelectric cell or other light-sensitive element which receives light transmitted through the printing paper and which functions to control in one way or another the duration of an exposure. Such a timing means is open to the objection, among others, that it is susceptible to the light-transmitting qualities of localized areas of the printing paper, and such light-transmitting qualities may vary from sheet to sheet or even over the area of a single sheet. Other prior automatic timing means have been open to other objections.

It is an object of my invention to produce an improved method and apparatus for automatically timing photo-printing exposures. More particularly, it is my object to provide an automatic timing method and apparatus which will accurately control the duration of the exposure in proportion to the intensity of the projected image to be printed and which will not be adversely affected by other variables. Another object of my invention is to produce a timing apparatus which can be adjusted to vary the slope of the curve expressing the relationship between image-intensity and exposure-time.

In carrying out my invention, I control the duration of exposure in accordance with the time required to discharge (or charge) a timing condenser over a circuit whose time constant varies with the intensity of the image being printed. The apparatus is adjustable to vary the charge on the condenser in accordance with the printing characteristics of the sensitized paper employed; and such condenser is arranged to discharge (or charge) through a photoelectric cell or other light-responsive element responsive to image-intensity. In the preferred form of the invention, as embodied in an enlarger, the image-intensity is measured by light reflected at a predetermined angle from a selected portion of the image as projected on the printing paper. In association with the timing condenser and the light-responsive element, I provide a means for controlling variation of the time constant of the circuit over which the condenser discharges (or charges), thus making it possible to vary the slope of the curve expressing the relationship between image-intensity and exposure-time.

The accompanying drawings illustrate the invention:

Fig. 1 is an elevational view, somewhat diagrammatic in character, illustrating a photographic enlarger and, in association therewith, a light-responsive device embodying my invention;

Fig. 2 is a diagrammatic view illustrating a timing circuit in which the duration of the exposure is controlled by the time required to discharge a condenser; and

Fig. 3 is a diagram of another form of timing circuit

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in which the duration of exposure is controlled by the time required to charge a condenser.

The enlarging apparatus illustrated in Fig. 1 comprises a projection lamp 10, a condensing reflector 11 therefor, a corrective light-diffusing screen 12, and a projecting lens 13. The negative 14 to be enlarged is supported in a suitable support between the diffuser 12 and the lens 13 so that an enlarged image will be projected onto the surface of a sheet of sensitized paper 15 on an appropriate support 16. The parts described, or their equivalents, are common to all photographic enlargers and may be varied without departing from my invention.

The preferred light-responsive device employed in practicing my invention comprises a base 17 adapted to rest on the support 16 and provided with a stem 18 which projects upwardly, conveniently at an angle to the vertical. Adjustably mounted on the stem 18 is a housing 19 containing a photo-electric cell 20 mounted on the axis of a condensing lens 21. Behind the photoelectric cell 20 is a ground-glass screen 22 or its equivalent, and behind the screen 22 there is mounted a lamp 23. The angular disposition of the housing 19 is such that light reflected from the surface of the sensitized paper 15 will be concentrated by the lens 21 on the cathode of the photo-electric cell 20. Desirably, the stem 18 and housing 19 are so arranged that while the housing can be adjusted along the stem 18 its angular disposition relative to the surface on which the base 17 rests will remain a constant.

In the use of the light-responsive device, a focused image of the negative 14 is projected onto the surface of the paper-support 16 or onto the surface of an unsensitized white paper on such support. With the lamp 23 turned on, the light-responsive device is moved around the periphery of the image, and the casing 19 is adjusted on the stem 18, until the image of the cathode of the photoelectric cell 20 covers an area which is regarded as representative in tone quality. This area, the selection of which rests with the operator, is preferably a medium gray. Depending on the character of the image on the negative 14, the area may be of uniform tone throughout or may be made up of properly balanced light and dark portions. If desired, the lamp 23 and its housing may be omitted and the position of the light-responsive device selected by the location of the cathode-shadow with respect to the image appearing on the ground-glass 22. In either arrangement, the desideratum is that the light condensed by the lens 21 on the cathode of the photo-electric cell 20 comes from an area of predetermined average tone quality in the image projected by the lens 13 of the enlarger. It is also desirable that in any one apparatus the axis of the light-responsive device be at a fixed angle to the surface of the support 16; for the intensity of light reflected from the surface of the sensitized paper will depend upon the angle of reflection.

The light-responsive unit above described is employed to control the operation of a timing circuit such as is illustrated in Fig. 2 or Fig. 3. The circuit of Fig. 2 comprises a pair of electron discharge devices, such as the pentodes 30 and 31, the cathode heating filaments of which are supplied with current from a step-down transformer 32 the primary of which is connected across an alternating-current supply line 33—34, conveniently providing the common 110-volt, 60-cycle current. One of the supply conductors, shown as the conductor 33, is directly connected to the cathode of the pentode 30 and connected to the cathode of the pentode 31 through a variable resistance 36. The anode or plate of the pentode 31 is connected to the other supply conductor 34 through the winding of a normally open holding relay 38 and a fixed resistance 39. The plate of the pentode 30 is connected to the conductor 34 through the resistance 39, a second fixed resistance 40, and a potentiometer 41

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having an adjustable tap 42. The control grid of the pentode 31 is directly connected to the plate of the pentode 30, while the control grid of the pentode 30 is connected to one terminal of a timing condenser 43.

The projecting lamp 10 is under the control of a relay 45 having a movable contact 46 and a fixed contact 47 separated from each other when the relay is de-energized. One terminal of the winding of the relay 45 is connected to the supply conductor 34, while the other terminal is connected to the supply conductor 33 through the normally separated contacts of the holding relay 38 and also through a normally open, push-button switch 48 in parallel with the contacts of the relay 38. To permit use of the projecting lamp 10 for set-up purposes, a manually controlled switch 49 may be connected in parallel with the contacts 46 and 47 of the relay 45.

As previously indicated, one terminal of the timing condenser 43 is connected to the control grid of the pentode 30. The other terminal of such condenser is connected to the movable contact 51 of a single-pole, double-throw switch the two stationary contacts 52 and 53 of which are connected respectively to the tap 42 of the potentiometer 41 and to the cathode of the pentode 30. The dotted line 54 in Fig. 2 indicates a mechanical interconnection between the movable contact 51 and the movable contact 46 of the relay 45, the arrangement being such that the movable contact 51 engages the fixed contact 52 when the relay 45 is de-energized and engages the fixed contact 53 when the relay 45 is energized.

Connected in parallel across the resistances 40 and 41 is a potentiometer 56 having an adjustable tap 57 connected to the anode of the photoelectric cell 20. The cathode of the photoelectric cell is connected to the control grid of the pentode 30. For a purpose which will hereinafter become apparent, a manual, normally open push-button switch 58 is connected across the terminals of the timing condenser 43.

The lamp 23 associated with the light-responsive element is shown in Fig. 2 as connected to the supply conductors 33 and 34 through a switch 60. The projecting lamp 10 is connected to the supply wires 33 and 34 through the parallel switches 46—47 and 49.

The parts are illustrated in Fig. 2 in the condition existing during the interval between exposures. In this condition, the relays 45 and 38 are de-energized, and the movable contact 51 is in engagement with the fixed contact 52 to connect the condenser 43 between the grid of the pentode 30 and the adjustable tap 42 of the potentiometer 41. Since the plates of both pentodes are connected to the same supply conductor 34 both pentodes will be non-conductive during one-half of each cycle of the supply current; and so far as operation of the pentodes is concerned, they may therefore be regarded as subjected to a direct-current plate voltage. The pentode 30 will be conducting, depressing the potential of its plate and that of the grid of pentode 31. The resistance 36 is great enough to insure that the grid of pentode 31 will possess a negative bias great enough to render that tube non-conductive, and thus maintain the relay 38 de-energized as long as the tube 30 is conductive.

It will be clear from Fig. 2 that in the condition there illustrated the potential difference between the control grid of the pentode 30 and the tap 42 of the potentiometer 41 will be applied across the timing condenser 43 to impart a charge thereto and that the potential to which the timing condenser is charged will depend upon the position of the tap 42. Assuming that the apparatus has been adjusted to take account of the printing qualities of the paper being employed, that the light-responsive device 20—21 has been properly positioned, and that everything is in readiness for the making of an enlargement, printing operation is started by closing the push-button switch 48. This operation completes a circuit through the winding of the relay 45, closes the switch 46—47, and causes the projecting lamp 10 to light. Energization of the relay

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45 also moves the movable contact 51 from engagement with the contact 52 into engagement with the contact 53. Such movement of the contact 51 connects the timing condenser 43 between the cathode and grid of the pentode 30 in such a way that the grid is negatively biased and the pentode 30 thereby rendered non-conductive. This causes an immediate rise in the potential of the plate of the pentode 30 and of the grid of the pentode 31. The pentode 31 thereupon becomes conductive, and the resultant current flowing through the relay 38 causes the contacts of such relay to close and make it possible for the operator to release the push-button switch 48 in parallel with such contacts, the relay 45 remaining energized and the projecting lamp 10 in operation. The condenser 43 now discharges through the photoelectric cell at a rate dependent upon the amount of light received by such cell; and as the condenser discharges, the negative bias of the grid of the pentode 30 decreases. Eventually, such bias becomes small enough to render the pentode 30 conductive, whereupon the potential of its plate and of the grid of the pentode 31 decreases, the pentode 31 becomes non-conductive, the relay 38 is de-energized to de-energize the relay 45, and the contacts 46 and 47 of the latter relay separate to extinguish the projecting lamp 10 and terminate the printing operation.

The position of the tap 42 along the resistance 41 determines the charge impressed on the timing condenser 43 during intervals between exposures, and the tap 42 may therefore be adjusted to suit the speed of the sensitized paper being used in the production of enlargements. In order to prevent the charge impressed on the condenser 43 during one setting of the tap 42 from influencing operation of the device after readjustment of such tap, the push-button switch 58 is momentarily closed to discharge the condenser 43 after each tap-readjustment.

It will be noted that the potentiometer 56 forms part of a circuit which includes the timing condenser 43 and photoelectric cell 20 and which is in parallel with the pentode 30. During a timed exposure, the voltage drop across this potentiometer will be slowly increasing as the condenser 43 discharges, the rate of change in such voltage drop depending upon the intensity of light striking the photoelectric cell and upon the setting of the tap 57. As a result, the positive potential applied to the anode of the photoelectric cell will be decreasing and will reduce the time constant of the circuit over which the condenser discharges. Obviously, the rate at which such time constant varies will depend upon the setting of the tap 57. Specifically, the rate of change of the potential applied to the anode of the photoelectric cell will increase as the tap 57 is moved toward that terminal of the resistance 56 which is connected to the plate of pentode 30. The greater the change in potential applied to the anode of the photoelectric cell, the longer will be the long exposures as compared with the short exposures, and vice versa. Hence, the potentiometer 56 enables the operator to control the slope of the curve representing the relation between light-intensity and exposure-time and thus compensate for such variables as grid current, condenser leakage, wiring leakage, and gas currents in the photoelectric cell and in the pentode 30.

The variable resistance 36 controls the cathode-potential, and hence the effective grid-potential, of the pentode 31. Its adjustment provides large current and voltage changes for the pentode 31 and can be employed to effect large changes in light-time values by shifting the operating characteristics of the circuit.

Desirably, the heating-filament circuit of the pentode 30 includes a resistance 62 which maintains filament heat, and thus grid and gas currents in the pentode 30, at a low value so as to reduce the magnitude of the factors compensated for by adjustment of the potentiometer 56.

To increase the range of adjustment, it may be desir-

able in some instances to vary the capacity of the timing condenser. To this end, a second condenser 43' may be connected in parallel with the condenser 43 through a switch 63 which can be closed or opened as necessary to increase or decrease the effective capacity of the timing condenser. If the voltage across the supply conductors 33 and 34 is subject to variation, it is desirable to employ a voltage-regulator tube 64 connected across such conductors. The degree of voltage provided by the tube 64 is controlled by the valve of the resistance 39.

It is common in photo-enlarging work to employ a so called "safe light" which projects light of a wave length which is visible but to which printing papers are not responsive. In ordinary work, such a safe light can be left on during a printing operation. With apparatus embodying my invention, however, it is advisable to extinguish the safe light during a printing operation because, although the sensitized paper may not be affected by the wave lengths it emits, the photoelectric cell 20 might be. Automatic control of the safe light may be conveniently effected through the expedient illustrated in Fig. 2, where a safe light 70 is shown as connected to the supply conductors 33 and 34 through a switch comprising the movable contact 46 of the relay 47 and a fixed contact 71 which such movable contact engages when the relay 45 is de-energized. With this arrangement, when the relay is energized to institute a printing operation, the safe light is automatically turned out as a result of operation of the contacts 46 and 71.

To set the device up for operation, a negative is positioned in the enlarger, the projection lamp turned on by closing the manual switch 49, and the enlarger is adjusted to project onto the surface of the support 16 a focused image of the desired size. The light-responsive control device is then positioned with respect to the image in the manner above described so that reflected light from an image-portion of the predetermined tone quality will be projected onto the cathode of the photoelectric cell 20. If the tap 42 of the potentiometer 41 is not properly adjusted for the speed of the printing paper to be used, its adjustment is appropriately changed and the push-button switch 58 momentarily closed to discharge the condenser 43 and thus insure that when recharged its potential will correspond to the new setting of the tap 42. With the manual switch 49 to extinguish the projecting lamp, the apparatus is in condition for the making of an exposure. With the aid of illumination provided by the safe light, which is connected to the supply conductors 33 and 34 through the interengaged contacts 46 and 71, the operator positions the printing paper on the support 16 and momentarily closes the push-button switch 48 whereupon the apparatus operates automatically to extinguish the safe light 70 and initiate an exposure by turning on the projection lamp 10. Upon termination of the exposure period, marked by the de-energization of the relays 38 and 45 as above set forth, the projection lamp 10 is extinguished and the safe light 70 again turned on.

In making a plurality of enlargements from a single negative, no further adjustment of the apparatus is required. It is only necessary to remove the exposed paper, position the new sheet, and again close momentarily the push-button switch 48. The minimum possible interval between exposures is much greater than that necessary to charge the condenser 43 fully. A change in negatives will ordinarily require a change in the positioning of the light-responsive control device, and a change in paper used may require a re-adjustment of the tap 42.

The only movable parts of the timing circuit which need be exposed for ordinary manual manipulation are a control for the tap 42 and the operating members of the push-button switches 48 and 58. The adjustments for the variable resistances 36 and 56 need not be, and desirably are not, readily accessible; for those adjustments

need be made only at infrequent intervals, as to compensate for aging of the tubes.

I am aware that it is old to time intervals by the discharge of a condenser associated with an electron discharge device, such as the pentode 30. In many of such prior devices, however, it is necessary to perform some manual operation, such as the opening of a switch, after the termination of the automatically timed interval in order to prevent the condenser from recharging and automatically instituting a new operation. When such a device is used to control a printing exposure, adventitious recharging of the condenser would result in a re-exposure which might be highly undesirable. No such adventitious re-exposure can occur in the use of my device; since the operation of the switch 51 and the control of an automatically timed interval prevents the recharging of the condenser from instituting a new operation.

While the apparatus above described is primarily suited for the timing of exposures in photo-enlarging, the circuit illustrated in Fig. 2 can be used in other situations, as the source of light which controls the photoelectric cell 20 is immaterial. It will also be understood that while I have illustrated in Fig. 2 a circuit specifically adapted for connection to an alternating-current supply the apparatus can be adapted, by obvious changes, for use with a direct-current supply.

In the timing circuit illustrated in Fig. 3, the simple photo-electric cell 20 has been replaced by a photo-multiplier 80. Further, the circuit is such that the duration of the exposure-interval is controlled by the time required to charge the timing condenser to a predetermined value rather than by the time required to discharge it.

Voltage for the photo-multiplier 80 is supplied by a step-up transformer 81, the voltage-divider 82 of the tube 80 being connected across the secondary 83 of the transformer 81 in series with a variable resistance 84 in such a manner that the resistance 84 will control the voltage across the last stage of the cell 80. In addition to the secondary 83, the transformer 81 may include a low-voltage secondary winding 86 providing current for the filament of an electron-discharge tube 87. To avoid undue complication of the drawing the connection of the winding 86 and such tube-filament is not illustrated.

The primary of transformer 81 is connected across the ordinary 110 volt supply line 33, 34 preferably through a variable resistor 90. The cathode of tube 87 is connected to an extension 34' of the supply line 34 through a variable resistance 91 which controls the effective plate-voltage of tube 87. The anode of tube 87 is connected to an extension 33' of the supply line 33 through the winding of the relay 38, a normally closed switch 92, and a resistor 93, the latter serving as a power resistor to eliminate excessive line surges on relay 38. The contacts of relay 38 are normally open and are connected in series with the winding of a second relay 94 between the conductors 33' and 34', so that energization of the relay 38 will effect energization of the relay 94.

The relay 94 has two movable contacts 95 and 96. The contact 95, which is connected to the conductor 34', engages a fixed contact 97 when the relay 94 is de-energized and a fixed contact 98 when such relay is energized. The contact 97 is connected through the safe-light 70 with the conductor 33' while the contact 98 is connected through the enlarger lamp 10 with that same conductor. As will be obvious from the arrangement of relay contacts just described, the safe light 70 will be lit and the enlarger lamp 10 out when the relay 94 is de-energized, while the enlarger lamp 10 will be lit and the safe light out when the relay is energized.

Co-operating with the second movable contact 96 of the relay 94 are two fixed contacts 100 and 101, the former engaged by the movable contact 96 when the relay 94 is de-energized and the latter engaged by such movable contact when the relay is energized. The fixed con-

tact 100 is connected to the adjustable tap of a potentiometer 102 which is connected in series with a rectifier 103 between the conductors 33' and 34', the rectifier being arranged to pass current from the conductor 33' to the conductor 34'. The stationary contact 101 is connected through a variable resistance 104 to the anode of the photo-multiplier tube 80 and through a resistor 105 to the control element of the tube 87. The resistor 105 is included in the lead to the control element of tube 87 as a precaution to prevent excessive grid current in the timing circuit.

A timing condenser 107 is connected between the relay contacts 96 and 100 in parallel with a variable resistance 108. One or more auxiliary timing condensers 107' adapted for selective connection, as through one or more switches 106, in parallel with the condenser 107 may be provided to increase the range of timing intervals which the apparatus provides.

In addition to the main elements so far identified, the circuit of Fig. 3 desirably includes certain additional elements designed to improve or facilitate operation. These additional elements include a condenser 110 connected across the winding of relay 38 to reduce pulsations in the half-cycle rectified plate current of tube 87 whereby to keep relay 38 from chattering. A condenser 111 and a resistance 112 connected in series with each other across the winding of the relay 94 are balanced to reduce arcing at the contacts of relay 38 due to inductive kicks from the winding of the 110-volt relay 94. The manually operable switch 49, which can be closed to provide for the supply of current to the enlarger lamp 10 for purposes of focusing, is connected across the relay contacts 95 and 98. A normally open initiating switch 48 is connected in parallel with the normally open contacts of relay 38.

The circuit illustrated in Fig. 3 operates as follows: Normally, the relays and switches are in the respective conditions illustrated in the figure. The relay contacts 95 and 97 are in engagement, thus causing current to be supplied to the safe light 70, while the circuit through the enlarger lamp 10 is open at 98—95. The relay contact 96 is in engagement with the fixed contact 100, thus short-circuiting the timing capacity 107 and insuring that there will be no voltage across such capacity upon the initiation of an exposure. Enough dark current will flow in the tube 80 to maintain on the control element of tube 87 a negative bias sufficient to insure de-energization of the relay 38.

For the purpose of focusing the enlarger, the switch 49 is closed, thus causing current to be supplied to the enlarger lamp 10. At the same time, and as set forth in connection with the circuit shown in Fig. 2, the light-responsive unit is positioned to be responsive to light reflected from the selected portion of the image projected by the enlarger. The enlarger having been properly focused and the light responsive unit properly adjusted, the switch 49 is opened to turn out the enlarger lamp 10, the printing paper is arranged on the easel of the enlarger, and the switch 48 is momentarily closed to complete a circuit from the conductor 34' through the winding of relay 94 to the conductor 33'. The resultant energization of the relay 94 moves the contact 95 to turn off the safe light 70 and turn on the enlarger lamp 10. Concurrent movement of the movable relay contact 96 connects the timing capacity 107, through the variable resistance 104, between the anode of tube 80 and the adjustable tap of the potentiometer 102. Because of the rectifier 103, the adjustable tap of the potentiometer 102 will be positive with respect to the cathode of tube 87, and since there is no initial charge on the condenser 107, engagement of the contact 101 by the contact 96 will place an effective positive potential on the control element of tube 87, thus rendering such tube conductive and causing the relay 38 to be energized. Resultant closure of the relay contacts 38 will complete a connection between the conductor 34'

and the winding of relay 94, so that upon subsequent opening of the switch 48 relay 94 will remain energized. Current flowing in the photo-multiplier tube 80 will gradually charge the condenser 107, tending to make the control element of the tube 87 negative with respect to the adjustable tap of potentiometer 102. Eventually, the negative potential across condenser 107 will rise to such a value that the tube 87 becomes non-conductive. When this happens, the relay 38 will be de-energized, thus opening the circuit through the relay 94. The resultant de-energization of the relay 94 extinguishes the enlarger lamp 10, lights the safe light 70, and discharges the timing condenser 107. An exposure can be terminated at any time merely by a momentary opening of switch 92, thus causing de-energization of the relay 38 in the manner effected at the end of a timed interval.

There is a wide variation in the speeds of papers used in photographic enlarging. Control of the device shown in Fig. 3 to accommodate for relatively minor variations in paper speed will in most cases be effected by adjustment of the potentiometer 102. The farther the tap of that potentiometer is from conductor 34', the greater will be the positive bias impressed on the grid of tube 87 at the start of the timing cycle and the greater will be the charge which must be built up on the timing condenser to render tube 87 non-conductive. Accordingly, adjustment of the top of potentiometer 102 away from conductor 34' will increase the exposure interval and adjustment toward such conductor will shorten the exposure, the intensity of the image projected on the paper remaining the same. For wider variations in paper speed, the timing capacity may be varied by adding or subtracting supplementary condensers 107'.

It is sometimes desirable to provide a stop, such as an iris diaphragm (not shown), in association with the lens 21 of the light-sensitive unit in order to vary the selectivity of that portion of the projected picture which is being used as a control area. Stopping the lens 21 will obviously reduce the light incident on the photo multiplier cell, which would increase the duration of the automatically timed exposure interval; but by increasing the magnitude of the timing capacity 107, 107' in an amount coordinated with the stopping of the lens, the exposure interval can be kept constant.

Variations between different photocells 80, or variation in the performance of any one cell with aging, may require adjustments other than those mentioned above as for the purpose of accommodating for variations in paper speed or in the aperture of lens 21. Such adjustments are provided by the variable resistor 90 in the primary circuit of transformer 81, by the resistor 84 which is connected across the final stage of the photocell 80, by the resistor 104 in the lead to the anode of the photocell, and by the resistor 108 in parallel with the timing capacity. Primarily, these variable resistors alter the slope of the light-time curve characteristic of the device. Thus, by increasing the resistance of the resistor 90, it is possible to reduce the voltage applied to the photocell and thereby to reduce its multiplying factor. The resistance 104 has a greater proportionate effect when strong light is striking the cell 80 than when the light striking such cell is weak. The resistance 108 provides a leakage path for the current which charges the timing capacity. This resistance permits a substantially constant leakage current, and hence affects the long exposures proportionately more than it does the short exposures. Varying the value of the resistance 84, by varying the potential across the last stage of the cell 80, likewise affects the long exposures more than it does the short ones. By appropriate adjustment of the several resistances mentioned, or any of them, it is possible to so set the device that the light received by the cell 80 will be an effective measure of the proper exposure interval.

With both of the circuits shown in Figs. 2 and 3 it is contemplated that the safe light 70 will be extinguished

during exposure. Some operators may desire to leave the safe light on at all times, as by connecting it to the conductor 34' independently of the relay contacts 95, 97. The most commonly used safe light for use with enlargers is yellow in color; and since photocells, as a general rule, are relatively more sensitive to yellow light than are printing papers, the duration of the exposure will be shortened if the safe light is left on during the operation. To prevent the safe light from thus affecting exposure duration, I may provide in association with the photocell a blue filter 20' (Fig. 1) to prevent reflected light from the safe light from impinging on the cell and shortening the exposure.

By way of illustration and not limitation, I set forth below specifications for the more important components of the circuit shown in Fig. 3, it being assumed that the supply is the customary 110-volt, 60-cycle supply:

Photomultiplier 80	Type 931-A.
Transformer 81	Plate-type power transformer, 650 volt, 40 milliamperes.
Voltage divider 82	Nine segments, 0.47 megohms each.
Resistor 84	0-5 megohms.
Tube 87	6J5.
Resistor 90	0-1000 ohms.
Resistor 91	0-1000 ohms.
Resistor 93	1000 ohms.
Resistor 102	50,000 ohms.
Rectifier 103	35 milliamperes.
Resistor 104	0-10 megohms.
Resistor 105	1.0 megohm.
Condensers 107, 107'	To provide incremental capacities from 0.1-4.0 mfd.
Resistor 108	0-200 megohms.
Condenser 110	20 mfd.
Condenser 111	1.0 mfd.
Resistor 112	600 ohms.
Relay 38	Plate-type, 2500 ohms.

This application is a continuation-in-part of my prior application Serial No. 83,897 filed March 28, 1949, now Patent No. 2,668,474, granted February 9, 1954, in which certain features of the described apparatus are claimed.

I claim as my invention:

1. In a device for automatically terminating a photographic exposure, an electron discharge device having a control element and an associated anode circuit current-flow in which is controlled by the potential of said control element, a first relay in said anode circuit having normally open contacts, a second relay, a holding circuit including the contacts of said first relay and the winding of said second relay whereby de-energization of the first relay will cause de-energization of the second relay, timing means for controlling the potential of said control element, said timing means comprising a timing circuit including a condenser and a light-responsive means for varying current in the timing circuit and coordinately varying the rate at which the potential of said control element decreases, and means operative upon de-energization of said second relay for terminating an exposure.

2. A device as set forth in claim 1 with the addition that said condenser is connected to said control element whereby the potential of the control element will be determined by the charge in the condenser.

3. A device as set forth in claim 1 with the addition of a second electron discharge device having an anode connected to the control element of the first electron discharge device and a control element connected to said condenser so that as the charge on said condenser decreases anode current in the second electron discharge device will decrease to cause an increase in the potential of the control element of the first electron discharge de-

vice, and means for preliminarily imposing a charge of predetermined magnitude on said condenser.

4. In a device for automatically terminating a photographic exposure, an electron discharge device having a control element, a cathode, and an associated anode circuit current-flow in which is controlled by the potential of said control element, a timing condenser connected between said cathode and control element whereby the potential of the control element will be proportional to the charge on the condenser, a condenser-charging circuit, light-responsive means in said condenser-charging circuit for varying the rate of condenser-charging, exposure-terminating means in said anode circuit, and a variable resistance in parallel with said condenser for bleeding off a controlled portion of condenser-charging current during the exposure interval.

5. In a device for automatically terminating a photographic exposure, an electron discharge device having a control element, a cathode, and an associated anode circuit current-flow in which is controlled by the potential of said control element, a timing condenser connected between said cathode and control element whereby the potential of the control element will be proportional to the charge on the condenser, a condenser-charging circuit, light-responsive means in said condenser-charging circuit for varying the rate of condenser-charging, exposure-terminating means in said anode circuit, and a variable resistance in series with said condenser and light-responsive means for regulating the condenser-charging current during the exposure interval.

6. In a device for automatically terminating a photographic exposure, an electron discharge device having a control element, a cathode, and an associated anode circuit current-flow in which is controlled by the potential of said control element, a timing condenser connected between said cathode and control element and chargeable to increase negative bias on said control element, a condenser-charging circuit, a photoelectric cell in said condenser-charging circuit for varying the rate of condenser-charging, exposure-terminating means in said anode circuit, and adjustable voltage-regulating means for varying the response of said photoelectric cell.

7. The invention of claim 6 with the addition that said photoelectric cell is a photomultiplier having a plurality of stages, said regulating means being associated with and effective upon only the last stage of said photomultiplier.

8. In a device for automatically terminating a photographic exposure, an electron discharge device having a control element, a cathode, and an associated anode circuit current-flow in which is controlled by the potential of said control element, a timing condenser connected between said cathode and control element and chargeable to increase negative bias on said control element, a condenser-charging circuit, a photomultiplier in said condenser-charging circuit for varying the rate of condenser-charging, exposure-terminating means in said anode circuit, and adjustable means for varying the affect of said photomultiplier upon the charging of the condenser.

9. Apparatus for use in a region illuminated by a colored safe light, comprising a photographic enlarger having a light-source and adapted to project an image for printing on a sensitized surface, automatic timing means, exposure-terminating means controlled by said timing means, said timing means including a light-responsive element positioned to receive light from said projected image and operative to vary the duration of the exposure inversely with respect to the intensity of the light it receives, and a light filter positioned in association with said light-responsive element to intercept all light falling thereon, said filter having a color complementary to that of said safe light whereby it will prevent light from the safe light from affecting said light-responsive element but

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will permit light of its own color received from said projected image to fall upon the light-responsive element.

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