United States Patent [19]

Drake

[11] **3,740,937**

[45] **June 26, 1973**

[54] **END-DOWN DETECTING MEANS FOR AUTOMATIC YARN PIECING APPARATUS**

[75] Inventor: **William H. Drake,** Clemson, S.C.

[73] Assignee: **Maremont Corporation,** Chicago, Ill.

[22] Filed: **Oct. 26, 1971**

[21] Appl. No.: **192,210**

[52] **U.S. Cl.** ..... **57/34 R,** 57/81, 250/219 R

[51] **Int. Cl.** **D01h 15/00**

[58] **Field of Search** ..... 57/34 R, 52, 53, 57/54, 80, 81, 156; 250/219 R

[56] **References Cited**

UNITED STATES PATENTS

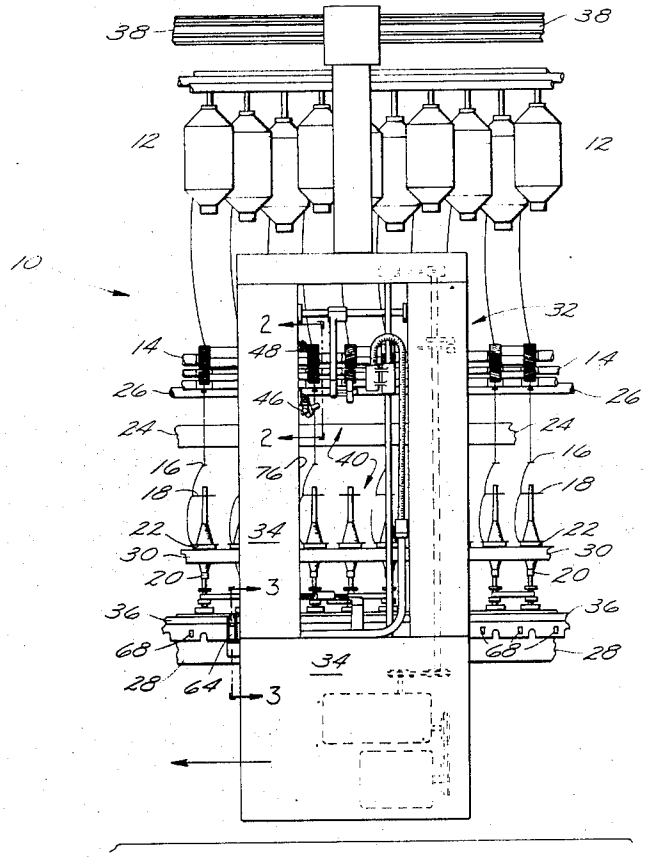
3,486,319	12/1969	Lee, Jr. et al.	57/34 R
3,498,039	3/1970	Kent et al.	57/34 R
3,638,412	2/1972	Rebsamen	57/52
3,659,409	5/1972	Saunders	57/34 R
3,672,143	6/1972	Whitney	57/53
3,680,298	8/1972	Saunders	57/34 R
3,680,299	8/1972	Lee, Jr.	57/34 R

Primary Examiner—John Petrakes
Attorney—Joseph H. Heard

[57] **ABSTRACT**

First and second photoelectric units mounted upon the carriage of an automatic yarn piecing apparatus movable along a textile spinning frame respectively detect whether the carriage is adjacent a yarn delivery zone of the spinning frame and whether yarn is present within each such zone. Variations from a pre-established norm in the photoelectric outputs of the units are converted into signals directed to a correlating circuit which includes a bistable memory device. The correlating circuit is effective to actuate a nand-gate type of control device that initiates a cycle of operation of the piecing apparatus when the carriage is in operative adjacent relationship to a yarn delivery zone wherein no yarn is detected. The correlating circuit may be temporarily disabled when desired, by inhibiting its memory device and as when the carriage of the piecing apparatus moves past an end of a spinning frame, to negate the possibility of a piecing operation being then inadvertently initiated. Inexpensive, durable and compact electrical components and circuits are employed to conserve space, to minimize manufacturing cost and maintenance, and to insure consistently reliable operation under adverse operating conditions. The successful use of a conventional phototransistor and light source in the photoelectric yarn-detection unit is achieved by restrictively limiting the vision of the phototransistor to a particular area of the spinning frame and by subjecting its electrical output to high-gain amplification, preferably in the approximate order of **50,000** times, prior to signal-conversion thereof.

16 Claims, 4 Drawing Figures



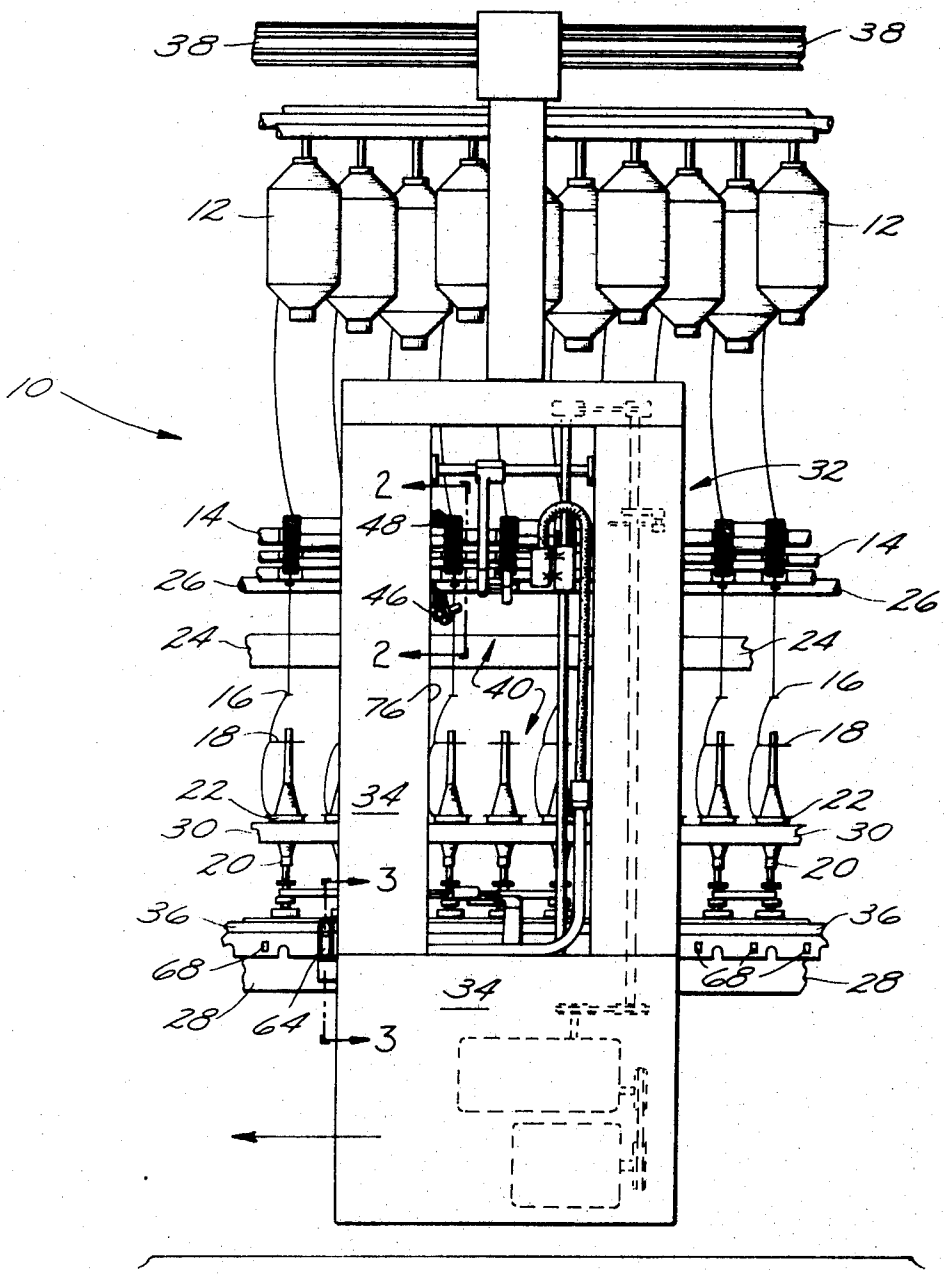


Fig. 1

INVENTOR.
WILLIAM H. DRAKE

BY Joseph H. Mears

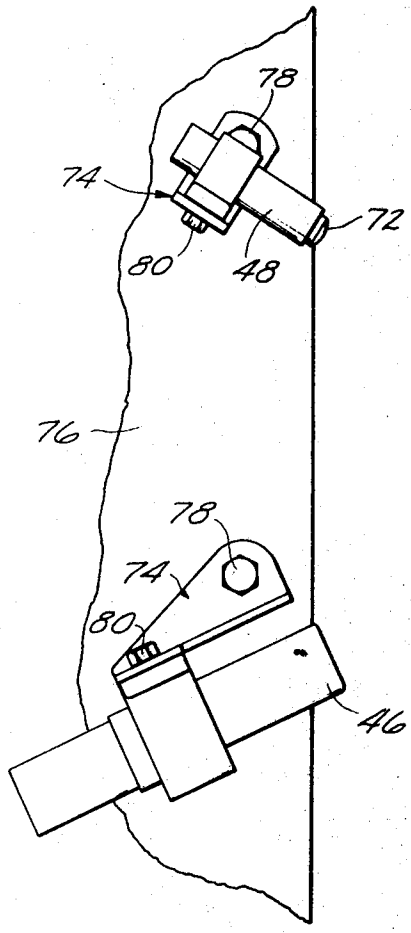
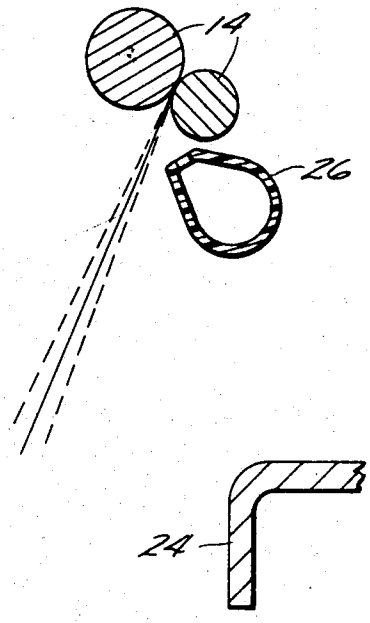


Fig. 2



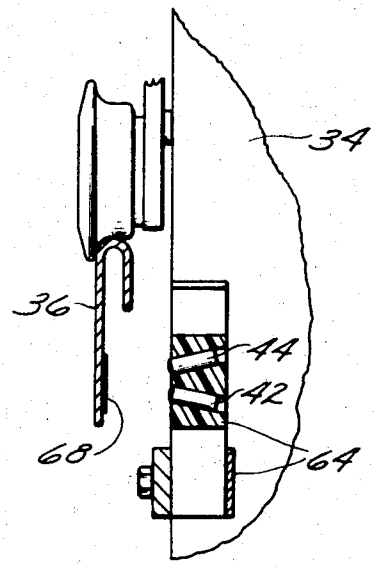


Fig. 3

INVENTOR.
WILLIAM H. DRAKE

BY

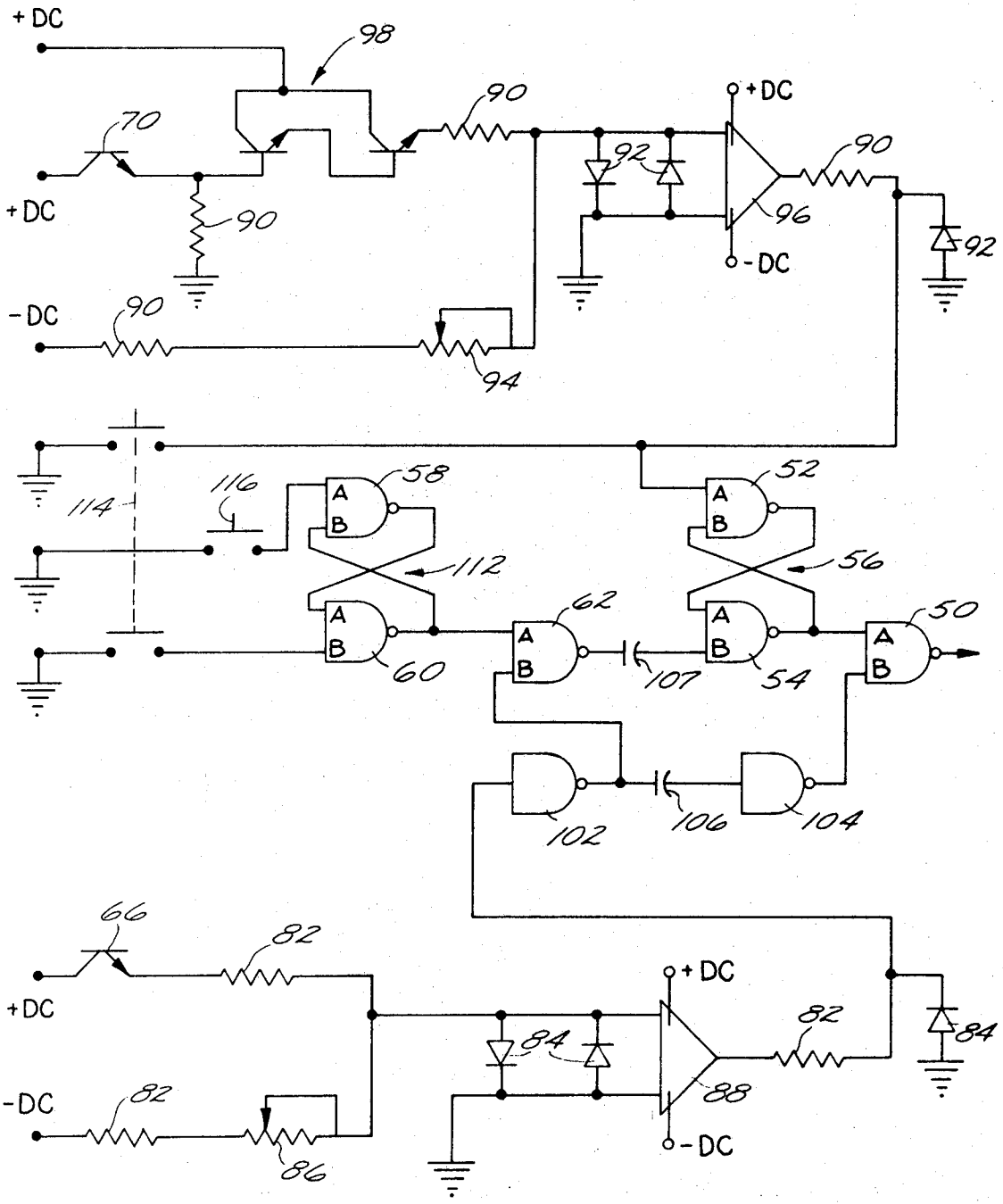


Fig. 4

INVENTOR.
WILLIAM H. DRAKE

BY Joseph A. Heard

END-DOWN DETECTING MEANS FOR AUTOMATIC YARN PIECING APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to the end-down servicing of textile spinning frames or like machines by automatic yarn piecing apparatuses, of which various illustrative types are disclosed in U.S. Pat. Nos. Re. 26,230, 3,486,319, 3,498,039 and 3,540,200.

Such apparatus customarily includes a mobile carriage which moves along at least one spinning frame having a plurality of yarn delivery zones spaced longitudinally thereof. At each delivery zone which is inoperative due to the existence of an end-down or broken-yarn condition, the carriage is halted and the yarn discontinuity is eliminated, in any one of several possible ways, by suitable piecing or yarn-joining instrumentalities mounted upon the carriage. Upon completion of each piecing operation, the carriage resumes its movement and moves on to the next yarn delivery zone requiring end-down servicing.

As is apparent from the foregoing, a basic prerequisite to automatic operation of a yarn piecing apparatus is reliable detection of those yarn delivery zones at which an end-down condition exits. The present invention is directed to an improved end-down detecting means, of the type employing photoelectric components, for an automatic yarn piecing apparatus.

The use of photoelectric end-down detecting means in association with a carriage movable along one or more spinning frames has heretofore been proposed not only in association with yarn piecing apparatuses, but also in connection with end-down monitoring devices which perform no piecing function: see, e.g., U. S. Pat. Nos. 3,099,829, 3,430,426 and 3,595,004. The requisite features of end-down detectors for such monitoring devices are not, however, precisely the same as those required in a detector for a yarn piecing apparatus. Thus, while malfunction of the detector of a mere monitoring device may cause such device to register an erroneous count and/or improperly actuate or fail to actuate an alarm, no great harm is likely to ensue from such results. On the other hand, if the end-down detector of an automatic yarn piecing apparatus malfunctions and causes such apparatus to commence a piecing operation at an improper location, extensive damage may and likely will be done to the apparatus and/or to the spinning frame being serviced. It is therefore most important that an end-down detector for an automatic yarn piecing apparatus possess a very high degree of reliability in operation, not only initially but also throughout the useful life of the apparatus. If such result is to be realized, the operation of the end-down detector for such an apparatus should rely as little as possible upon the use of mechanical-type switches, switch actuators, relays and like components which tend to fail after a period of use due to wear or, in some instances, due to exposure to the oft-times humid and lint-congested atmosphere prevalent within many textile spinning mills. The use of vacuum tubes and other expensive, delicate and or bulky components should also be avoided. The shocks and impacts generated or received by a yarn piecing apparatus, as for instance by chance encounters with movable spinning-frame cleaning equipment, tend to quickly render such components inoperative. Additionally, since a yarn piecing apparatus must of necessity carry a relatively large number of piecing instrumentalities within a confined space, and since such apparatuses cannot service as large a number of spinning frames as a mere monitoring device, the cost and size of the components employed in end-down detector are of considerable significance and must be minimized insofar as possible.

Although acceptable in end-down detectors for certain types of monitoring devices, the use of timers should also be avoided in a detector for a yarn piecing apparatus. The patroling carriage of a mere monitoring device may move continuously at a uniform velocity along each spinning frame which it services. The location of the carriage in relation to each yarn delivery zone of the spinning frame or frames may therefore be ascertained, with a degree of accuracy sufficient at least for a monitoring device, by a timing process. The carriage of a piecing apparatus, on the other hand, must necessarily decelerate and stop, and thereafter accelerate and start, at each randomly-located yarn delivery zone requiring end-down servicing. An end-down detector which determines carriage location by a timing process and by reliance upon a constant rate of carriage movement therefore does not possess the degree of reliability necessary in a yarn piecing apparatus. Due to the previously-mentioned serious consequences which are capable of ensuing from malfunction of the end-down detector of an automatic yarn piecing apparatus, it is decidedly preferable for such a detector to be a condition-responsive, rather than time-responsive, in all aspects of its operation.

While some consideration has been given various of the foregoing factors in previously proposed photoelectric end-down detectors for yarn piecing apparatuses, a need exists for such a detector which fully possesses each of the required characteristics of reliability, durability, economy and compactness.

OBJECTS OF THE INVENTION

With the foregoing in mind, the primary object of the present invention is the provision, in an automatic yarn piecing apparatus, of an improved end-down detector which is highly reliable in operation both initially and after extensive use; which is of a durable construction not easily adversely affected by shocks, impacts or exposure to a humid and lint-congested atmosphere; which is economical from the viewpoint both of initial cost and subsequent maintainence; and which is of such a compact construction as to not in any way impede the mounting or operation of the various piecing instrumentalities of the apparatus.

A related and more specific object of the invention is the provision of such an end-down detector which employs solid-state and integrated-circuit electrical components, including a plurality of nand-gate coincidence units or devices, virtually exclusively, and which is free from a vacuum tubes, oscilators tuned amplifiers, mechanical switches and switch actuators, relays and similar components which would tend to detract from the desired reliability, durability, compactness, and/or economy of the detector.

Another related and more specific object is the provision, in an apparatus of the type described, of photoelectric yarn-detecting and signal-producing means comprised of a conventional light source, a standard photo-transistor device and other components of equally simple, durable, inexpensive and compact con-

struction, which are so positioned and interconnected as to produce an operating reliability and efficiency equal or superior to that achieved with more expensive, delicate and/or bulky components such as photomultiplier tubes, modulated light sources, tuned amplifiers, and the like.

Still another object is the provision, in association with the electrical circuitry of an end-down detector for a yarn piecing apparatus, of means by which the detector can be readily disabled when desired, as for instance upon movement of the carriage of the apparatus past an end portion of a spinning frame, and thereafter can be restored with equal facility to normal operation.

SUMMARY OF THE INVENTION

With the foregoing objects in mind, the present invention provides, in association with the carriage of an automatic yarn piecing apparatus movable along a textile spinning frame or like machine having a plurality of yarn delivery zones spaced along its length, first and second photoelectric signal-producing means for independently detecting whether the carriage of the apparatus is in adjacent relationship to one of the yarn delivery zones of the spinning frame and whether yarn is present within a particular area of each of such zones; a nand-gate (i.e., "not and") type of control device effective when actuated to initiate a piecing operation of the apparatus, and so actuable by the coincidental receipt of actuating-type input signals at each of two input terminals thereof; and signal-correlating circuit means interconnecting the aforesaid first and second signal-producing means and the control device for actuating the latter when no yarn is detected by the second photoelectric means within a yarn delivery zone detected by the first photoelectric means. The signal-correlating circuit includes a bistable memory device effective only when in a first operating condition to produce an actuating-type signal at one of the input terminals of the control device. Such memory device, which is comprised of suitably interconnected nand-gate units, is caused to assume or maintain its aforesaid first condition upon the detection by the first photoelectric means of the yarn delivery zone, and assumes its second condition only if yarn is detected within such zone by the second photoelectric means. The signal-correlating means further includes a branch circuit interconnecting the other input terminal of the control device and the first photoelectric means, and effective to produce an actuating-type signal at the other input terminal of the control device upon cessation of detection of the yarn delivery zone by the first photoelectric means. If no yarn is present within the yarn delivery zone, the production of the aforesaid signal actuates the control device and thereby causes the initiation of a yarn piecing operation.

The control device and all nand-gate units of the signal-correlating means are of intergrated circuit construction, and no mechanical switches, relays or timers are utilized.

In the preferred embodiment of the invention, inhibiting means is also provided to temporarily inhibit the memory device of the signal-correlating circuit when desired, as for instance upon movement of the carriage of the apparatus past an end portion of a spinning frame. When inhibited, the memory device is maintained in its second operating condition, irrespective of signals produced by the first photoelectric means, and the control device is therefore rendered incapable of initiating a cycle of operation of the piecing apparatus. The inhibiting means is comprised primarily of nand-gate components similar to those employed in the signal-correlating circuit, and may be placed into and out of effect with facility.

The first and second signal-producing photoelectric means each includes a standard light-producing unit, a light-receiving unit of the phototransistor type, a potentiometer for balancing the output of the phototransistor so as to compensate for ambient light conditions, and a differential amplifier for producing an electrical signal in response to variations in the balanced output of the phototransistor. In the case of the first photoelectric means, which detects whether the carriage is adjacent a yarn delivery zone of the spinning frame, the light-producing and light-receiving units may be and are mounted quite closely to the supporting track upon which the carriage of the apparatus moves along the spinning frame. A plurality of light-reflective strips, which correspond in number and spacing to the yarn delivery zones of the spinning frame, are provided upon such track. As the carriage of the piecing apparatus moves along the track, its passage into initial proximity with a yarn delivery zone of the spinning frame is reliably detected by a corresponding one of the strips reflecting the light beam of the light-producing unit to the phototransistor of the light-receiver. The cessation of reflection of light from the strip, which occurs as the light-producing and light-receiving units continue to move with the carriage along the track, is also "seen" by the phototransistor and signifies with equal reliability that the carriage has passed that location within which the second photoelectric detecting means should have detected whether yarn was present within the delivery zone of the spinning frame.

The highly reliable operation of the first photoelectric means, utilizing only the conventional and relatively inexpensive components described above, is realized in large part by mounting of the light-producing and receiving units thereof in quite close confronting relationship, preferably within approximately one-half inch, to the carriage-supporting track and the reflective strips provided thereon. In the case of the second photoelectric means, which detects whether yarn is present within each delivery zone of the spinning frame, reliability of operation cannot be achieved in the same manner but nevertheless is realized without the use of bulky, highly sophisticated or expensive components.

The light-producing and light-receiving units of the second photoelectric means are similar to those described above and are adjustably mounted upon the carriage of the piecing apparatus, in vertically spaced and angularly inclined relationship to each other, for precise focusing upon an area of the spinning frame closely beneath the front or yarn-delivery pair of its drafting rolls. At such location fluctuations in the path of travel of yarn issuing from the delivery rolls, which fluctuations are occasioned by the customary vertical movement of certain of the spinning-frame components, are of minimal scope and a "dead" or empty space exists rearwardly of the yarn path and between the suction-duct and roller beam of the spinning frame. To permit effective utilization of the aforesaid target stability and prominence at the location in question, the inherently narrow field of vision of the phototransistor component of the light-receiving unit is further

restricted by the lense component of such unit, preferably so as to encompass an arc of only approximately four degrees. While the output of the phototransistor of the light-receiving is extremely small under the described conditions, such output provides a highly reliable indication of whether yarn is present within the field of vision of the phototransistor and is capable of being greatly amplified without the normally-attendant "noise" or interference problems which would otherwise frustrate such amplification. Accordingly, in accordance with the present invention, the phototransistor output is subjected to exceedingly high-gain amplification, which is preferably in the approximate order of 50,000 times and is achieved by the use of a two-stage Darlington-type amplifier. The thus-amplified phototransistor output is utilized in the remainder of the circuit of the second signal-producing means in substantially the same manner as the output of the phototransistor of the first signal-producing means is employed in the previously-described circuitry thereof.

DESCRIPTION OF THE DRAWINGS

Other features and advantages of the invention will be apparent from the following description of a preferred embodiment thereof, which should be read in conjunction with the accompanying drawings, in which:

FIG. 1 is a rear elevational view of an automatic yarn piecing apparatus mounted upon a fragmentarily-shown textile spinning frame or like machine and equipped with end-down detecting means in accordance with the invention;

FIG. 2 is an enlarged view, partially in elevation and partially in vertical section, taken substantially along line 2—2 of FIG. 1 and showing one set of light producing and receiving units of the end-down detecting means, together with immediately adjacent components of the piecing apparatus and the spinning frame;

FIG. 3 is an enlarged view, partially in elevation and partially in vertical section, taken substantially along line 3—3 of FIG. 1 and showing another set of light producing and receiving units of the end-down detecting means, together with immediately adjacent components of the piecing apparatus and the spinning frame; and

FIG. 4 is a schematic showing of the electrical circuitry of the end-down detecting means.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The spinning machine **10** fragmentarily shown in FIG. 1 is of a conventional type having a plurality of yarn delivery zones spaced along each of its opposite sides. At each delivery zone of machine **10** yarn as roving normally passes downwardly from creel **12** through sets of drafting rolls **14**, a guide number **16**, and a control ring **18** to twist-inserting collecting means in the form of a rotating spindle-bobbin assembly **20** encircled by a spinning ring **22**. On the side of spinning machine **10** fragmentarily shown in FIG. **1**, drafting rolls **14** are mounted upon a roller beam **24** and a conventional suction-duct **26** (also shown in FIG. 2) is provided beneath the front or delivery pair of such rolls: All spindles of the spindle-bobbin assemblies **20** are supported by a stationary spindle rail **28**, while all spinning rings **22** are supported by a ring rail **30**. As is well known to those skilled in the art, ring rail **30**, control rings **18** and guide members **16** are moved vertically during operation of machine **10** to traverse the yarn longitudinally of spindle-bobbin assemblies **20** as it is collected thereby. The same arrangement of components is present on the opposite side of machine **10** not shown in FIG. **1**.

The yarn piecing apparatus **32** shown in FIG. 1 comprises a mobile carriage **34** mounted as by a track **36** and overhead rail **38** for patrolling movement, illustratively in the leftward direction indicated by the arrow in FIG. **1**, longitudinally of and closely adjacent at least the illustrated one side of spinning machine **10**, to any one of its yarn delivery zones requiring servicing by reason of an end-down condition thereat. In lieu of the foregoing carriage **10** might of course be contructed so as to patrol in the opposite direction, or alternately in both directions, and normally would be so mounted as to be capable of movement along and servicing of more than a single side of one spinning machine **10**.

Upon arrival of carriage **34** adjacent a yarn delivery zone of machine **10** at which an end-down condition is detected, a cycle operation of apparatus **32** is initiated. Upon initiation of each such cycle of operation, carriage **34** is halted in operative adjacent relationship to the yarn delivery zone requiring servicing, and suitable piecing instrumentalities mounted within the open center section **40** of carriage **34** repair the yarn discontinuity, after which movement of the carriage is resumed. The mechanisms and instrumentalities employed for halting carriage **34** and for repairing the yarn discontinuity may be of various types and form no part per se of the present invention, which is directed to improved means for detecting end-down conditions at the various yarn delivery zones of spinning machine **10** and for initiating the aforesaid cycles of operation of apparatus **32**.

Referring now also to FIGS. **2–4**, such means generally comprises first photoelectric signal-producing means, which includes the respective light-producing and light-receiving units **42,44** best shown in FIG. **3**, for detecting whether carriage **34** of piecing apparatus **32** is in adjacent relationship to a yarn delivery zone of spinning machine **10**; second photoelectric signal-producing means, including the respective light-producing and light-receiving units **46,48** best shown in FIG. **2**, for detecting whether yarn is present within an area of each such delivery zone closely adjacent the front or delivery pair of rolls **14** of machine **10**; a nand-gate control device identified in FIG. **4** by the numeral **50**, effective when actuated by the coincidental receipt of actuating-type input signals at both input terminals A,B thereof to initiate a cycle of operation of apparatus **32**; signal-correlating circuit means, including a pair of nand units **52,54** (FIG. **4**) so interconnected as to form a bistable memory device **56**, interconnecting the aforesaid first and second signal-producing means and control device **50** for actuating device **50** when no yarn is detected by units **46,48** within a yarn delivery zone detected by units **42,44**; and means including additional nand units **58,60** and **62** for, when suitably actuated, inhibiting memory device **56** and thereby rendering control device **50** temporarily incapable of instituting a cycle of operation of apparatus **32**. All of the various nand units are of integrated circuit construction, and illustratively are each of the type which produces a low output signal only upon the coincidental receipt of high input signals at both inputs thereof.

As is shown in FIGS. 1 & 3, light-producing and receiving units 42,44 are mounted by a suitable bracket 64, which extends outwardly from carriage 34 in the direction of its patrolling movement, closely adjacent carriage-supporting track 36, the distance between units 42,44 and track 36 preferably being no more than approximately one-half inch. Both units 42,44 are of an inexpensive and commercially-available construction, including a generally cylindrical housing having a lense at one end thereof. Within the housings of units 42,44 there are respectively mounted a light bulb (not shown) and a phototransistor 66 (schematically shown in FIG. 4) of standard types. Units 42, 44 are mounted in non-parallel relationship to one another (FIG. 3), such that the light beam emitted from unit 42 is received by unit 44 if reflected from the adjacent surface of track 36. To at desired times produce such reflection of the light beam, a plurality of reflective areas are provided upon the aforesaid surface of track 36, as by affixing strips 68 (FIGS. 1 & 3) of reflective tape or foil thereto. The number and spacing of strips 68 along track 36 corresponds, in a manner which will be made more apparent hereinafter, to the number and spacing of the yarn delivery zones of spinning machine 10.

Referring now to FIGS. 1 & 2, the second set of light-producing and receiving units 46, 48 are of generally the same inexpensive and simple construction as the units 42, 44 previously described. Units 46 includes a conventional light source (not shown) within its housing, for producing unmodulated light of only medium intensity, while the housing of unit 48 encloses a conventional phototransistor 70 (schematically shown in FIG. 4). The inherently rather-limited field of vision of phototransistor 70 is further restricted by lense 72 of unit 46 so as to encompass an arc of only approximately four degrees. Brackets 74 respectively mount units 46, 48 in vertically-spaced and substantially coplanar relationship to each other at a location within section 40 of carriage 34 closely adjacent the inner wall 76 of the leading (in relation to the direction of carriage movement) side section of carriage 34. Each bracket 74 includes a first section secured to wall 76 by a bolt 78, and a second section secured to the first section by a bolt 80 and encircling the housing of the corresponding unit 46 or 48. By loosening the bolts 76, 78 of its bracket 74, the position of either unit 46, 48 can be pivotally adjusted, as desired and independently of the other unit, about either or both of the bolt axes.

The aforesaid adjustment capability is desirable since, in accordance with the present invention, units 46,48 are precisely aimed toward a particular area of spinning machine 10 immediately below the front or delivery pair of its drafting rolls 14. More specifically, and as is shown in FIG. 2, unit 48 is positioned so that its path of vision extends angularly downwardly toward and substantially normal to the usual path of travel of yarn issuing from delivery rolls 14, and on the opposite or rearward side of such yarn-path extends in closely adjacent but downwardly-spaced relationship to the suction duct 26 underlying delivery rolls 14 and into the "dead" space between duct 26 and roller beam 24. Light-producing unit 46 directs its beam of light upwardly at an angle such as to cause any yarn present at the aforesaid location to reflect light to unit 48, and as to discourage the receipt by unit 48 of whatever light might be reflected from those components of spinning machine 10 disposed rearwardly of the yarn path of travel.

The aforesaid arrangement is significant in that fluctuations of the path of travel of yarn issuing from delivery rolls 14, which fluctuations are indicated by the dash lines in FIG. 2 and necessarily ensue from the previously-mentioned movement of certain yarn-engaging components of spinning machine 10, are of a minimum magnitude closely adjacent delivery rolls 14. The yarn closely adjacent such rolls therefore provides a "target" which, although quite small, is sufficiently stable as to be capable of photoelectric detection without the use of modulated and/or high-intensity light. By reason of its restrictive scope and downward inclination, the vision of unit 48 can be precisely aimed at the aforesaid relatively stable "target," with minimum possibility of the unit receiving reflected light other than from yarn thereat, as from suction-duct 26 or other components of spinning machine 10. The upward inclination of unit 46, and its location in vertically spaced and substantially co-planar relationship to unit 48, also contribute to the aforesaid result. The overall effect of the foregoing is for the receipt or non-receipt of reflected light by unit 48 to accurately indicate, with an exceedingly high degree of reliability, whether yarn is or is not issuing from delivery rolls 14 at the particular location beneath their nip and along their length then viewed by unit 48.

The relative spacing of units 42,44 and 46,48 and of reflective strips 68 is such that, as carriage 34 moves into proximity with each yarn delivery zone of machine 10, light is reflected from a corresponding one of the strips 68 to unit 44 (FIG. 3). Each strip 68 is sufficiently long that light continues to be reflected therefrom to unit 44 as the further movement of carriage 34 transports units 46,48 (FIG. 2) to and through that location within the yarn delivery zone at which unit 48 will receive reflected light from yarn issuing from delivery rolls 14, if any such yarn is present within the zone. Further movement of carriage 34 transports units 42,44 beyond the aforesaid strip 68, whereupon the light beam produced by unit 42 ceases to be reflected to unit 44. If prior to the cessation of the receipt of reflected light by unit 44, the light beam produced by unit 46 was in fact reflected to unit 48 from yarn within the subject delivery zone of machine 10, carriage 34 should continue its patrolling movement without interruption. If, however, an end-down condition at the delivery zone causes the light from unit 46 to not be reflected to unit 48 prior to the passage of units 42,44 beyond reflective strip 68, a cycle of piecing operation of apparatus 32 should be instituted.

Before describing the electrical circuitry by which the foregoing results are achieved, it should be noted that units 42,44 and 46,48 are mounted forwardly, in relation to the direction of movement of carriage 34, of the piecing instrumentalities within open center section 40 of the carriage. This permits carriage 34 to be decelerated and halted, without the necessity of reversing its movement and without subjecting any of its components to undue stress, with the aforesaid piecing instrumentalities located in desired operative relationship to the yarn delivery zone at which an end-down condition is detected in the manner described.

FIG. 4, to which reference is now made, schematically illustrates the electrical circuitry by which a piecing cycle of operation of apparatus 32 is initiated when

no yarn is detected by unit **48** within a yarn delivery zone detected by unit **44.** Phototransistor **66** of unit **44** forms part of a first signal-producing subcircuit shown at the lower portion of FIG. **4** and further including current-limiting fixed resistors **82,** clamping diodes **84,** a potentiometer **86** and a differential amplifier **88.** Resistors **82** and diodes **86** protect other components of the circuit from damage by limiting the current and voltage at selected locations within the circuit to safe magnitudes. Potentiometer **86** permits balancing of the positive output voltage of phototransistor **66** against a fixed negative voltage. Potentiometer **86** is adjusted such that when photo-transistor **66** "sees" only ambient light, differential amplifier **88** receives a low (negative or zero) input voltage and produces a high (positive) output signal; but when phototransistor **66** receives light reflected by a strip **68** from light-producing unit **42** (FIG. **3**), and thereupon increases its output, differential amplifier **88** receives a high voltage input and produces a low (negative or zero) output signal.

The second signal-producing subcircuit, which includes phototransistor **70** of unit **48** and is shown at the upper portion of FIG. **4,** is similar to that described above in its inclusion of resistors **90,** clamping diodes **92,** a potentiometer **94,** and a differential amplifier **96,** all which of which perform the same basic functions as the corresponding components of the first signal-producing subcircuit. The two subcircuits differ significantly in one important respect, however. Due to the relatively shielded location of units **42,44** and their extremely close proximity to reflective strips **68** (FIGS. **1** & **3**), the output of phototransistor **66** is sufficiently great to reliably insure the described production of signals by amplifier **88.** The output of phototransistor **70** is, in comparison, much smaller than that of phototransistor **66,** due to units **46,48** necessarily being mounted in a more exposed location and directed toward a smaller, more distant and less reflective target. As an additional component, therefore the second signal-producing circuit further includes a two-stage Darlington-type amplifier **98,** which subjects the relatively weak output of phototransistor **70** to exceedingly high-gain amplification, such amplification preferably being in the approximate order of 50,000 times. While it might be expected that such high-gain amplification would be frustrated by "noise" or background interference, such is not the case due, apparently, at least in significant part, to the vision of phototransistor **70** being restricted in scope and precisely focused as previously described herein. The thus-amplified positive-voltage output of phototransistor **70** may be and is utilized in the second signal-producing subcircuit in the same manner as the unamplified output of phototransistor **66** is employed in the first subcircuit, that is, the amplified output of phototransistor **70** is balanced by potentiometer **94** against a fixed negative voltage, such that differential amplifier **96** produces a high output when phototransistor sees only ambient light, and produces a low (negative or zero) output when the light beam of unit **46** (FIG. **2**) impinges upon yarn and is reflected thereby to phototransistor **70.**

Referring now particularly to the signal-correlating circuit shown in the center-right portion of FIG. **4,** the output side of differential amplifier **96** is directly connected to one input of bistable memory device **56,** specifically to input A of its nand unit **52,** and the output of device **56** is directed to and received by input terminal A of control device **50.** The output side of differential amplifier **88** is connected to the second input of control device **50** by a branch circuit including signal everters **102,104** and a capacitor **106** therebetween, and is additionally connected to the second input (terminal B of nand **54**) of memory device **56** through signal everter **102,** input terminal B of nand unit **62,** and a capacitor **107.** As noted previously herein, memory device **56** is effective in a first one of its bistable operating conditions to produce an actuating-type input signal at control device **50,** specifically at input A thereof, but is ineffective in the second of its operating conditions to produce an actuating-type signal at control device **50.** In the present illustrative embodiment of the invention, control device **50** is actuated and initiates a cycle of piecing operation of apparatus **32** only when both inputs of the device are high, at which time its output becomes low. Memory device **56** therefore is effective in its first operating condition to produce a high input signal at terminal A of control device **50,** and in its second operating condition to produce only a low signal.

Condition changes of memory device **56** of course occur only in response to signal variations at alternate ones of its two inputs (i.e., input A of nand **52** and input B of nand **54**). Thus, if device **56** changed from its first to its second bistable condition in response to a signal variation at input A of its nand **52,** a change back to its first bistable condition is producible only by a signal variation at input B of its nand **54.** It therefore follows that by prohibiting variations in the signal at its aforesaid terminal B, memory device **56** can be inhibited and prevented from assuming its first operating condition.

As has been previously noted, nand **62** comprises part of means for inhibiting, as aforesaid and at desired times, memory device **56.** Such inhibiting means further includes (see the left-center portion of FIG. **4**) a second memory device **112,** which is similar to memory device **56** and is comprised of suitably interconnected nand-gates **58,60,** and a pair or normally-open switch elements **114,116.** The output of memory device **112** is normally high, and is received by input A of nand **62.** Closure of switch **114** grounds one input (terminal B of nand **60**) of device **112,** thereby changing its output to low and producing the desired inhibiting action in a manner described more fully hereinafter, and simultaneously grounds one input (terminal A of nand **52**) of memory device **52.** Closure of switch **116** grounds the other input (terminal A of nand **58**) of device **112** and "resets" the same by thereby causing its output to again become high.

OPERATION OF THE PREFERRED EMBODIMENT

While carriage **34** of apparatus **32** is intermediate delivery zones of spinning machine **10** and phototransistors **66, 70** are therefore both receiving only ambient light, the outputs of amplifiers **88,96** are both high, as noticed previously herein. The signal-conditions elsewhere in the FIG **4** circuit at this time are as follows. Both inputs of nand **58** are high, which causes its output and input A of nand **60** to be low. Input B of nand **60** is high, as is its output and therefore input A of nand **62.** Input B of nand **62** is low, as required by the then high input to everter **102** and its consequential low output. The combination of high and low inputs to nand **62** causes its output to be high. Both inputs of nand **54** of memory device **56** are high, which causes its output

and the input at terminal A of control device **50** to be low: that is, memory device **56** is in its second operating condition. Input A of nand **52** is high, in accordance with the then high output of amplifier **96**, while input B of nand **52** is low, in accordance with the output of nand **54**. The output of nand **52** of course has the same condition, that is high, as input A of nand **54**. The input to everter **104** is high, this being possible notwithstanding the then low output of everter **102** due to the capacitor **106** therebetween, which causes the output of everter **104** and input B of control device **50** to be low. Since both inputs of control device **50** are low, its output is high and ineffective to initiate a cycle of operation of apparatus **32**. As noted previously, device **50** initiates a cycle of operation only upon a coincidental receipt of high input signals at both of its input terminals, at which time its output becomes low.

When movement of carriage **34** brings units **42,44** to a position where light is reflected from the former to the latter by one of the reflective strips **68** (FIG. **3**), the output of amplifier **88** and therefore the input to everter **102** change from high to low. This change in input of everter **102** changes its output, and therefore input B of nand **62**, from low to high. The combination of two high inputs at nand **62** changes its output from high to low, whereupon capacitor **107** discharges. This in turn causes input B of nand **54** of memory device **56** to momentarily change from high to low, whereupon memory device **56** assumes its first bistable operating condition and produces a high or actuating-type input at terminal A of control device **50**. The output of control device **50** does not change, however, since input B thereof remains low due to the continued low output of everter **104**.

Further movement of carriage next brings units **46,48** to a position where light is reflected from the former to the latter by yarn issuing from delivery rolls **14** (FIG. **2**), if any such yarn is present within the delivery zone in question. Assuming yarn is present, the output of amplifier **96** and therefore the input to terminal A of nand **52** of memory device **56** change from low to high. This causes memory device **56** to again assume its second operating condition and produce a low input at terminal A of control device **50**. The combination of two low inputs at control device **50** of course does not change its output, which remains high.

Due to the continued movement of carriage **34**, the aforesaid yarn is only momentarily within the field of vision of phototransistor **70** of light-receiving unit **48**. The output of amplifier **96** therefore quickly again becomes high, as phototransistor **70** sees only ambient light. The resulting high input at terminal A of nand **52** of memory device **56** does not cause another change in the operating condition of the memory device, however, since the immediately-preceding condition change of device **56** resulted from a signal variation at the same input thereof.

The final step in the sequence of operation occurs as continued movement of carriage **34** transports units **42,44** beyond the reflective strip **68** theretofore reflecting light from the former unit to the latter one. When this occurs the output of amplifier **88**, and therefore the input of everter **102**, change to high. The output of everter **102**, and therefore input B of nand **62**, change to low. The then-present combination of high and low inputs at nand **62** causes its output to become high. Since capacitor **107** does not discharge, however, no signal variation occurs at input terminal B of nand **54** of control device **56**. Device **56** therefore remains in its second operating condition, and input A of control device **50** remains low. The output of control device **50** thus remains high, even though input B thereof momentarily changes to high as the previously noted change in output of everter **102**, from high to low, causes capacitor **106** to discharge and thereby produces a momentary low input and high output at everter **104**.

Following recharging of capacitor **106**, which transpires immediately and automatically after its aforesaid discharge, the entire FIG. **4** circuit is again in its original state and therefore is ready for passage of carriage **34** into proximity with the next-adjacent yarn delivery zone of machine **10**.

At a yarn delivery zone whereat an end-down condition exists, the first of the previously-described changes in the state of the FIG. **4** circuit will again occur. That is, the change to low in the output of amplifier **88**, resulting from phototransistor **66** "seeing" the reflective strip **68** associated with the yarn delivery zone, causes memory device **56** to assume its first operating condition and produce a high input at terminal A of control device **50**. No further changes occur as further movement of carriage **34** transports units **46,48** through that location within the zone at which yarn would normally by "seen" by phototransistor **70** of unit **48**, due to the end-down condition within the zone. Input A of control device **50** is therefore still high when phototransistor **66** no longer "sees" reflective strip **68**, and input B of control device **50** momentarily goes high. The coincidental receipt of two high inputs actuates control device **50**, which produces a low output effective to initiate a cycle of operation of piecing apparatus **32** at the yarn delivery zone requiring end-down servicing.

As noted previously herein, the locations of units **42,44** and **46,48** upon carriage **34** of apparatus **32** are such as to permit carriage **34** to be non-abruptly decelerated and halted, upon the detection as aforesaid of an end-down, with its centrally-mounted piecing instrumentalities in proper operative relationship to the yarn delivery zone requiring servicing. Reverse movement of carriage **34** is not required.

Upon the completion by apparatus **32** of the piecing operation and the resumption of movement of its carriage **34**, the overall state of the FIG. **4** circuit will be the same as that ordinarily possessed by it only immediately after phototransistor **66** "sees" a reflective strip **68**. That is, memory device **56** will be in its first operating condition. This does change the previously described sequence of operation, however, except in the fact that memory device **56** merely maintains, rather than assumes, its first operating condition when phototransistor **66** "sees" the next reflective strip **68**.

Momentary closure of double-contact switch **114** disables the FIG. **4** circuit and prohibits all possability at desired times, as when carriage **34** is moving past an end of spinning machine **10**, of a cycle of operation of apparatus **32** being instituted. The closure of one contact of switch **114** grounds and therefore produces a low signal at input A of nand **52** of memory device **56**. Such signal causes memory device **56** to assume its second operating condition if, contrary to the normal situation, the memory device is not already in its second condition. The simultaneous closure of the other contact of switch **114** grounds and therefore produces a

low signal at input B of memory device **112**. This causes the output of device **112**, and therefore input A of nand **62**, to change from high to low. For so long as input A of nand **62** remains low, its output and therefore input B of nand **54** of memory device **56** must remain high, irrespective of variations in the signals produced by amplifier **88**. Memory device **56** is therefore inhibited and prevented from assuming its first bistable operating condition, and control device **50** cannot be actuated.

Termination of the period of inhibition of memory device **56** is effected, when desired and with equal facility, by momentary closure of "reset" switch **116**. This grounds and produces a low input at terminal A of nand **58** of device **112**, causing the output of device **112** and input A of nand **62** to change once again to high. Switches **114,116** may of course be constructed for automatic actuation, at desired times and as by suitable photoelectric means (not shown) provided in association therewith, in a particular use-environment of apparatus **32**.

While a preferred embodiment of the invention has been shown and described, this was for purposes of illustration only, and not for purposes of limitation.

That which is claimed is:

1. In an automatic yarn piecing apparatus adapted to service a textile spinning frame having a plurality of horizontally spaced yarn delivery zones whereat yarn normally passes downwardly from delivery rolls and past a suction duct to yarn collecting means, said apparatus including a carriage adapted to move along said spinning frame and to be halted upon institution of piecing operations adjacent yarn-delivery zones requiring servicing by reason of an end-down condition thereat, improved means for detecting said end-down conditions and for initiating said piecing operations, comprising:

first photoelectric signal-producing means for detecting whether said carriage is adjacent a yarn delivery zone of said spinning frame;

second photoelectric signal-producing means for detecting whether yarn is present within an area of each said zone closely adjacent said delivery rolls of said spinning frame;

a nand-gate control device effective when actuated to produce an output signal initiating a piecing operation, said device having a pair of input terminals and being actuated by the coincidental receipt of actuating-type input signals at each of said terminals;

and signal-correlating circuit means interconnecting said first and second signal-producing means and said control device for actuating said control device when no yarn is detected by said second means within a yarn delivery zone detected by said first means.

2. Apparatus as in claim **1**, wherein said signal-correlating means includes a bistable memory device effective in a first operating condition to produce an actuating-type signal at one of said input terminals of said control device and ineffective in a second operating condition to produce an actuating-type signal at said one input terminal of said control device; said memory device assuming or maintaining said first condition thereof upon detection by said first means of a yarn delivery zone and assuming said second condition upon yarn-detection by said second means.

3. Apparatus as in claim **2**, wherein said signal-correlating means further includes a branch circuit interconnecting the other of said input terminals of said control device and said means for producing an actuating-type signal at said other input terminal of said control device upon cessation of the detection of a yarn delivery zone by said first means.

4. Apparatus as in claim **3**, wherein said branch circuit includes capacitor means and signal-everting means for limiting the time of production of said actuating-type signal at said other input terminal of said control device.

5. Apparatus as in claim **2**, and further including inhibiting means effective when actuated to inhibit said memory device and maintain the same in said second condition thereof irrespective of signals produced by said first signal-producing means.

6. Apparatus as in claim **5**, wherein said inhibiting means includes a nand-type unit within that portion of said signal-correlating circuit interconnecting said first signal-producing means and said memory device, said nand-type unit normally varying its output in response to signal variations of said first means and upon actuation of said inhibiting means being rendered unresponsive to signal-variations of said first means.

7. Apparatus as in claim **6**, wherein said nand-type unit has a pair of input terminals and said first signal-producing is connected to one of said input terminals, and wherein said inhibiting means further includes a bistable memory unit connected to the other of said input terminals of said nand-type unit, said nand-type unit varying its output in response to signal-variations of said first means when said memory unit is in a first operating condition and said nand-type unit being unresponsive to signal-variations of said first means when said memory unit is in a second operating condition, and switch means for varying as desired the operating condition of said memory unit.

8. Apparatus as in claim **1**, wherein said second signal-producing means includes a light-producing unit and a light-receiving unit mounted upon said carriage in vertically-spaced relationship to each other, the path of vision of said light-receiving unit extending through and substantially normal to the ordinary path of travel of yarn issuing from said delivery rolls of said spinning frame and projecting beyond said path of travel in closely adjacent but downwardly-spaced relationship to said suction duct of said spinning frame.

9. Apparatus as in claim **8**, including means mounting said light-receiving unit and said light-producing unit upon said carriage for independent positional adjustment of each said unit about either of two axes.

10. Apparatus as in claim **8**, wherein said light-receiving unit comprises a phototransistor device having a narrow field of vision, and lense means for further narrowing said field of vision of said phototransistor device.

11. Apparatus as in claim **10**, wherein said second signal-producing means further includes Darlington-type amplifier means for subjecting the output of said phototransistor device to high-gain amplification.

12. Apparatus as in claim **11**, wherein the high-gain amplification of said output of said phototransistor device is in the approximate order of 50,000.

13. Apparatus as in claim **11**, wherein said second signal-producing means further includes potentiometer means for balancing the output of said Darlington-type

amplifier as required to compensate for ambient light conditions at said phototransistor device, and a signal-producing differential amplifier connected in series with said Darlington-type amplifier and responsive to uncompensated for variations in output thereof.

14. Apparatus as in claim **1**, and further including track means carried by an extending longitudinally of said spinning frame and mounting said carriage of said piecing apparatus for movement therealong, light reflecting means upon said track means corresponding in number and spacing to said yarn delivery zones of said spinning frame, said first signal-producing means including a light-producing unit and a light-receiving unit mounted upon said carriage in closely adjacent confronting relationship to said track means for cooperation with said reflecting means during movement of said carriage along said track means.

15. Apparatus as in claim **14**, within said light-receiving means includes a phototransistor, and said first signal-producing means includes potentiometer means balancing the output of said phototransistor to compensate for ambient light conditions thereat, and a differential amplifier connected in series with said phototransistor and responsive to uncompensated for variations in said output.

16. Apparatus as in claim **14**, wherein said reflecting means comprises a reflective strip for each of said delivery zones of said spinning machine, and said signal-producing means is responsive to movement of said units thereof both into and out of confronting relationship with each said reflective strip.

* * * * *