United States Patent [19]

Post et al.

[11] **3,880,516**

[45] **Apr. 29, 1975**

[54] **DIAGNOSTIC CIRCUIT BOARD**

[75] Inventors: **Donald S. Post**, Fairport; **Gerald R. Helbig**, Webster; **Kenton W. Fiske**, Fairport, all of N.Y.

[73] Assignee: **Xerox Corporation**, Stamford, Conn.

[22] Filed: **Feb. 22, 1974**

[21] Appl. No.: **444,997**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 312,396, Dec. 5, 1972, abandoned.

[52] **U.S. Cl.** ..... **355/14**; 235/92 T

[51] **Int. Cl.** **G03g 15/22**

[58] **Field of Search** ..... 355/14, 3 R; 324/181, 73; 235/92 SB, 92 T, 92 CT

[56] **References Cited**

UNITED STATES PATENTS

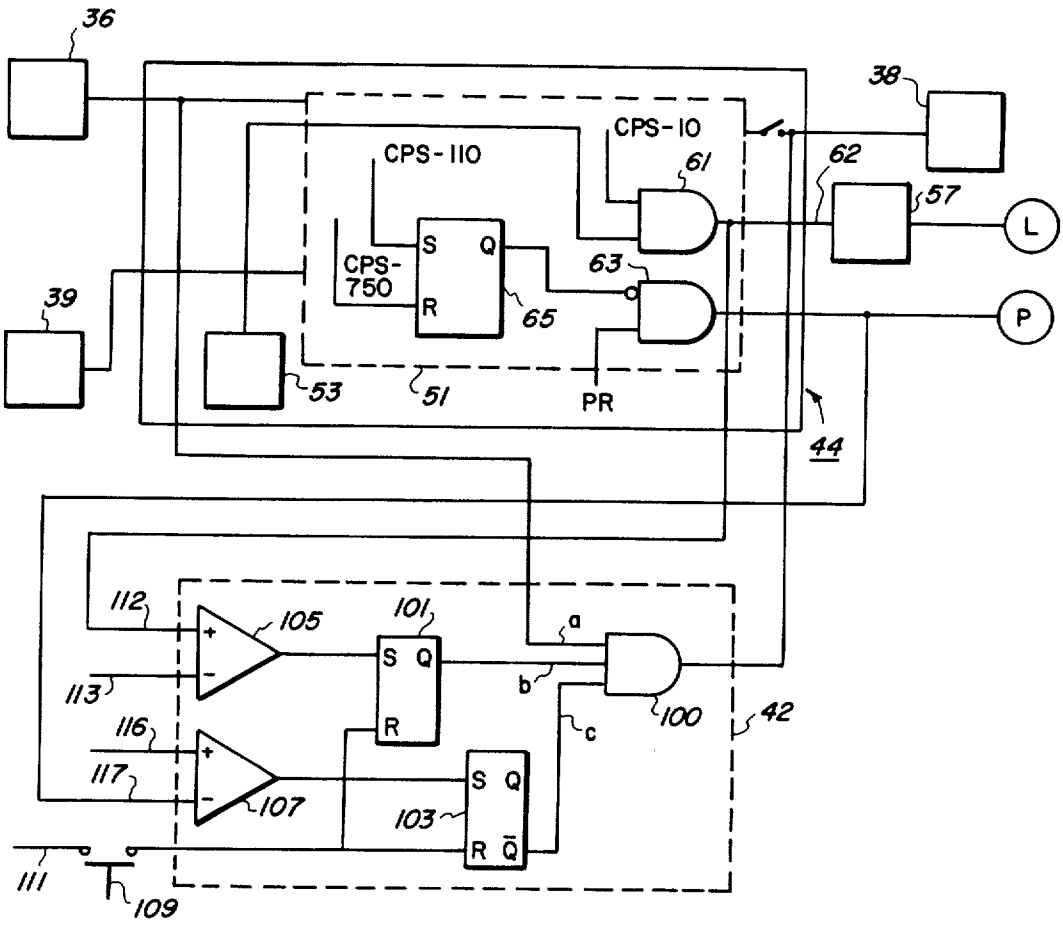
3,296,525	1/1967	Sakuma	235/92 T
3,450,995	6/1969	Hirsch	355/14 UX
3,732,005	5/1973	Lloyd	355/14
3,790,270	2/1974	Donohue	355/14

Primary Examiner—Samuel S. Matthews
Assistant Examiner—Kenneth C. Hutchison

[57] **ABSTRACT**

A diagnostic aid for use in a reproduction machine having a counter incorporated therein to register the number of copies produced by the machine. A circuit board, adapted for interconnection with the control circuit of the machine is employed to convert the copy counter into a timed pulse counting mechanism to determine if sequenced events during machine operation occur during the proper time interval.

6 Claims, 4 Drawing Figures



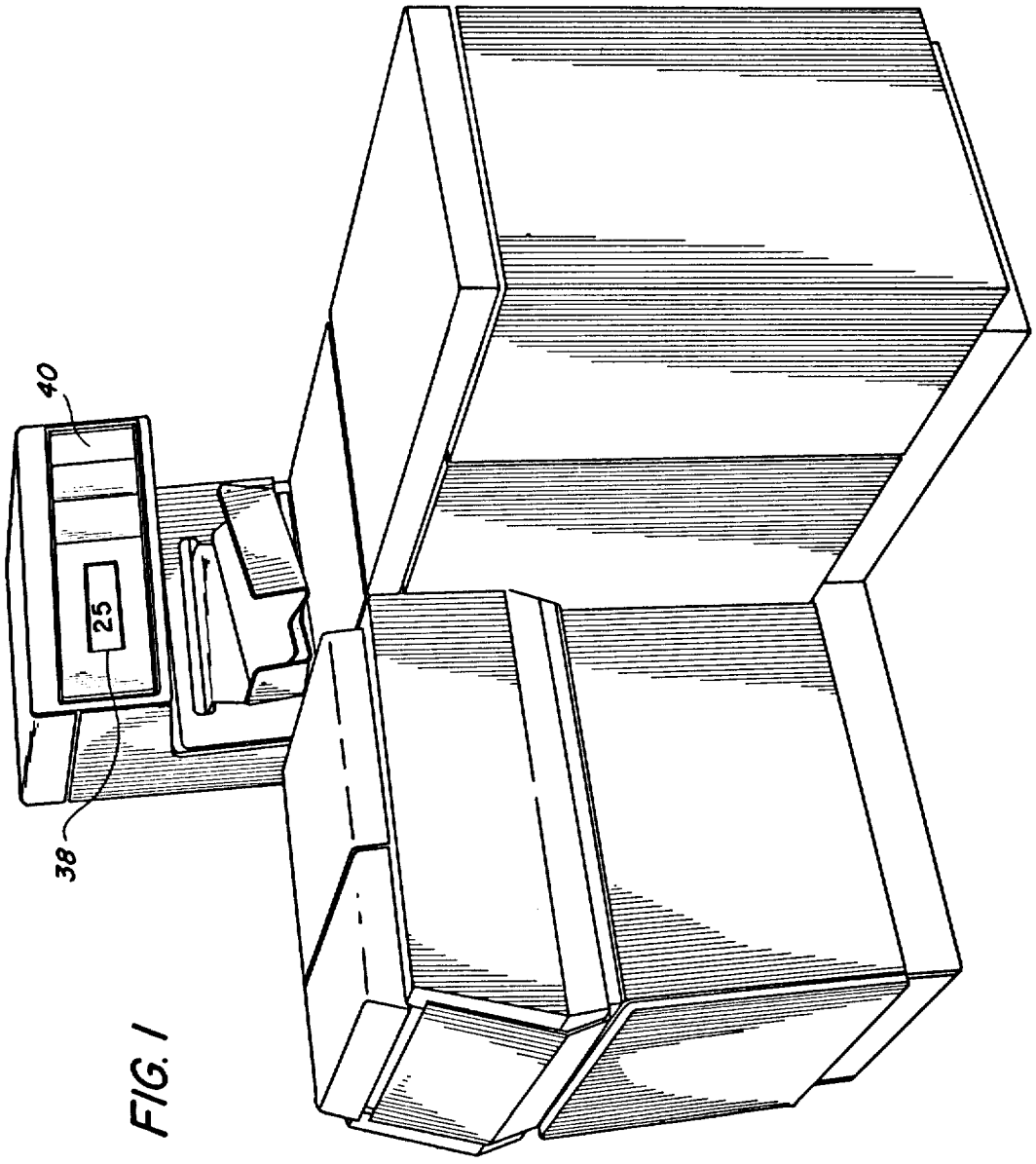


FIG. 1

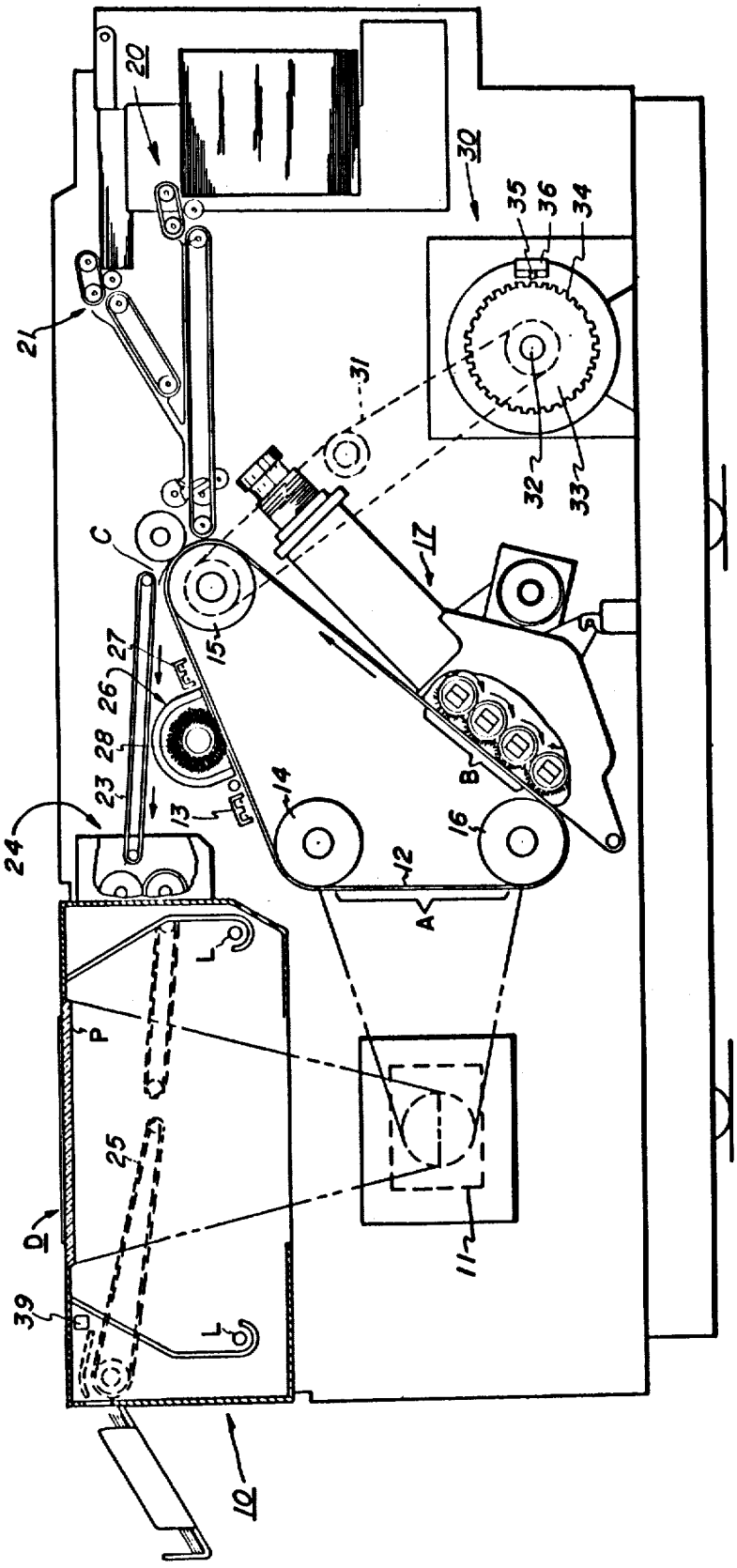

20
30
35
36
34
21
31
32
33
C
17
15
27
26
28
23
24
13
14
16
12
B
A
L
P
25
D
39
11
10

FIG. 2

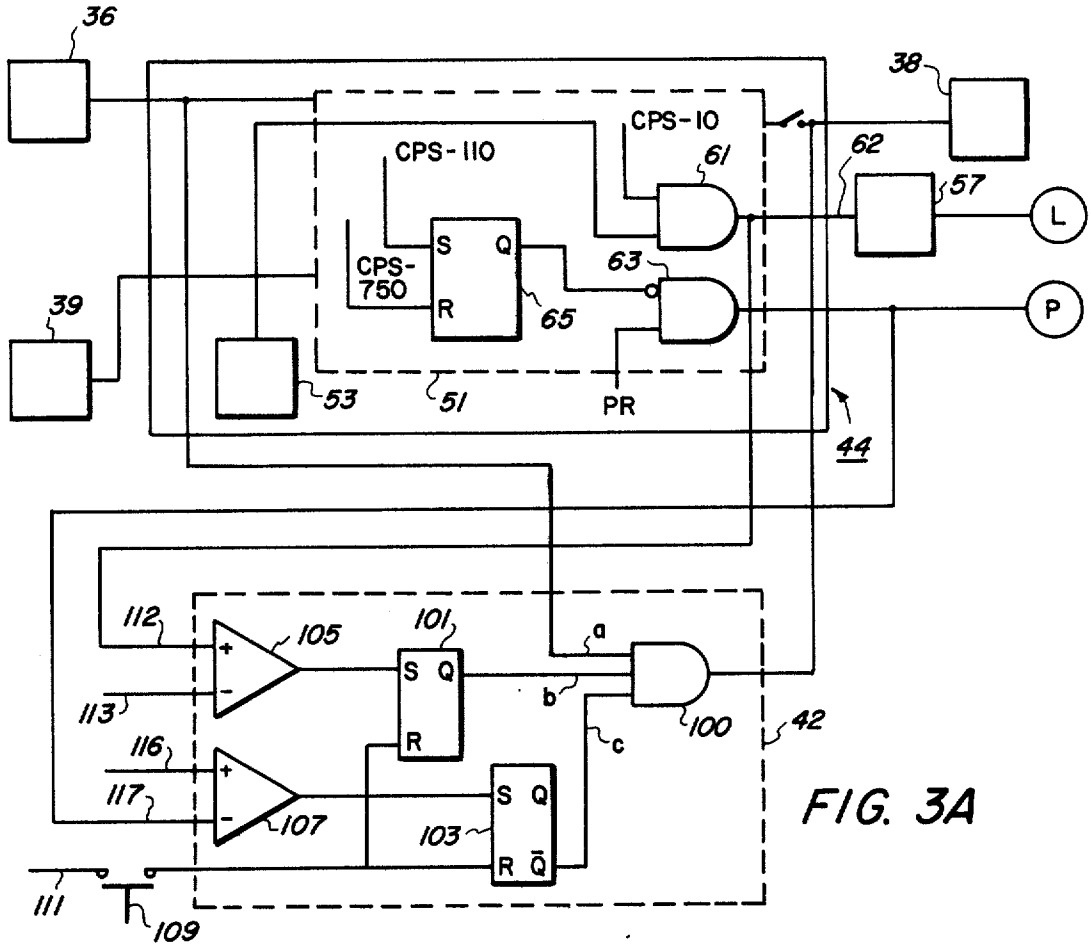

36
38
CPS-10
CPS-110
61
62
57
L
CPS-750
S Q
R
63
65
39
P
53
51
PR
44
112
105
101
a
113
S Q
b
R
100
42
116
c
117
107
S Q
103
R Q̄
111
109

FIG. 3A

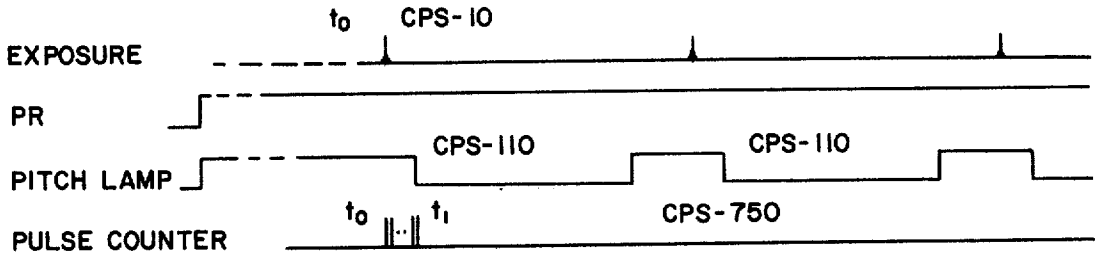

t_0 CPS-10
EXPOSURE
PR
CPS-110
CPS-110
PITCH LAMP
t_0 t_1
CPS-750
PULSE COUNTER

FIG. 3B

DIAGNOSTIC CIRCUIT BOARD

This is a continuation-in-part application of application Ser. No. 312,396 filed Dec. 5, 1972, now abandoned.

BACKGROUND OF THE INVENTION

Electrostatic copying machines of the type using a photoconductive layer for developing a latent electrostatic image of the document to be copied and thereafter developing and transferring the image to a copy sheet employ various processing stations for uniformly charging, exposing and developing the photosensitive surface, transferring the developed image to the copy sheet, fusing the transferred image on the copy sheet, cleaning the photoreceptive surface, etc. For high speed operation of this machine, it is necessary to provide an accurately timed sequence of operation of the processing stations in order to maintain proper registration of all processing functions relative to the image. There must also be provision for the efficient and accurate movement of sheets of copy paper from the supply station to the transfer station of the machine in timed sequence relative to the production of electrostatic latent images, the development thereof, the proper orientation of each sheet to the developed image, the energization of various charging devices in the machine and all of the sensing elements throughout the machine utilized to detect copy sheet location, accurate positioning of the copy paper and the possibility of paper jam. In order to monitor and initiate all of the timed sequences and operations of the machine in a high speed copier, an electronic control system may be employed.

In the event of a machine malfunction causing paper jams or unacceptable copies, it may be necessary to determine if the various time-related functions are occurring during the proper time intervals or that the paper sensors are actually being energized at the time when a paper should be present for sensing thereby.

In a high speed machine, it is extremely difficult to determine if these timed events are occurring at the proper time in attempting to diagnose a malfunctioning machine.

SUMMARY OF THE INVENTION

This invention relates to a reproduction machine having a copy counter associated therewith to register the number of copies produced by the machine. Means, adapted for connection to the control circuit of the machine, are provided to convert the copy counter into a timing mechanism to register the timed sequence or interval at which the various machine functions occur.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an isometric view of a xerographic reproduction machine.

FIG. 2 is a schematic sectional view of a reproduction machine.

FIG. 3A is an electrical schematic illustrating a portion of the control circuit of the reproduction machine and a diagnostic board connected thereto.

FIG. 3B is a time chart illustrating the initiation and termination of a number of time related machine functions.

DESCRIPTION OF THE PREFERRED EMBODIMENT

For a general understanding of an electrostatic processing system in which the invention may be incorporated, reference is had to FIG. 2 in which various components of a system are schematically illustrated. As in most electrostatic systems such as a xerographic machine, a light image of an original to be reproduced is projected onto the sensitized surface of a xerographic plate to form an electrostatic latent image thereon. Thereafter, the latent image is developed with an oppositely charged powder to form a xerographic powder image corresponding to the latent image on the plate surface. The powder image is then electrostatically transferred to a support surface to which it may be fixed by a fusing device whereby the powder image is caused to permanently adhere to the support surface.

The electrostatically attractable developing material commonly used in electrostatic reproduction systems comprises a pigmented resinous powder referred to here as "toner", and a "carrier " of larger granular beads formed from a material removed in the triboelectric series from the toner so that a triboelectric charge is generated between the toner powder and the granular carrier. The carrier also provides mechanical control so that the toner can be readily handled and brought into contact with the exposed xerographic surface. The toner is then attracted to the electrostatic latent image from the carrier to produce a visible powder image on the xerographic surface.

In the illustrated machine, an original D to be copied is placed upon a transparent support platen P fixedly arranged in a illumination assembly generally indicated by the reference numeral **10.** While upon the platen, an illumination system comprising two or more lamps L and reflectors is flash energized to direct light rays upon the original to produce image rays corresponding to the informational areas on the original. The image rays are projected by means of an optical system **11** to an exposure station A for exposing the photosensitive surface of a moving xerographic plate in the form of a flexible photoconductive belt **12.** In moving in the direction indicated by the arrow, prior to reaching the exposure station A, that portion of the belt being exposed would have been uniformly charged by a corona device **13** indicated at a belt run extending between belt supporting rollers **14** and **15,** the latter being the drive roller for the belt. The exposure station extends between the roller **14** and a third support roller **16.** The belt run between these rollers is encompassed entirely by the exposure station for minimizing the space of the belt and its supporting rollers.

The exposure of the belt to the light image discharges the photoconductive layer in the areas struck by light whereby there remains on the belt a latent electrostatic image in image configuration corresponding to the light image projected from the original on the support platen. As the belt surface continues its movement, the electrostatic image passes around the roller **16** to a developer station B located at a third run of the belt and in which there is positioned developing apparatus generally indicated by the reference numeral **17.** The developer apparatus **17** comprises a plurality of brushes which carry developer to the adjacent surface of the upwardly moving inclined photoconductive belt **12** to provide development of the electrostatic image.

The developed electrostatic image is transported by the belt **12** to a transfer station C located at a point of tangency on the belt around the drive roller **15** whereat a sheet of copy paper is moved at a speed in synchronism with the moving belt in order to accomplish transfer of a properly registered developed image.

There is also provided a copy sheet supplying apparatus comprising a main paper feed supply **20** and an auxiliary paper feed supply **21.** Each of the paper supplies is adapted to separate sheets from their respective supply stacks and to transport the sheets to a sheet registration station and eventually into contact with the developed image on the belt as the same is carried around the drive roller **15.** A suitable timing control mechanism is operatively associated with each of the paper supply mechanisms **20, 21** and the flash illumination devices L, for producing an electrostatic latent image on the belt **12** to present a developed image at the transfer station C in timed sequence with the arrival of a sheet of paper, and is coordinated with the activation of other processing and control devices at the precise time that these elements are to function for their intended purpose.

After the developed image is transferred to a sheet of paper, it is stripped from the belt **12** and conveyed by conveying system **23** into a fuser apparatus generally indicated by reference numeral **24** wherein the developed and transferred xerographic powder image on the sheet material is affixed thereto. After fusing, the finished copy is discharged from the apparatus by a conveyor **25** at a suitable point for collection externally of the apparatus. The toner particles remaining as residue on the developed image and those particles not otherwise transferred are carried by the belt **12** to a cleaning apparatus **26** positioned on the run of the belt between the rollers **14** and **15** adjacent the charging device **13.** The cleaning apparatus comprises a discharge device **27** for neutralizing charges remaining on the particles and a rotating brush **28** which operates in conjunction with a vacuum system to remove the residual toner particles from the brush.

Belt **12** is driven by a drive means **30** comprising a constant speed drive motor and gear box coupled to the drive roller **15** by a suitable drive train or timing belt **31** interconnecting a sprocket or pulley mounted on the shaft for the foller **15** and the drive means output shaft **32.**

Accurate sequencing of the various machine operations is provided by a programming control including a pulse generator. The pulse generator includes a gear **33** mounted on the motor drive shaft **32,** the gear including a predetermined number of teeth **34,** each of which becomes aligned with a stationary magnetic pickup element **35** during rotation of the gear. The element **35** is associated with a generating device **36** which produces a square wave signal having peaks corresponding to the successive alignment of the teeth **34** with the pickup element **35.** As each tooth moves adjacent the device **35,** the magnetic field in the device varies and thereby produces a peak in the signal.

Thus a program control including the timing device mechanically coupled to the shaft of the drive means **30** is operational whenever the roller **15** is rotating. The pulse generating device **36,** which is part of the timing apparatus, is set to produce a continuous train of timed pulses which is proportional to the rotational speed of the drive means **30** and the number of teeth **34** on the gear **33.** Any machine event or processing step can be initiated, that is, turned "on" and "off", or energized for any period of time, through suitable control circuitry in response to a numbered pulse or series of pulses from the timing device. For a more complete description of the control system reference may be had to application Ser. No. 284,835, filed Aug. 30, 1972 now U.S. Pat. No. 3,790,271.

In the event of a machine malfunction it may be necessary to determine if a particular operation is occurring at the desired pulse or for the desired number of pulses or if the various paper sensors, paper feeder or other elements of the machine which are operated in timed sequence are energized at the proper pulse.

In high speed machines of the type described, an electronic copy counter **38** may be provided to count and register the number of copies printed to enable the operator to follow the machine programming and determine when the desired number of copies are completed. This counter or copy count register **38,** which may operate in response to signals received from a paper sensor **39** at the copy discharge portion of the machine, may be located on the control panel **40** or console of the machine at a convenient location such that it may be easily seen by the machine operator.

In order to determine if the various operations or sequence of events within the machine are occurring at the proper timed pulses, a diagnostic board **42** is provided which is adapted for interconnection with the control system **44** of the machine. The diagnostic board preferably is a simple electronic circuit adapted to disengage the copy counter from the copy sensing device utilized as the signal generator for the counter and electrically connect the copy counter to the pulse generator to enable the counter to count and register pulses generated thereby. If the paper sensor signal provided to the copy counter is of the same voltage and amperage as the pulses produced by the pulse generator, the circuit could merely be a device to interrupt the signal from the paper sensor to the copy counter and substitute the signals from the pulse generator therefor. In the event the signals are of a different voltage, the circuit board may contain devices for reducing or increasing the signal from the pulse generator to provide the required input to the counter. Upon energization of the machine, a serviceman can easily determine if a machine operation is occurring at the proper time or pulse by reading the pulse count registered on the "copy counter " when the machine operation in question was initiated, or the number of discrete pulses generated during a particular machine operation to determine if the operation or machine element was energized for the required period of time. Since the copy counter is ordinarily in a very convenient and easily visible location as an aid to the machine operator, it is also in a logical position for employment by a machine serviceman for diagnosing machine malfunctions. All that is required is a simple circuit board which may be plugged into suitable connections provided in the machine control circuit.

As stated heretofore, the diagnostic board described may be used to test for proper operation of numerous electrostatic reproduction machine functions. Typically, electrostatic reproduction machines include means to implement processing steps such as document feeding, copy sheet feeding, image exposure, pitch fadeout, edge fadeout and transfer, and means to moni-

tor the copy sheets as they travel through the machine to sense jamming or stoppage of sheets therein. Many or all of these functions may require precisely timed operations.

To provide the necessary control, the machine may be provided with control logic means for producing precisely timed control signals. To derive these precise time signals, as illustrated in block diagram form in FIG. 3A, the control means is provided with synchronous section **51** which derives control signals from the machine clock or pulse generator **36** and machine pitch information from a pitch pulse generation means **53**. For a more detailed description of the control means, one may refer to the U.S. applications, Ser. No. 438,972 filed on Feb. 4, 1974 or U.S. patent application Ser. No. 445,013 concurrently filed herewith, both applications being assigned to the assignee of the present invention and expressly incorporated herein by reference. The outputs of synchronous logic section **51** are utilized to actuate or run the various elements of the machine which have to be precisely timed.

As an example, the exposure lamp L must be triggered once every pitch interval and the pitch fadeout lamp P must be turned on and off at precisely timed intervals to discharge areas between the images formed on the photoreceptor belt. For example, at start-up, the pitch lamp is turned on by a print signal PR for a period of time to clean the belt of any residual images. Then the first image is flashed by applying a trigger signal pulse to the trigger circuit **57** of the flash lamp. This is designed to occur at a specific clock time, for example, clock pulse count signal **10**, or CPS **10**. Once set, flash occurs at CPS **10** for every pitch interval. As the leading edge of the image reaches the pitch fadeout lamp, the lamp must be turned off. This may occur at CPS **110** or **100** clock pulse signals after flashing of lamp L. After the image passes the pitch lamp P is turned on again, for example, at CPS **750**, to coincide with the trailing edge of the image. To implement the aforementioned operation, suitable logic network such as AND gate **61**, inhibit gate **63**, latch **65**, are shown operatively connected in FIG. 3A. It is to be understood that the logic network is merely schematically shown to illustrate the logical operation involved. For the more detailed description of the aforedescribed control circuits, one may refer to the aforementioned applications and to U.S. application Ser. No. 445,013 concurrently filed herewith, assigned to the asignee of the instant case and expressly incorporated herein by reference. It is evident from the foregoing that the pitch lamp P be turned on and off at the correct time interval to provide accurate pitch fadeout operation.

It is an aspect of the present invention to provide a suitable diagnostic means for testing the machine functions, especially those events which require critical timing of the operational sequences or steps. FIG. 3A shows an exemplary embodiment of the diagnostic board **42** in schematic form. It is to be understood from the outset however that the circuit shown is for illustration and not to be construed to limit the scope of the present invention to such illustrated circuit only.

The board includes suitable circuitry having a coincidence gate **100**, two latches **101**, **103** and comparators **105** and **107** connected operatively so that the gate **100** allows clock pulses to go therethrough when the latch **101** is set and prevent passage of clock pulses when the latch **103** is set. Note that the latches **101** and **103** can and should be reset initially using any suitable reset signal via a switch means **109**. The reset signal could come from the reset or pitch pulse means **53** of the control means **44** via an input lead. The input pairs **112** and **113** and **116** and **117** are respectively connected to the positive or negative polarity terminals of the comparators **105**, **107**. The comparators may be any well known devices wherein when positive or negative going logic pulse or waves are provided to inputs of matching polarity, they will provide an output logic **1** or a set pulse. The input *a* of the AND gate **100** may be connected to any suitable clock source such as clock **36** of the machine.

Returning to the exposure lamp L and pitch fadeout lamp P operation, one can readily see the application of the present diagnostic board to test or measure the time interval between the firing of the flash lamp L and the turning on or off of the pitch fadeout lamp P. By connecting lead *a* of the AND gate **100** to the clock **36**, the input **112** to the exposure trigger signal path **62** and the input **117** to the output of the inhibit gate **63**, the measurement between flashing of the exposure lamp at time t_0 (FIG. 3B) and turning off the pitch fadeout lamp P at time t_1 is made in terms of the clock count pulses. The clock pulses pass through the AND gate between the time the latch is set, ie. its Q output goes to logical **1** in response to the flash pulse applied to set lead *s* via lead **112** and comparator **105**, and the time latch **103** sets when the inhibit gate output **63** goes negative at t_1 as the pitch fadeout lamp is turned off. The count may be registered in the counter to the output of the AND gate **100**.

The operator can readily measure the time between the exposure flash and turning off the pitch fadeout lamp using the diagnostic board armed with specific knowledge as to what the time interval should be comparing it with the actual measured time interval. The operator is then able to determine whether machine is functioning properly or not and take necessary appropriate measures.

As another example, if for any reason the serviceman finds it necessary to determine the length of time or the number of pulses between images that the pitch fadeout lamp is on, he would be instructed by his service manual to connect lead **112** to the line between inhibit gate **63** and the pitch lamp and also connect lead **117** to the same point. Thus, the positive signal received through lead **112** upon initiation or energization of the pitch lamp would cause latch **101** to set and allow passage of clock pulses to the counter. Upon de-energization of the lamp P, the latch **103** would be set to prevent further passage of clock pulses to the counter. Thus, the resulting count registered on the counter would be the number of clock pulses during which the lamp was energized.

While the timing of flash and pitch fadeout has been used to describe the subject invention, it can be seen that the diagnostic board may be utilized to determine timing sequences of any timed function of the machine, for example, the number of pulses after flash at which a copy sheet is fed from the paper supply to the transfer station to assure that the copy sheet arrives at the transfer station in synchronism with the developed image on the belt for transfer of the image to the copy sheet, etc. While only a few examples have been mentioned, it should be readily apparent that any two intervals of timed events signified by changes in the signal from one

to another level or polarity can be measured by using the present circuit board.

Thus, by use of a simple diagnostic board, the copy counter on the printing machine may be utilized when necessary as a pulse counter to determine if the various machine operations and events are occurring at the desired pulse produced by the control pulse generator.

While we have described a preferred embodiment of our invention, it is to be understood that the invention is not limited thereto, but may be otherwise embodied within the scope of the following claims.

What is claimed is:

1. In an electrostatic printing apparatus for reproducing copies of an original having a plurality of processing stations arranged for producing toner images of the original and the production of fixed toner images on copy sheets, and sheet feed means for feeding copy sheets through the apparatus, the improvement comprising:

a pulse producing means to produce a series of pulses for use as timing signals,

control means connected to said pulse producing means to generate control signals for activating one or more of the processing stations at preselected pulses in said series;

counter means for registering the number of copies produced by the apparatus;

detachably connected testing means for inhibiting said counter means from registering the number of copies produced and for interconnecting said pulse producing means, said control means, and said counter means to cause said counter means to count the number of pulses passing through said testing circuit means from said pulse producing means to said counting means during a copy cycle; and,

interrupting means for stopping said pulse from reaching said counting means after said control means generates one of said control signals.

2. An electrostatic printing apparatus for producing copies of an original including:

a plurality of electrostatic processing stations for producing toner images of the original for transfer to suitable copy paper;

paper feed means for feeding copy paper through the apparatus for transfer of the toner image thereto;

a pulse generator for providing a series of discrete pulses;

control means connected to said pulse generator to generate control signals for activating said processing stations and said paper feed means at preselected pulses in said series to produce toner images and provide for proper registration of the toner images on the copy paper;

counter means for registering the number of copies produced by the apparatus;

testing circuit means detachably connectable to said counter means, said pulse generator and said control means for inhibiting said counter means from registering the number of copies produced and for causing said counter means to count the number of pulses passing through said testing circuit means from said pulse generator to said counting means during a copy cycle; and,

interrupting means to prevent passage of pulses to said counting means after said control means generates one of said control signals.

3. An electrostatic printing apparatus for reproducing copies of an original on a movable photoconductive member including:

a plurality of processing stations for producing a developed image of the original on the photoconductive member;

drive means for moving the photoconductive member past said processing stations;

paper feeding and transporting means for passing paper through the apparatus for producing copies of the original thereon;

monitoring means for determining proper positioning of the copy paper throughout its path of travel through the apparatus;

a pulse generator for producing a series of discrete pulses in synchronism with said drive mechanism for each copy to be produced;

control means connected to said pulse generator to activate said processing stations, said paper feeding and transporting means, and said monitoring means at preselected pulses in said series to provide proper sequencing of the apparatus functions;

counter means for registering the number of copies produced by the apparatus;

testing circuit means detachably connectable to said counter means, said pulse generator and said control means for inhibiting said counter means from registering the number of copies produced and for causing said counter means to count the number of pulses passing through said testing circuit means from said pulse generator to said counting means during a copying cycle from a first preselected control signal from said control means; and,

interrupting means to prevent passage of pulses to said counting means after said control means generates a second, preselected control signal.

4. An electrostatic printing apparatus for reproducing copies of an original including:

an imaging member,

a plurality of processing stations for producing an image of the original on said imaging member;

paper feeding and transporting means for passing paper through the apparatus for receiving images of the original from said imaging member;

a drive mechanism for driving said imaging member;

monitoring means for determining proper positioning of the copy paper throughout its path of travel through the apparatus;

a pulse generator for producing a series of discrete pulses in synchronism with said drive mechanism of the apparatus for each copy to be produced;

control means connected to said pulse generator to activate said processing stations, said paper feeding and transporting means and said monitoring means at preselected pulses in said series to provide proper sequencing of the apparatus functions; and,

counter means connected to said control means and said pulse generator to register the numbers of the pulses in the pulse series at which said control means activates said processing stations, said paper feeding and transporting means and said monitoring means.

5. In an electrostatic printing apparatus for reproducing copies of an original having a plurality of processing stations arranged for producing toner images of the original on copy paper and paper feed means for feed-

ing copy paper through the apparatus, the improvement including:

means for producing a series of pulses utilizable in the control of one or more of the processing stations,

control means connected to said pulse producing means for activating one or more of the processing stations at preselected pulses in said series,

counter means for registering the number of copies produced by the apparatus; and,

testing circuit means, detachably connectable to said pulse producing means, said control means and said counter means for inhibiting said counter means from registering the number of copies produced and for causing counter means to count the number of pulses produced by said pulse generator from the initiation of a copy cycle to the activation of at least one of said processing stations or said paper feed means.

6. In an electrostatic printing apparatus for reproducing copies of an original having a plurality of processing stations for producing copies of the original and sheet feeding and transporting means for passing sheets through the machine for producing copies of the original thereon, the improvement including:

monitoring means for determining proper positioning of the copy sheets throughout their path of travel through the apparatus;

a pulse generator for producing a discrete series of pulses for each copy to be produced;

control means connected to said pulse generator to activate one or more of the processing stations, the paper feeding and transporting means and said monitoring means at preselected pulses to provide proper sequencing of the apparatus functions; and,

counter means connected to said control means and said pulse generator to register the number of the pulse in the pulse series at which said control means activates said processing stations, and paper feeding and transporting means and said monitoring means.

* * * * *