

April 28, 1942.

F. H. GULLIKSEN

2,280,948

INSPECTION SCHEME

Filed Sept. 7, 1939

Fig. 1.

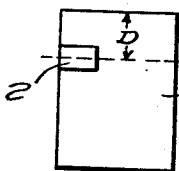


Fig. 2.

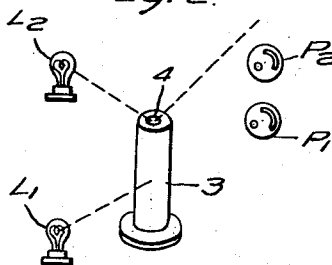


Fig. 3.

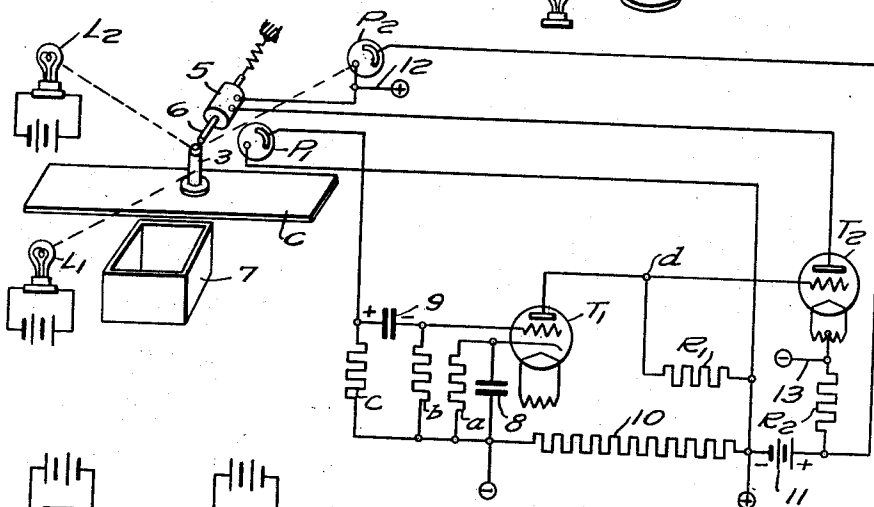
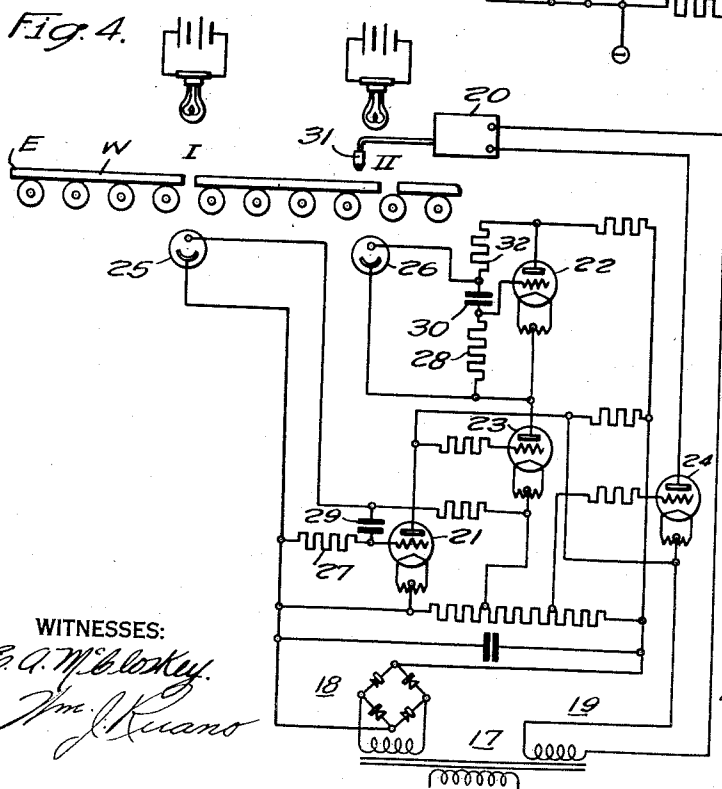


Fig. 4.



Interchange
Tube 26 and
Resistor 32 to
have operation
responsive to
decrease instead
of increase of
illumination on
phototubes.

WITNESSES:

E. A. McElroy.
Jm. J. Ruano

INVENTOR

Finn H. Gulliksen

BY

Paul E. Friedman
ATTORNEY

UNITED STATES PATENT OFFICE

2,280,948

INSPECTION SCHEME

Finn H. Gulliksen, Pittsburgh, Pa., assignor to
Westinghouse Electric & Manufacturing Com-
pany, East Pittsburgh, Pa., a corporation of
Pennsylvania

Application September 7, 1939, Serial No. 293,735

7 Claims. (Cl. 250—41.5)

My invention relates to photo-electric apparatus and is directed more specifically to a special type control system.

An object of my invention is to provide photo-electric apparatus which is responsive solely as the result of a predetermined condition of illumination occurring simultaneously on two separate light-sensitive devices.

Another object of my invention is to provide a relay which is energizable solely as the result of predetermined conductivity of an impulse control discharge tube and a static control discharge tube occurring simultaneously.

Another object of my invention is to provide a relay which is energizable solely in response to increase (or decrease) in illumination of one light-sensitive device and which is deenergizable solely as a result of increase (or decrease) in illumination of another light-sensitive device.

Other objects and advantages will become more apparent from a study of the following specification when considered in conjunction with the accompanying drawing, in which:

Figure 1 is a schematic showing of an object having a certain characteristic on a portion thereof which is to be analyzed;

Fig. 2 is a schematic showing of an optical system for photo-electrically analyzing an object, such as a rivet;

Fig. 3 is a schematic showing of a control system for analyzing the presence or absence of a hole in a rivet; and

Fig. 4 is a schematic showing of a modification of the control system in Fig. 3 wherein such control system is adapted for the spraying of wall boards or similar devices.

Referring more particularly to Fig. 1, numeral 1 denotes an object of any kind such as, for example, a letter, card, piece of sheet metal, or, in fact, any object which has a certain characteristic indicated by numeral 2 wherein it is desired to know either the presence or absence of such characteristic or whether or not such characteristic is positioned correctly on said object. More specifically, such as in the case of a letter, numeral 2 would denote a postage stamp in the case where it is desired to sort letters so that the postage stamps will occur at the upper right-hand corner, and if any of them do not, then a relay will be operative to move such letter into the correct position. Object 1 could likewise be a plate which is to be analyzed to determine whether or not a hole or punching 2 is present or whether such hole or punching is at the correct location. While a hole is mentioned as an example of the characteristic, other characteristics may equally be analyzed such as color, or the presence or absence of a projection on a particular part (2) of an object or, in fact, any characteristic which is reflective in a certain

way to an incident light beam and which is reflective in a different way as the result of the absence of such characteristic.

In the past, inspections have been generally made by mechanically registering the position of the article. However, this scheme is slow and expensive and is not adapted for high-speed analysis of objects while in motion. Such systems, in the past, have generally involved the use of mechanical limit switches which had to be periodically replaced because of excessive wear due to the high number of operations required within a short period of time.

As an example of an object which is to be analyzed for the presence or absence of a certain characteristic, a rivet 3 is shown in Fig. 2 which normally should have a hole 4 coaxially drilled into one end thereof if all previous operations have been carried out correctly. A light source L_1 emits a light beam which normally falls on a phototube P_1 when the rivet is not in the position in which it is to be analyzed. However, when such rivet has been moved into the analyzing position by a conveyor C, the illumination of P_1 is interrupted. Another light source L_2 normally does not illuminate a phototube P_2 , either when the rivet is out of the analyzing position or when it is in the analyzing position and a hole 4 occurs therein, because in the latter instance the hole 4 disperses a light beam in some other direction than the direction of P_2 . However, if for some reason, due to faulty operation of some part of the machine which forms the rivet, hole 4 has not been made, then a reflective surface will be present at the edge of the rivet which will reflect light onto phototube P_2 such as shown in Fig. 3. When such condition exists a magnetically-operated, spring-released plunger 6 will be operated to throw rivet 3 into a container 7. Phototube P_1 controls an impulse responsive amplifier tube T_1 so that this tube will produce a control effect operative only for the short time during which the impulse is obtained due to the movement of the rivet into the light beam between L_1 and P_1 . Tube T_1 has associated therewith a stabilizing condenser 8 which, in conjunction with resistors a and b and condenser 9, maintains a substantially constant bias on the grid of tube T_1 such as is conventional in impulse controlled discharge tubes. Tube T_1 controls the voltage across resistor R_1 which is connected to the grid circuit of the main control tube T_2 . A source of direct current potential indicated by (+) and (−) is applied across a resistor 10. A different direct current source indicated by (+) and (−) is applied to conductors 12 and 13. It will thus be seen that phototube P_2 can control tube T_2 only during the short time when P_1 exercises impulse control on tube T_1 which will appear more clearly hereinafter.

Assume P_1 is normally continuously illuminated so that its resistance is low. This means that condenser 9 is charged as indicated. Resistor a limits the negative bias on the grid of tube T_1 to a given value and the result is that tube T_1 carries a predetermined current between its principal electrodes. When the light beam between L_1 and P_1 is intercepted by the presence of a rivet, the resistance of P_1 abruptly rises and condenser 9 discharges through resistors b and c and thus places a very high negative bias on the grid of tube T_1 . The current between the principal electrodes of tube T_1 drops to some relatively low value, that is, toward zero current, for the period of discharge of condenser 9. From this analysis it is apparent that P_1 and T_1 are connected for dark spot operation. It takes an abrupt change from light to dark on P_1 to change the current in T_1 .

When the current in T_1 is driven to zero, the junction d becomes positive and tube T_2 will conduct current or not conduct current depending on the conditions of lumination on P_2 .

Since tube P_2 is of the type to be normally non-conducting, it becomes conducting only when illuminated by reason of the presence of a defective rivet in such position as to illuminate P_2 . The negative bias produced by battery 11 on the grid of tube T_2 will in such case be sufficient to prevent tube T_2 from increasing its current between its principal electrodes even though junction d becomes more positive by reason of the sharp decrease in current through tube T_1 .

However, when P_2 is illuminated its resistance drops abruptly. Resistor R_2 is preferably chosen to have a larger resistance value than resistor R_1 . This means when tube T_1 is momentarily non-conducting, that the negative bias of battery 11 is overcome and junction d becomes sufficiently positive to cause an increase in current through tube T_2 to thus energize solenoid 5. P_2 will not influence the anode-cathode circuit impedance of T_2 because it is in parallel therewith and because of the magnitude of this impedance with respect to the anode-cathode circuit impedance of the vacuum tube T_2 . However the negative grid potential of T_2 is decreased by virtue of current flow through P_2 as the result of an IR drop through R_2 . This drop together with the decreased drop across R_1 (due to an impulse from P_1) results in a grid voltage in tube T_2 which is greater than its critical voltage which therefore allows tube T_2 to become conducting. The length of time tube T_2 is heavily conductive depends on the constants of the elements of the circuits. I so chose the constants of condenser 9, resistors R_1 , R_2 , etc., to make certain that solenoid 5 is energized long enough to actuate plunger 6 to throw the rivet into the receptacle 7. As soon as the rivet has been sorted out the circuits are again stabilized to be ready to again operate when a defective unit is in the paths of the light beams.

I designate tube T_1 an impulse tube because its grid bias, for the operations hereinbefore discussed, changes solely in proportion to the rate of change of illumination of P_1 , whereas tube T_2 I designate as a static control tube because its grid bias changes only in accordance with the change of illumination of P_2 . The grid of tube T_2 may have a small positive bias so that T_2 carries a small current not sufficient to operate solenoid 5. When tubes P_1 , P_2 , and T_1 produce their effect, the grid characteristics as to polarity, but not as to value, remain the same. It is necessary either

than the impulse on tube T_1 occurs after the time the control potential on the static controlled tube T_2 is applied (and while it is still on) or at the same time thereof, in other words, both must occur simultaneously. If the impulse occurs before the static control is operative the relay will not be operated.

The wallboard spraying machine control as shown in Fig. 4 also avoids the use of mechanical limit switches and is arranged so that relay 20 must become energized when the trailing edge E of the wallboard W leaves position I, and the relay 20 will remain energized until the trailing edge E leaves position II, positions I and II being in the paths of the respective light beams.

My control system illustrated in Fig. 4 will accomplish this control sequence without using any mechanical interlock relays. As shown in Fig. 4, two high vacuum tubes 21 and 22 and two thyatron tubes 23 and 24 are used. Phototubes 25 and 26 control tubes 21 and 22, and are connected to give "impulse" control so that the current through tubes 21 and 22 will remain constant unless the illumination on the phototubes is changed abruptly. Tubes 21 and 22 have such characteristics that a normally zero grid voltage supplied by resistors 27 and 28 will produce a current through the tubes, normally near the maximum value. Due to the "impulse" capacitors 29 and 30 the current through tubes 21 and 22 will remain at maximum value, except when the illumination on the phototubes is increased suddenly, in which case the tube current will be reduced to practically zero. An alternating current source 19 and a direct current source 18, of a conventional type, are fed by a transformer 17 are shown at the lower portion of Fig. 4. In other words serially connected tubes 22 and 23, when both conductive, apply a negative potential to tube 24 with respect to its own grid, that is, the grid voltage of tube 24 is increased to a value which exceeds its critical grid bias. This action is tantamount to connecting the cathode of tube 24 to the cathode of tube 23, the latter being at a more negative potential than the grid of tube 24 hence the grid voltage of tube 24 is in excess of the critical grid bias thereof making tube 24 conductive providing the anode voltage is at the correct polarity and potential. Tube 24 does not conduct when 22 and 23 are non-conducting due to the negative DC voltage applied to the grid of tube 24 from the right hand section of the DC potentiometer resistor source.

Assuming now that the wallboard is in the position shown in Fig. 4, the tubes 23 and 24 will be deenergized and tubes 21 and 22 will conduct maximum current. When the wallboard moves toward the right, conditions remain unchanged until the trailing edge E leaves position I. At this instant the current through tube 21 is momentarily reduced to zero and thyatron tube 23 becomes ionized through tube 22, thus effecting conduction of tube 24 and energizing relay 20. The relay now remains energized until edge E leaves position II, when, due to the impulse action of capacitor 30 the current through tube 22 is momentarily reduced to zero, thus de-ionizing tube 23 and deenergizing tube 24 and relay 20. When relay 20 is energized it operates a valve (not shown) which opens a nozzle 31 which sprays paint on the wallboard. It will be obvious that instead of operating a nozzle, relay 20 could operate any other means such as a machining tool, saw or any other device which performs an operation on the wallboard only during the pe-

riod starting when trailing edge E leaves position I until it leaves position II on its movement to the right.

To briefly summarize the operation in Fig. 4, it will be seen that only upon increase in illumination falling on phototube 25 does relay 20 become energized, and only upon increase of illumination of phototube 26 does relay 20 become deenergized. Decreasing of illumination of either tube has no effect. If, however, it were desired to have a system in which a decrease in illumination on phototube 25 energizes relay 20 and a decrease in illumination of phototube 26 deenergizes relay 20, it is merely necessary to interchange the electrical positions of phototube 25 and resistor 32.

I am, of course, aware that others, particularly after having had the benefit of the teachings of my invention, may devise other devices embodying my invention, and I, therefore, do not wish to be limited to the specific showings made in the drawing and the descriptive disclosure hereinbefore made, but wish to be limited only by the scope of the appended claims and such prior art that may be pertinent.

I claim as my invention:

1. An electrical control system comprising, in combination, a light source, a light responsive device cooperating therewith to detect the presence of an object, energy storing means and an impulse controlled electrical discharge device connected to said light responsive device so as to be responsive solely to the rate of change of illumination on the light responsive device, a second light responsive device in electrical circuit relationship with said first light responsive device, a second electric discharge device, relay means operable solely in response to a predetermined simultaneous condition of conductivity of both of said electric discharge devices.
2. Apparatus as set forth in claim 1 in which said second electric discharge device is statically controlled by said second light sensitive device, being responsive solely to the change of illumination thereof.
3. An electrical control system for analyzing objects comprising, in combination, a light source, a photo-electric device cooperating therewith to detect the presence of an object, a condenser and an impulse controlled electrical discharge device connected to said light responsive device so as to be responsive solely to the rate of change of illumination thereof, a second photo-electric device which is effective to detect the presence of a certain characteristic of said object, a second electric discharge device controlled thereby and relay means connected to said electric discharge devices so as to be responsive solely to a simultaneous occurrence of a predetermined positioning of the object and a predetermined characteristic thereon.
4. Apparatus as set forth in claim 3 in which said second electric discharge device is statically controlled by said second photoelectric device, that is, it is responsive to a change of illumination thereof.
5. An electrical control system comprising, in combination, a light source, a light sensitive device cooperating therewith to detect the presence of an object, a condenser, an impulse controlled electrical discharge tube connected with said light sensitive device and condenser so as to be responsive solely to the rate of change of illumination on said light sensitive device, a second light source, a second light sensitive device co-

operating therewith so as to detect the presence of a certain characteristic on a portion of said object, and a second electric discharge device having an anode and a cathode and a control grid, and the anode of the first discharge device being connected to the grid of the second tube, a resistor connected in parallel with first discharge device thereby controlling the potential of the grid of said second discharge device, said first light sensitive device being in the grid circuit of the first discharge device and said second light sensitive device being in shunt with the anode-cathode circuit of said second discharge device, a source of direct current potential connected across said first discharge device and said resistor in series relationship, a second source of direct current potential connected across said second discharge device, a relay connected in series with said second discharge device and which is operable solely in response to simultaneous presence of the object in said first light beam and the presence of a certain characteristic of said object in the second light beam.

6. An electrical control system comprising, in combination, a light source, a light sensitive device cooperating therewith to detect the presence of an object, a condenser, an impulse controlled electrical discharge tube connected with said light sensitive device and condenser so as to be responsive solely to the rate of change of illumination on said light sensitive device, a second light source, a second light sensitive device cooperating therewith so as to detect the presence of a certain characteristic on a portion of said object, a second impulse controlled discharge tube, a "thyatron" amplifier tube having a grid whose potential is controlled in accordance with the plate current of one of said impulse controlled discharge tubes, a second thyatron amplifier tube having a grid whose potential is controlled in accordance with the plate current of the other of said impulse controlled discharge tubes, a relay which is connected across said second amplifier tube and which is energized solely in response to change of illumination in a predetermined direction of one of said impulse controlled tubes and which is deenergized solely in response and change of illumination in a predetermined direction of the other of said impulse controlled tubes.

7. An electrical control system comprising, in combination, a light source, a light sensitive device cooperating therewith to detect the presence of an object, a condenser, an impulse controlled electrical discharge tube connected with said light sensitive device and condenser so as to be responsive solely to the rate of change of illumination on said light sensitive device, a second light source, a second light sensitive device cooperating therewith so as to detect the presence of a certain characteristic on a portion of said object, a second impulse controlled electric discharge tube, a thyatron amplifier tube having a grid whose potential is controlled in accordance with the plate current of one of said impulse controlled discharge tubes, a second thyatron amplifier tube having a grid whose potential is controlled in accordance with the plate current of the other of said impulse controlled discharge tubes, a source of direct current potential, the grid-cathode circuits of said amplifier tubes being connected in series relationship with respect to said source of direct current potential.

FINN H. GULLIKSEN.