

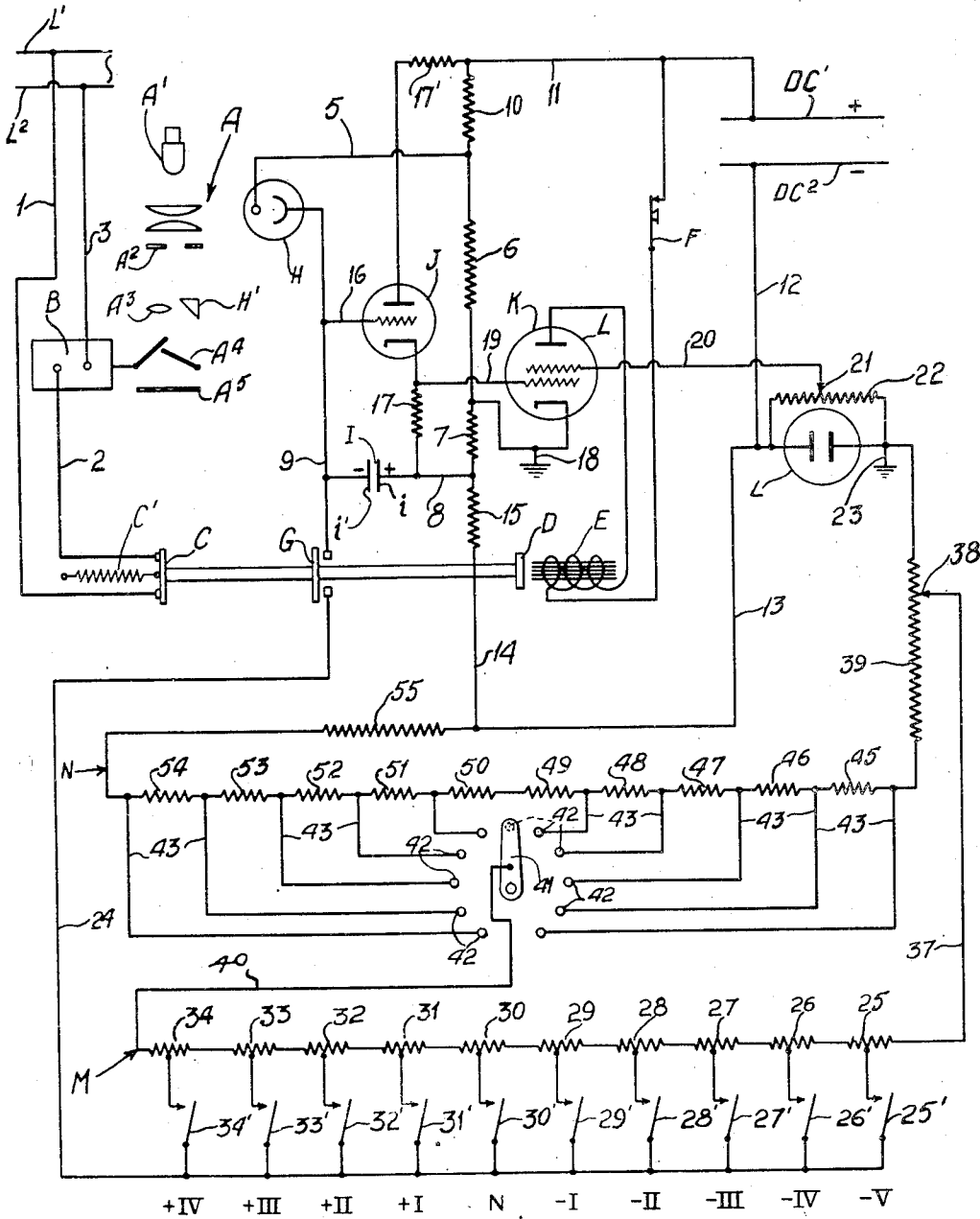
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EXPOSURE TIMING MECHANISM

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EXPOSURE TIMING MECHANISM

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The present invention relates to timing mechanisms of projection printers, used to control the exposure period in the photographic reproduction of a transparent picture by passing printing light through the picture to light sensitive paper or film material on which the picture is reproduced. In the operation of a projection printer of the above-mentioned type, the duration of the exposure period required for optimum results in printing a picture with light of standard intensity, depends primarily on three factors; namely, on the character of the light sensitive material and particularly on the sensitivity or speed of the light sensitive emulsion coating of said material, on the average density of the negative or other transparency bearing the picture reproduced, and on differences between the densities of different portions of the picture. Thus, for example, if some portion of the picture, such as a child's face, is of special interest, the exposure period should be longer when that portion of the picture is relatively dense than when it is relatively transparent, even though the average density of the picture is the same in each case.

A primary object of the present invention is to provide improvements in an automatic timing mechanism for projection printers of the type disclosed in an article by J. Robins and L. E. Varden, printed in the June, 1946, issue of the periodical "Electronics." That timing mechanism includes means for projecting light from the source of printing light through a transparent picture being reproduced to a photocell to thereby produce a photocell current of a magnitude which depends on the average density of the transparent picture and which is used to discharge a timing condenser previously given a regulated charge. Since the photocell current is a function of the intensity of the light received by the photocell, the time required to discharge a condenser charge of given magnitude varies with variations in the average density of the picture being reproduced.

In timing mechanisms of the above-mentioned type heretofore used, the corrective changes in the exposure period to compensate for variations in the sensitivity or speed of the photographic material emulsion and for differences between the average density of the transparent picture reproduced and the density of the portion of that picture which is of special interest, are effected by adjusting the condenser charging circuit to thereby vary the charge put on the timing condenser.

The major object of the present invention is to provide timing mechanisms of the above-mentioned type with improved means for selecting or regulating the charges put on the timing condenser. In accordance with the present invention, the regulable condenser charging means includes two voltage dividers, each of which com-

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prises a plurality of resistor elements permanently connected in series. One of said voltage dividers is connected across a source of constant voltage, and the other voltage divider is connected in shunt to a variable portion of the other voltage divider. In prior timing mechanisms of the above-mentioned type, the compensating variations made in the charges put on the timing condenser, were effected by adjustments of a single voltage divider connected across a source of constant voltage, and the adjustments made included the operative connection in and removal from the voltage divider of a plurality of resistor sections, with a corresponding change in the voltage drop across each resistor section operatively retained in the voltage divider. In the practical use of the prior timing mechanisms to obtain a sufficient range of variation in the exposure period it was found necessary to operatively add to and eliminate from the voltage divider carbon resistors having resistance values which were much higher than any suggested in the above-mentioned "Electronics" article, and too high to permit those resistors to be wire wound variable resistors.

The improvement gives important practical advantages. In particular, it permits the use of individual resistor elements having resistance values small enough so that each such element may be a wire wound resistor and hence have a stability and life length not obtainable when the resistances of the individual resistors are so high that it is practically necessary that the latter be made of carbon. The invention also permits of a wider range of variation in the condenser charge and hence in the exposure period than is practically possible with the prior arrangement. Furthermore, the improved arrangement permits compensating adjustments of the condenser charges to be made in a suitable multiplicity of predetermined steps, the relative operative effects of which are not significantly varied by the corrective adjustment made necessary by variations in the emulsion characteristics of the photographic material on which the pictures are printed.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages, and specific objects attained with its use, reference should be had to the accompanying drawing and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

The one figure of the drawing is a diagram illustrating a preferred embodiment of the present invention.

The apparatus diagrammatically illustrated in the drawings, comprises means for automatically

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controlling the duration of the exposure periods of a projection printer A. The latter as diagrammatically illustrated, comprises a source of printing light A' which ordinarily is a tungsten filament lamp, a support A² for transparency to be reproduced, an objective lens A³, a shutter A⁴, and a support A⁵ for photographic material on which a transparent picture positioned by the support A² may be reproduced by light transmitted through the picture and the lens from the lamp A' to the photographic material on the support A⁵, when the shutter A⁴ is open. The shutter A⁴ is opened and closed by shutter operating mechanism B when an energizing circuit for the latter is opened and closed by the adjustment of a switch member C between open and closed positions.

The energizing circuit closed when the switch member C is in its closed position comprises a conductor 1 connecting a stationary switch contact to a supply conductor L', and a conductor 2 connecting a second stationary switch contact to one terminal of the shutter operating mechanism B. The second terminal of the device B is connected by the conductor 3 to a supply conductor L². The conductors L' and L² may supply alternating current of ordinary voltage and frequency. For example, 110-115 volts and 60 cycles per second. The stationary switch contacts to which the conductors 1 and 2 are connected, are bridged by the switch member C when the latter is in its closed position. The switch member C is biased to its closed position as by means of a spring C' but is connected to a relay armature D which cooperates with the relay winding E to hold the switch member C in its open position when said winding is energized. The winding E is normally energized as hereinafter explained, but may be deenergized to initiate an exposure period by the momentary opening of a normally closed switch F. A second switch member G shown as rigidly connected to the switch member C and relay armature D controls the condenser charging circuit, as herein described. As the switch member C is adjusted between its closed and open positions, the switch G is respectively adjusted between its open and closed positions and thereby opens and closes the condenser charging circuit.

As diagrammatically illustrated, a prism H' passes some of the light transmitted through the picture on the support A² to the cathode of a photocell H and makes the latter conductive. When the deenergization of the relay winding E causes the switch G to be moved into its open position, the photocell H initiates a current flow through a condenser discharging circuit and thereby effects the removal of all but a predetermined portion of the charge which the timing condenser I had previously acquired in a manner hereinafter described. The condenser discharging circuit comprises a conductor 5 connecting the anode of the photocell H to one end of a resistor 6, and a resistor 7 which connects the second end of the resistor 6 to one end of a conductor 8. The other end of the conductor 8 is connected to the terminal or plate *i* of the condenser I. The second terminal or plate *i'* of the condenser I, is connected by a conductor 9 to the cathode of the photocell H. The resistors 6 and 7 form part of a voltage divider, the junction of the conductor 5 and resistor 6 being connected through a resistor 10 and conductor 11 to the positive supply conductor DC' of a direct current distribution system. The neg-

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ative terminal DC² of said distribution system is connected through conductors 12, 13 and 14 and a resistor 15 to the junction of the resistor 7 and conductor 8. The voltage across the resistors 6 and 7 due to their connection to the D. C. supply conductors DC' and DC², causes a current flow in the condenser discharging circuit when the photocell H is made conductive by the light passing to it and the switch G is open.

The direction of the condenser discharging current flow is from the cathode of the photocell H to the condenser plate or terminal *i'*, and from the second condenser terminal or plate *i* through the conductor 8, resistors 7 and 6 and conductor 5 in the order stated, to the anode of the photocell. As hereinafter explained, the charge previously acquired by the condenser I when the switch G is closed, makes the condenser plate or terminal *i* positive relative to the plate or terminal *i'*. The condenser discharging current continues to flow until a predetermined portion of the original condenser charge is eliminated. The portion of the condenser charge thus eliminated is that required to make an electronic valve J conductive. The valve J is a triode, shown as having its control grid connected by a conductor 16 to the conductor 9 and hence to the negative terminal or plate *i'* of the condenser I. The cathode of the valve J is connected by a cathode bias resistor 17 to the conductor 9 and thereby to the positive terminal or plate *i* of the condenser I. The anode of the valve J is connected to the supply conductor DC' by a resistor 17' and the conductor 11. The charge acquired by the condenser I prior to the opening of the switch G makes the control grid of the valve J sufficiently negative relative to the cathode to make the tube J non-conductive and to keep it non-conductive until the end of the exposure period. As the condenser charge is being reduced by the condenser discharging current flow, the potential of the control grid of the valve J progressively increases relative to the potential of the valve cathode, until the valve becomes conductive.

As shown, the upper or positive end of the resistor 7 is connected to ground by the ground connection 18, and current flow through the cathode resistor 17, which occurs when the valve J is made conductive, increases the potential of the cathode of the valve J relative to the ground potential, and causes a previously non-conductive valve K to become conductive, and thereby effects the reenergization of the relay winding E and the adjustment of the relay armature D to the right. The resultant opening movement to the right of the switch C deenergizes the shutter mechanism B and thus terminates the exposure period initiated as a result of the deenergization of the relay winding B. The adjustment of the switch member D to the right also moves the switch member G into its closed position and thus closes the hereinafter described condenser charging circuit. The valve K is a thyatron having its cathode connected to ground and having its control grid connected by a conductor 19 to the cathode of the valve J. As shown, the thyatron K has a screen grid connected by a conductor 20 to a slider contact 21 engaging and adjustable along a potentiometer resistance 22 in shunt to a voltage controller shown as a glow tube L having its cathode connected to the supply conductor DC² by the conductor 12, and having its anode connected to a ground connection 23. In practice, the glow tube

L may well be of such type and form as to maintain a potential difference between its anode and cathode of 150 volts, so that the potential of the negative supply conductor DC² is 150 volts negative relative to the ground potential. The potential of the positive supply conductor DC¹ may well be, and is assumed to be 250 volts positive relative to the ground connection.

The switch F may well be and is assumed to be of a self-closing type and is closed except when momentarily opened to initiate an exposure period. The opening of the switch F opens circuits and deenergizes the thyatron K as well as the relay winding E, and the thyatron K remains in its deenergized condition throughout the exposure period initiated when the switch F is opened. This results from the fact that the voltage of the control grid of the thyatron K remains too negative relative to the cathode of the thyatron to cause the latter to fire, until the reduction in the charge of the condenser I is sufficient to make the valve J conductive. When the valve J becomes conductive, the voltage drop in the cathode resistor 17 raises the potential of the control grid of the thyatron K relative to the potential of the thyatron cathode to fire the latter and thereby reenergize the relay winding B and almost instantly gives the condenser a charge which makes the valve J not conductive. The resultant decrease in the potential of the thyatron control grid relative to the potential of the cathode of the thyatron does not make the latter non-conductive, as is well known.

The movement of the switch member G into its closed position, effected when the relay winding E is reenergized, closes a charging circuit for the condenser I. The condenser charging circuit, closed by the closure of the switch G, comprises one stationary switch terminal connected to the negative terminal or plate *i'* of the condenser I, and a cooperating stationary switch contact connected to a conductor 24 and connected to the first mentioned stationary switch contact by the switch member G when the latter is in its closed position. The charging circuit also includes the previously mentioned conductor 8 and resistor 15, and includes voltage divider elements M and N through which the conductor 24 is connected to the resistor 15.

The voltage divider element M comprises a plurality of resistance sections 25—34, connected end to end in series, a separate tap 35 through which each of said resistance sections 25—34 is connected to a corresponding one of a plurality of separate switches 25'—34'. Each of said switches 25'—34' when closed connects the corresponding resistance section to the conductor 24. In normal operation only one of the switches 25'—34' is closed at the same time. The free end of the resistance section 25 is connected by a conductor 37 and slider contact 38 to a slide wire resistance 39 included in the circuit of the voltage divider N. The free end of the resistance section 34 of the voltage divider M is connected by a conductor 40 to a pivoted switch arm 41 adapted to engage one or another of a circular series of eleven switch contacts 42. Each of those contacts is connected by a corresponding conductor 43 to one end of one or another of ten series connected resistance sections 45—54. The end of the resistance section 45 not connected to the adjacent resistance section 46, is connected to one end of the resistance 39. The other end of that resistance is connected to

the anode of the glow tube L and to the corresponding ground connection 23. The end of the resistance section 54 not connected to the adjacent resistance section 53 is connected through a resistor 55 to the junction of the conductors 14 and 13, and through the latter is connected to the cathode or negative terminal of the glow tube L.

With the voltage divider elements M and N arranged as described, the resistance sections 38, 45—54 and the resistor 55 of the voltage divider N are connected in series across the glow tube L, and the resistance sections 25—34 of the voltage divider element M are connected across the portion of the resistance of the voltage divider N, between the point along the resistor 39 engaged by the slider contact 38, and the point at the left end of whichever of the resistance sections 45—54 is then connected by the corresponding conductor 43 and switch contact 42 to the switch arm 41.

In the neutral or mid-position of the switch arm 41, shown in the drawing, it connects conductor 40 to the conductor 43 which is connected to the connected ends of the resistors 49 and 50. With that switch arm position, the voltage divider M is connected in shunt to the portion of the voltage divider N including the resistors 49, 48, 47, 46 and 45 and the portion of the resistor 39 between the slider contact 38 and the resistor 45. As the switch arm 41 is rotated clockwise into engagement with the lower right hand switch contact 42, the resistance sections 49, 48, 47, 46 and 45 are successively eliminated from the portion of the voltage divider N to which the voltage divider M is in shunt. This raises the potential of the negative plate *i'* of the condenser I and thus decreases the charge put on the condenser I and consequently shortens the exposure period. When the switch arm 41 is turned counterclockwise from its mid-position into engagement with the lower left hand switch contact 42, the resistors 50, 51, 52, 53 and 54 are successively added to the portion of the voltage divider N to which the voltage divider M is in shunt and the exposure period is correspondingly lengthened.

The operative effect of the voltage divider N on the charge given the condenser I preparatory to an exposure, depends upon which of the switches 25'—34' is closed. In the neutral adjustment of the voltage divider M, the switch 30' is closed and the remaining switches of the voltage divider are open. With the switch 30' closed, the potential given the negative condenser plate *i'* is the ground potential less the voltage drop in the portion of the resistance 39 between the ground connection 23 and the slider contact 38, plus the voltage drop in the resistor sections 25, 26, 27, 28 and 29, and the portion of the resistance section 30 at the right of its connection to the corresponding tap 35. The actual potential drop occurring in each of the resistor sections 25 to 34 depends upon the position of the contact 38 along the slide wire resistance 39 and on the adjustment of the switch arm 41, and does not depend on which of the switches 25'—34' is closed since there is no current flow through the closed switch, except during the small fraction of a second, following each closure of the switch G, in which the potential of the condenser terminal *i'* becomes equal to the potential of whichever of the switches 25'—34' is closed.

As will be apparent, the effect of successively

closing the switches 25', 26', 27', 28' and 29', one at a time, is to successively increase the potential of the condenser plate *i*, and to correspondingly decrease the exposure period. Similarly, the effect of successively closing the switches 31', 32', 33' and 34', one at a time, is to successively decrease the potential of the condenser plate *i'* and to correspondingly increase the exposure period.

In the practical use of the invention, the switches 25'—34' are ordinarily adjusted as required to compensate for differences between the average density of each transparent picture reproduced and the density of a particular interest portion of the picture, when the difference is of a character to require compensation. The need for compensation can be determined with substantial accuracy by a suitably skilled operator from a visual examination of the picture. The need for such compensation can be determined more easily and more accurately by the use of an automatic coder which provides a measure of the ratio of the density of the special interest portion of the picture to the average density of the picture, as is explained in the above-mentioned "Electronics" article. In the practical use of the present invention, in the commercial reproduction of transparent pictures, each picture is coded and then passed to the operator of the projection printer by which the picture is to be reproduced, with a code indication as to which of the particular switches 25'—34' should be closed in reproducing the picture.

The accuracy with which the needed compensation results are obtained in commercial operation, is increased by suitably relating the values of the resistance sections between each adjacent pair of taps 35. In practice, the resistance sections are advantageously arranged so that the effect of opening one of the switches 25'—34' previously closed, and the closure of the adjacent switch at the left of the switch opened, is to increase the exposure period $1.414 (\sqrt{2})$ times. This means that the closure of any one of the switches following the opening of the second switch to the right of the switch closed doubles the exposure period for the same transparency. Similarly, the effect of closing any one of the switches following the opening of the second switch to the left of the switch closed, is to shorten the exposure period by one-half.

It is not essential, of course, that there should be any particular number of switches associated with the resistance sections of the voltage divider M, or that the resistance should have their resistance values related as just described. Regardless of the number of switches and the relative values of the associated resistance elements of the voltage divider M, it is practically desirable, however, that the voltage dividers M and N be associated with one another in the condenser charging network in the general manner described. When the voltage dividers are so associated, the adjustments of the switch arm 41 needed to compensate for variations in the sensitivity or speed of the photographic printing material coated with emulsions made in different batches, do not change the relative effects of the much more frequently made adjustments of the different switches 25'—34' of the voltage divider element M needed to compensate for the difference between the exposure time actually needed in reproducing a particular transparent picture, and the exposure time for the picture

corresponding to and based directly on the average density of said picture.

In ordinary practice, the various switches 25'—34' may advantageously be actuated by an electromagnetic relay mechanism including selector switch push buttons conveniently located for actuation by the operator, in the general manner disclosed in the prior application of Jacob Rabinowitz, Ser. No. 594,403, filed November 13, 1945. In such case, it is ordinarily convenient to have the switch actuating relay system arranged so that at the conclusion of the printing of one or more pictures from any particular transparency, the switch system is left in, or is automatically adjusted into the condition shown in the drawing in which the neutral or mid-position switch 36' is closed and all of the other switches 25'—34' are opened.

For the convenience of the operator of the printing machine the switches 25'—34', or the push buttons through which they are controlled, are conveniently designated by suitable symbols, such as the symbols -V, -IV, -III, -II, -I, N, +I, +II, +III and +IV shown in the drawing as respectively associated in the order stated with the switches 25', 26', 27', etc. 34' respectively. When the resistors 25—34 are wire wound resistors of commercial magnitudes, the tap connection 35 to each resistor may be adjusted along the length of the latter in assembling the unit 10 so as to properly relate the resistance values of the sections of the voltage divider between the different switches 25, 26, etc.

In an embodiment of the invention now in commercial use, the switch arm 41 is adjusted from time to time as required to correct for variations in the sensitivity of the emulsion coating of the photographic material on which pictures are being printed. The quantity or batch of photographic material coated with the same emulsion ordinarily put in stock in a commercial printing plant may well be so large that thousands of pictures are printed from said batch. In said commercial embodiments of the invention, the various resistors of the voltage divider N have such resistance values that an adjustment of the switch arm in the clockwise direction from any one contact to the immediately adjacent contact, will increase the exposure period approximately 10%, and each similar adjustment step of the switch arm 41 will shorten the exposure period approximately 10%. In said embodiment, the resistance values of the various resistors in the voltage dividers M and N are approximately as follows:

Resistor	Resistance in Ohms
25.....	2,000
26.....	2,000
27.....	3,000
28.....	3,000
29.....	7,500
30.....	7,500
31.....	10,000
32.....	20,000
33.....	20,000
34.....	25,000
35.....	20,000
36.....	2,200
37.....	2,200
38.....	2,700
39.....	3,000
40.....	3,000
41.....	3,300
42.....	3,300
43.....	3,300
44.....	3,600
45.....	3,600
46.....	4,700

By way of further illustration and example, it

is noted that the resistors 7 and 15 may have resistance of 1000 and 25,000 ohms, respectively, and that suitable resistance values for the resistors 6, 10, 17 and 17' are 15,000 ohms, 25,000 ohms, ½ megohm and 1 megohm. It is to be noted, however, that while the resistance values hereinbefore stated are suitable, and suitably related, for practical use, none of those resistance values is sharply critical. The capacity of the timing condenser I should be suitably related to the conditions of use, and in particular to the magnitude of the charging voltages impressed on it, and to the voltage difference between the condenser plates *i* and *i'* at the instant in which the tube J becomes conductive and operates through the thyatron K and relay winding E to close the switch G and thus interrupt the condenser discharging operation. In practice, with the resistance values above stated and with 150 volts across the glow tube L, the capacity of the condenser I may vary between .05 and .006 microfarad, and the maximum voltage impressed on the condenser plates *i* and *i'* may vary from a maximum of 140 volts to a minimum of about 5 or 6 volts. With a condenser having a capacity of .02 microfarad and with an effective charging voltage of 140 volts, the exposure period used in reproducing a transparent picture of average density on photographic printing material of average sensitivity, will be about 30 seconds. With the same condenser, transparent picture and printing material, the exposure period may be about one-half of a second when the effective charging voltage is only six volts.

It is believed that the operation of the apparatus illustrated and described herein has now been made apparent.

The timing mechanism illustrated and described herein comprises improvements on the invention disclosed and claimed in the above-mentioned prior application of Jacob Rabinowitz.

While in accordance with the provisions of the statutes, I have illustrated and described the best form of embodiment of my invention now known to me, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit of my invention, as set forth in the ap-

ended claims, and that in some cases certain features of my invention may be used to advantage without a corresponding use of other features.

Having now described my invention, what I claim as new and desire to secure by Letters Patent is:

1. In a projection printer comprising mechanism for reproducing a transparent picture by projecting light through the picture to photographic printing material and comprising exposure timing means including a timing condenser having two terminals and means for proportioning each exposure period to the time required to effect a predetermined reduction in the charge previously given said timing condenser by a discharge current which flows through a photocell included in said mechanism and rendered conductive by light projected through said picture, and which is proportional to the average density of said picture, the combination with said mechanism, of means for varying the charge put on the condenser preparatory to an exposure comprising a voltage source, a voltage divider having resistance sections connected in series across said source, a second voltage divider having resistance sections connected in series with one another, switching means operative to connect said second voltage divider in shunt to a variable portion of the first mentioned voltage divider, and means for connecting one terminal of said timing condenser to said second voltage divider at one or another of a plurality of points differing in potential from one another, and a source of predetermined potential to which the second terminal of said condenser is connected.

2. A combination as specified in claim 1, in which said switching means comprises a plurality of contacts, a switch arm connected to one end of said second voltage divider and adjustable into different positions to thereby engage the different contacts one at a time, and conductor means connecting the different contacts to said first mentioned voltage divider at respectively different points along the length of the latter.

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No references cited.