March 28, 1967 H. K. KING 3,311,224

ARTICLE-SPACING INSPECTION SYSTEM

Filed Nov. 29, 1963 2 Sheets-Sheet 1

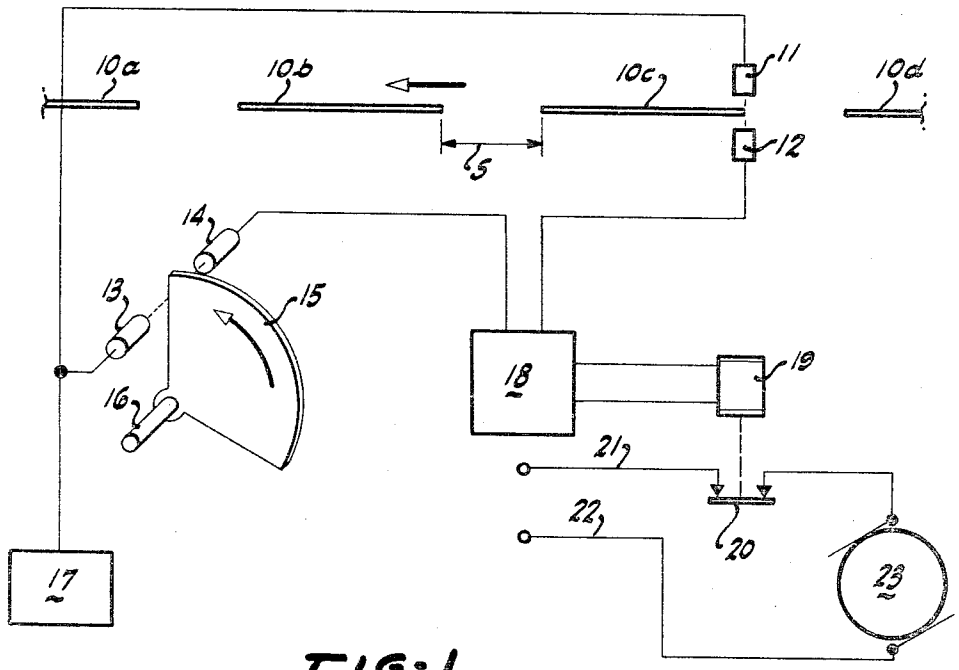


FIG-1

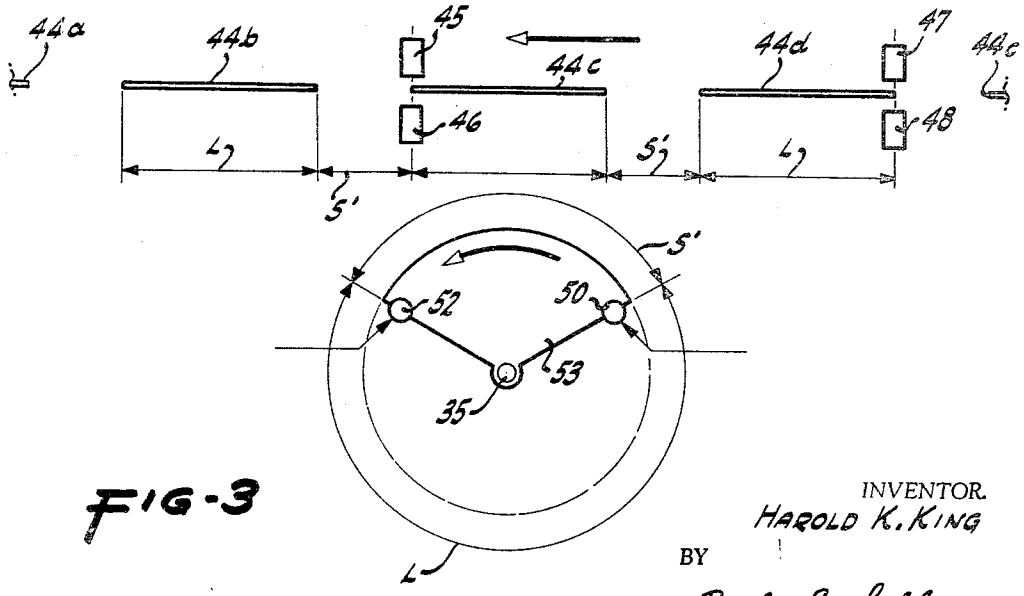


FIG-3

INVENTOR.
HAROLD K. KING

BY

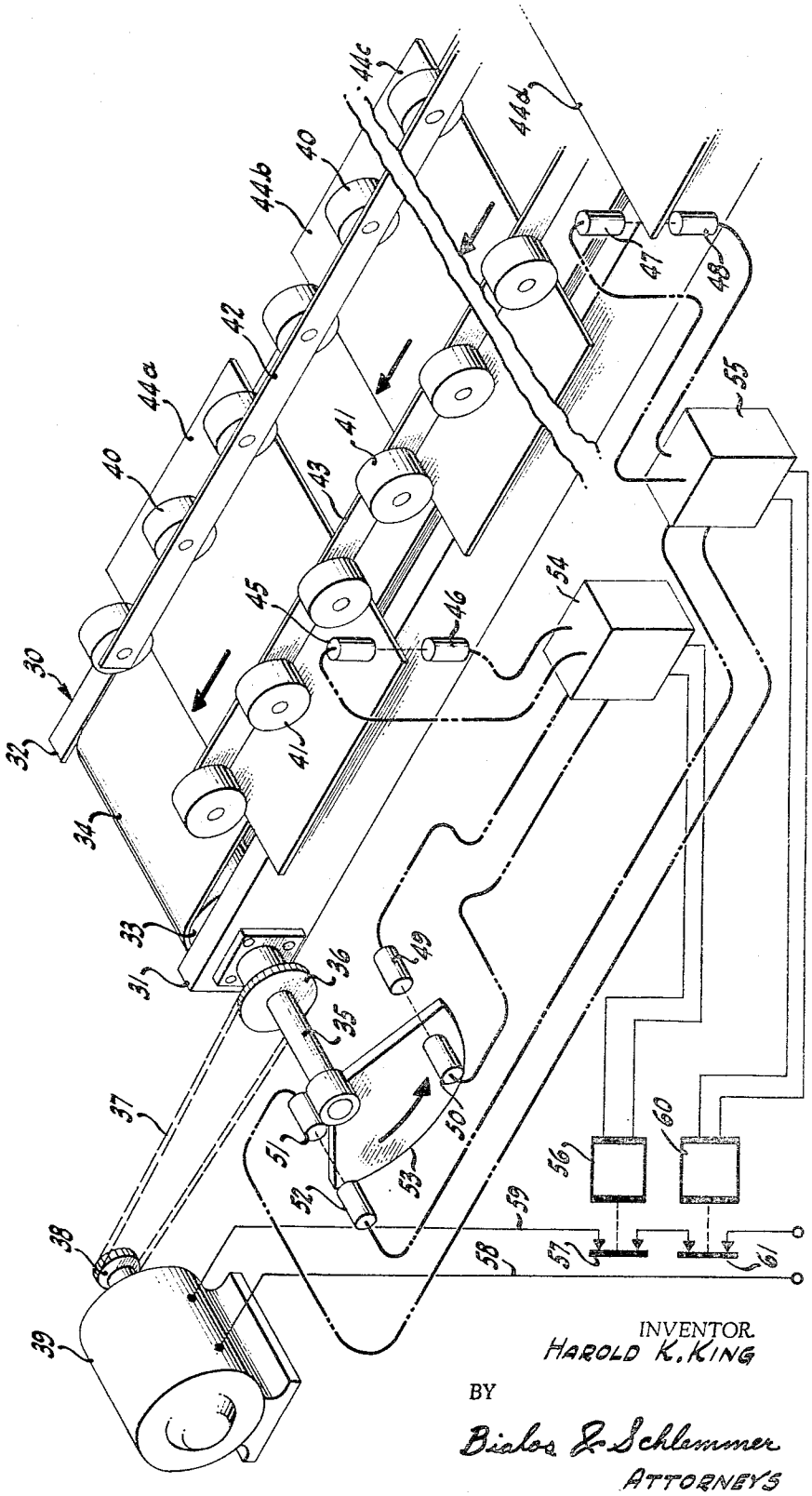
Bialos & Schlemmer
ATTORNEYS

March 28, 1967 H. K. KING 3,311,224

ARTICLE-SPACING INSPECTION SYSTEM

Filed Nov. 29, 1963 2 Sheets-Sheet 2

FIG. 2



INVENTOR.
HAROLD K. KING

BY

Bialos & Schlemmer

ATTORNEYS

United States Patent Office 3,311,224 Patented Mar. 28, 1967

3,311,224

ARTICLE-SPACING INSPECTION SYSTEM

Harold K. King, Los Angeles, Calif., assignor to Crown Zellerbach Corporation, San Francisco, Calif., a corporation of Nevada

Filed Nov. 29, 1963, Ser. No. 326,748
20 Claims. (Cl. 198—232)

This invention relates to an article-spacing inspection system and, more particularly, to apparatus for and a method of policing a succession of articles being advanced along a path to terminate the advancement of such articles if the spacing therebetween deviates significantly from a predetermined norm.

In the production of various articles, it is necessary to advance the same from one station to another at each of which an operation is performed that contributes to the fabrication of the completed article. In many cases, the articles are advanced in succession at relatively high speeds by appropriate conveying systems, and the articles should be maintained in proper spaced apart relation in order that the operation at each station can be performed successfully. A specific example is in the manufacture of paperboard boxes wherein paperboard sheets are cut to size, scored, slotted when necessary, folded, and glued at various stations along an assembly line.

It is not uncommon in the fabrication of such boxes to have jam-ups occur, especially in the folding operations in which the blanks are progressively folded into box form as they are advanced by a conveyor along a predetermined path. In a typical production line, the occurrence of a jam-up often damages as many as 20 partially formed boxes or blanks and requires from three to fifteen minutes to clear, depending upon how quickly the conveyor line can be shut down after the occurrence of a jam-up.

A potential jam-up along a production line of this general type can often be anticipated by detecting a change in position of one article in relation to the articles respectively leading and trailing the same, and systems of this character have been proposed in the prior art. An example thereof is found in Grover Patent No. 2,158,069, in which a plurality of light sources are spaced apart along a conveyor and are angularly disposed so that the light therefrom converges toward and is incident upon a photoelectric cell. The spacing between the converging light beams is so related to the spacing between successive articles that only one beam is interrupted at any particular time if the spacing between successive articles is proper. However, should a jam-up occur, all of the light beams are interrupted by the articles and the conveyor system is then deenergized. Another example is found in Broido Patent No. 2,946,992, in which a plurality of light beams are directed across a conveyor advancing articles therealong in spaced apart succession. Such light beams are all intended to be incident upon photoelectric means at certain times if the spacing between the articles is proper; but if the spacing between the articles becomes abnormal and any one light beam is interrupted when it would not otherwise be, the conveyor is deenergized.

An object of the present invention, among others, is in the provision of an improved inspection system in which a non-variable reference is employed to provide a positive indication of where one article should be with respect to another at any particular instant. In the system, a pair of energy-transmitting and -receiving units are provided—one of which is an inspection unit arranged with a conveyor so that a succession of articles being advanced therealong in spaced apart relation interrupt an inspecting energy-beam only when each such

article in turn is in alignment therewith, and the other of which is a control unit arranged with an interrupter cyclically movable in timed relation with the advancement of articles along such conveyor so as to interrupt a control energy-beam only during those intervals that the inspection beam should be aligned with a space between properly positioned articles. The cyclically movable interrupter provides the non-variable reference against which the placement of each article is gauged or measured; and should the spacing between the articles become improper, both the inspection beam and control beam are simultaneously interrupted and the conveyor is then deenergized. In the typical box production line referred to hereinbefore, utilizing the present inspection system, it has required only 10 to 40 seconds to clear a jam-up and the number of boxes or box blanks damaged has ranged from one to three for each jam-up.

Additional objects and advantages of the invention will become apparent as the specification proceeds.

Embodiments of the invention are illustrated in the accompanying drawings, in which:

FIGURE 1 is a diagrammatic view of an inspection system embodying the invention;

FIGURE 2 is a diagrammatic perspective view illustrating a variant form of inspection system in association with a conveyor; and

FIGURE 3 is a diagrammatic view illustrating the determination of the angular width of the interrupter in relation to the length of and spacing between articles.

The inspection system of FIGURE 1 is shown in association with a plurality of articles in the form of box blanks **10***a*, **10***b*, **10***c* and **10***d* being advanced along a predetermined path in the direction of the arrow by suitable conveyor means (not shown). Positioned along such path of advancement is an inspection unit comprising an energy transmitter **11** and an energy receiver **12** therefor. The transmitter **11** and receiver **12** are oriented so that the beam of energy directed therebetween is interrupted whenever one of the articles **10** passes therethrough. Also comprising a part of the system is a control unit including an energy transmitter **13** and an energy receiver **14** therefor.

An interrupter **15** is located so as to cyclically and repetitively intercept the energy beam directed from the transmitter **13** to the receiver **14** in timed relation with the advancement of such articles **10**; and in the form shown, such interrupter **15** is a generally wedge-shaped element supported upon a shaft **16** for rotation about the axis thereof in the direction of the arrow. The angular width of the interrupter **15** throughout that portion thereof which describes an arc intersecting the energy beam is substantially equal to the normal spacing between the successive articles **10**. For purposes of identification, such spacing is denoted by the dimension S.

The inspection and control transmitters **11** and **13** are connected to a power source **17** appropriate to effect energization thereof, and the receivers **12** and **14** are each connected to an amplifier **18**—the output of which is used to energize a solenoid **19** having a contact **20** connected in series with the power circuit **21**–**22** of a motor **23** which drives the conveyor used in advancing the articles **10**. So long as the solenoid **19** remains energized, the power circuit for the motor **23** is closed through the contact **20**, but deenergization of the solenoid **19** opens the contact **20** and the motor **23** is then deactuated.

The form of energy beam directed by the transmitters **11** and **13** toward the receivers **12** and **14** respectively associated therewith may be of any appropriate type as, for example, light energy—in which case the transmitters **11** and **13** will be light sources and the receivers **12** and

14 will be photoelectric cells such as multiplier phototubes. The power source 17 in such instance may be a convenience outlet supplying 115-volt alternating current to the light sources, and the amplifier 18 may be either a standard vacuum tube or transistorized amplification circuit operative to accept the signal outputs of the receivers 12 and 14 and provide an output current in response to either of sufficient magnitude to energize the solenoid 19.

However, in the specific systems illustrated and described herein, the energy form employed is vibratory energy in the ultrasonic frequency range; and the transmitters 11 and 13, receivers 12 and 14, and the amplifier 18 (as well as the power supply and control relay) are commercially available components supplied as a total system by the Delavan Manufacturing Company of West Des Moines, Iowa, under the trade name "Sonac Ultrasonic Sensor." The "General Purpose Assembly" model of such company has proven satisfactory. In such system, the transmitters and receivers are interchangeable and they should be connected with the amplifier and power source as directed in the manufacturer's specifications. Such system requires a 115-volt single-phase 60-cycle A.C. power source, and the power consumption is approximately one watt. The amplifier furnishes the electrical gain necessary to compensate for losses in the energy beam being transmitted from the transmitters to the receivers, and all of the units may be hermetically sealed when purchased so as to be both waterproof and explosion-proof.

Ultrasonic energy has proven to be superior to light energy in certain environments because ambient illumination and changes therein do not influence the system; and smoke, fumes, dust, etc. have little effect thereon. Also, the acoustic lenses of the ultrasonic system are substantially unaffected by mist from oil, ink, paint, or similar substances.

In operation of the system, the box blanks 10 are of known length and the spacing S therebetween should be a uniform predetermined distance. The interrupter 15—which, in the ultrasonic system, is formed of a material substantially impervious to the transmission of ultrasonic energy therethrough as, for example, a synthetic plastic sold under the trade name "Micarta"—is timed with the rate of advancement of the articles 10 so as to make one complete 360° revolution for the passage of one complete space and adjacent article through the inspecting energy beam directed from the transmitter 11 to the receiver 12. Further, the interrupter 15 is so oriented that it intercepts the control energy beam passing from the transmitter 13 to the receiver 14 whenever a space between adjacent box blanks 10 is or should be aligned with the inspecting energy beam passing from the transmitter 11 to the receiver 12 and, as stated hereinbefore, the angular width of the interrupter 15 is essentially equal to the dimension of a normal space or the distance S.

Consequently, and considering the relative orientation shown in FIGURE 1 as a starting condition, the space between the adjacent box blanks 10*c* and 10*d* is commencing to become aligned with the energy beam passing between the inspection transmitter 11 and receiver 12, and the interrupter 15 is commencing to intercept the energy beam passing between the control transmitter 13 and receiver 14. These conditions pertain, with the inspection unit looking at the space between the box blanks and the control unit looking at the interrupter 15, until the box blank 10*d* commences to interrupt the energy beam passing from the inspection transmitter 11 to the receiver 12. At this time, the interrupter 15 has advanced from its leading edge to the trailing edge thereof through the energy beam passing from the control transmitter 13 to the receiver 14, and is about to discontinue its interruption of such energy beam.

Subsequently, the next box blank 10*d* in its advancement interrupts the energy beam passing from the inspection transmitter 11 to the receiver 12; and throughout the entire period that it is so intercepting this beam, the interrupter 15 is remote from the energy beam passing from the control transmitter 13 to the receiver 14 and is not in a position to interrupt the same. When the box blank 10*d* has passed completely through the inspection energy beam and such beam is commencing to be transmitted through the space defined between the box blank 10*d* and the blank following the same, the interrupter 15 is again in the position illustrated and the cycle is repeated.

So long as either one or the other of the receivers 12 and 14 is being energized by the energy beam incident thereon from the respectively associated transmitters, the output of the amplifier 18 is sufficient to maintain the solenoid 19 in an actuated state and the power circuit of the drive motor 23 is completed through the contact 20. Thus, the conveyor handling the box blanks 10 continues to advance the same. However, if the normal spacing between the successive box blanks 10 changes significantly so that the inspection beam passing from the transmitter 11 to the receiver 12 is interrupted by a box blank at the same time that the interrupter 15 is intercepting the control beam passing from the transmitter 13 to the receiver 14, the output of the amplifier 18 will then be insufficient to maintain the solenoid 19 in an actuated state, the contact 20 will open the power circuit to the motor 23, and the conveyor will cease to advance the box blanks.

Such change in the relative position of the successive box blanks is an indication that a jam-up has occurred or may be commencing; and as an example of how it can cause a change in the relative position of the box blanks, consider a situation in which the advancement of the box blank 10*a* is terminated due to its misalignment or because it is prevented from advancing by engagement thereof with a prior box blank. The box blank 10*b* will continue to advance until it abuts the blank 10*a*; and similarly, the blank 10*c* will advance until it abuts the blank 10*b*, and so on. At such time, the blank 10*d* or the next succeeding blank will be in alignment with the inspection unit and will prevent the transmission of energy from the transmitter 11 to the receiver 12. As soon as the interrupter 15 comes into alignment with the control unit, it will terminate the transmission of energy from the transmitter 13 to the receiver 14. With both receivers deenergized, the solenoid 19 is deactuated and will cause the contact 20 to open with the result that the conveyor will be shut down.

The angular velocity of the interrupter 15 is readily synchronized with the rate of advancement of the box blanks 10 by driving the interrupter from the motor 23 or from the conveyor powered thereby. With such an arrangement, the velocity of the interrupter is automatically synchronized with the movement of the conveyor and, therefore, with the rate of advancement of the box blanks. Quite evidently, the inspection unit comprising the transmitter 11 and receiver 12 is advantageously located along the conveyor system wherever a jam-up is most likely to occur so that this potential trouble spot is directly policed and the corrective response to a jam-up most rapid.

The modified inspection system of FIGURE 2 is shown in association with an illustrative conveyor 30 comprising a pair of transversely spaced frame elements or supports 31 and 32 having a drive roller 33 extending therebetween. The drive roller 33 is rotatably supported, and entrained thereabout is an endless belt 34. The roller 33 is equipped with a shaft 35 extending laterally outwardly beyond the frame element 31, and mounted thereon is a sprocket 36 having a drive chain 37 entrained thereabout. The drive chain 37 is engaged by a drive sprocket 38 driven by an appropriate prime mover in the form of an electric motor 39.

Arranged above the belt 34 are a plurality of idler rollers oriented in two groups, respectively designated with the numerals 40 and 41, appropriately supported on frame components 42 and 43. The idler rollers 40 and 41 are operative to hold articles placed thereunder in engagement with the belt 34 so that such articles are advanced thereby, and in FIGURE 2 a plurality of articles in the form of box blanks are shown in position to be advanced by the conveyor in the direction of the arrows. For purposes of identification, the boxes are denoted with the numerals 44*a*, 44*b*, 44*c* and 44*d*.

The inspection system is arranged with the conveyor 30 so as to police the spacing (between the articles 44 being advanced thereby along a predetermined path) at two different locations along the conveyor, as indicated by the break shown in the illustrative conveyor. Such locations may be distinct from each other and unrelated in a specific sense of cooperation; and ordinarily, their placement will be chosen to correspond to points at which jam-ups commonly occur. The system includes a pair of inspection units—one of which comprises an energy transmitter 45 and an energy receiver 46 therefor, and the other of which also comprises an energy transmitter 47 and an energy receiver 48 therefor. The transmitters 45 and 47 are oriented so that the beams of energy respectively directed thereby toward the receivers 46 and 48 are interrupted whenever one of the articles 44 passes therethrough.

Also comprising a part of the system are a pair of control units—one of which includes an energy transmitter 49 and an energy receiver 50 therefor, and the other of which also includes an energy transmitter 51 and an energy receiver 52 therefor. A single interrupter 53 is located so as to cyclically and repetitively interrupt the energy beams directed from the transmitters 49 and 51 to the receivers 50 and 52 in timed relation with the advancement of the articles 44. In the form shown, the interrupter 53 is a generally wedge-shaped element supported upon the shaft 35 so as to be rotated thereby in the direction of the arrow. The angular width of the interrupter 53 throughout that portion thereof which describes an arc intersecting the control energy beams, and the positioning of the two control units, bear a particular relationship to the length of and spacing between the articles 44 and will be described in detail in connection with FIGURE 3.

The inspection transmitters 45 and 47 are respectively connected to control boxes 54 and 55, as are the control transmitters 49 and 51. In a similar manner, the inspection receivers 46 and 48 are connected to the control boxes 54 and 55, as are the control receivers 50 and 52. The control boxes include a power supply and are connected to a 115-volt alternating current outlet by suitable electric conductors (not shown). In addition to providing a power supply, each of the control boxes 54 and 55 includes an amplifier that receives the outputs from the respectively associated energy receivers, and the outputs of the amplifiers are respectively connected (as shown) to a solenoid 56 having a contact 57 connected in series with the power circuit 58–59 for the motor 39 and to a solenoid 60 having a contact 61 also connected in series with the motor power circuit. So long as the solenoids 56 and 60 remain energized, the power circuit 58–59 is closed through the contacts 57 and 61, but if either of the solenoids is deenergized the power circuit is opened and the motor 39 deactuated.

As in the inspection system illustrated in FIGURE 1, the energy form employed is vibratory energy in the ultrasonic frequency range; and all of the transmitters, receivers and control boxes are commercially available components as heretofore indicated, and are interconnected as directed by the manufacturer thereof.

The angular width of the interrupter 53 (as shown in FIGURE 3) is substantially equal to the normal longitudinal distance S' between successive box blanks 44; and therefore, the exterior angular distance between the leading and trailing edges of the interrupter is essentially equal to the length L of each blank 44. The rate of rotation of the interrupter 53 is timed with the rate of advancement of the blanks 44 so as to make one complete 360° revolution for the passage of one complete space S' and adjacent box blank through the inspecting energy beam directed from the transmitter 45 to the receiver 46, and also for the passage of one complete space and adjacent box blank through the inspecting beam directed from the transmitter 47 to the receiver 48.

The interrupter is oriented so that it intercepts the control energy beam passing from the transmitter 49 to the receiver 50 whenever a space between adjacent box blanks 44 is or should be aligned with the inspecting beam passing from the transmitter 45 to the receiver 46, and so that it intercepts the control energy beam passing from the transmitter 51 to the receiver 52 whenever a space between adjacent box blanks 44 is or should be aligned with the inspecting beam passing from the transmitter 47 to the receiver 48. This result is achieved when the control units are angularly spaced from each other by a distance substantially equal to the space S', as shown in FIGURE 3, with the inspecting units positioned so that the beam of one thereof is commencing to be intercepted by a box blank when the other is commencing to face a space, and with the interrupter 53 located so that the leading and trailing edges thereof are substantially aligned with the control beams.

In operation of the apparatus shown in FIGURE 2, the motor 39 is energized and drives the shaft 35, which in turn rotates the belt roller 33 and interrupter 53, with the result that box blanks 44 are advanced in the direction of the arrows. Considering the relative orientation of the box blanks and components of the inspection system as shown in FIGURE 2, the inspection unit 45–46 is commencing to look at a space between the adjacent blanks 44*a* and 44*b*, and the energy beam of the associated control unit 49–50 is commencing to be intercepted by the interrupter 53. If the spacing between the adjacent boxes is normal, the interrupter 53 will have rotated to a position in which the trailing edge thereof is leaving the control beam at the time that the box blank 44*b* is commencing to interrupt the energy beam of the inspecting unit 45–46. Throughout the interval that the inspection beam is interrupted by the blank 44*b*, the interrupter 53 is remote from the energy beam passing from the control transmitter 49 to the receiver 50 and is not in a position to interrupt the same. When the box blank 44*b* has been advanced out of alignment with the energy beam of the inspection unit 45–46, the interrupter is again in the position illustrated in FIGURE 2, and the cycle is repated.

So long as either one or the other of the receivers 46 and 50 is being energized by the energy beam incident thereon from the respectively associated transmitters, the output of the amplifier contained within the component 54 is sufficient to maintain the solenoid 56 in an actuated state, and the power circuit for the drive motor 39 is completed through the contact 57, provided that the contact 61 is also closed. However, if the normal spacing between the successive blanks as viewed by the inspection unit 45–46 changes significantly so that the inspection beam passing from the transmitter 45 to the receiver 46 is interrupted by a box blank at the same time that the interrupter 53 is intercepting the control beam passing from the transmitter 49 to the receiver 50, the output of the amplifier contained within the component 54 will then be insufficient to maintain the solenoid 56 in an actuated state, the contact 57 will open the power circuit to the motor, and the conveyor 30 will cease to advance the box blanks.

In an identical manner, the inspection unit 47–48 will be looking at a box blank during those intervals that the interrupter 53 is remote from the energy beam passing from the control transmitter 51 to the receiver 52, and

will be looking at a space between adjacent box blanks during each interval that the associated control beam is being intercepted by the interrupter **53** so long as the relative orientation of the successive articles being inspected by the unit **47–48** is normal. If such spacing becomes abnormal so that both the inspection beam and control beam are simultaneously interrupted, the output of the amplifier comprised by the component **55** will be insufficient to maintain the solenoid **60** in an energized state, whereupon the contact **61** will be opened and the drive motor deactuated.

Evidently, the paired inspection and control units **45–46**, **49–50** and **47–48**, **51–52** are functionally connected in series with the drive motor **39** (which is evidenced by the series connection of the solenoid contacts **57** and **61** in the power circuit of the motor), with the result that a significant change in the relative position of adjacent articles at either inspection station will cause the conveyor to be deactuated and the advancement of articles **44** terminated. This system has the advantage of policing the article spacing at two different locations, each of which will ordinarily be a point at which jam-ups are most likely to occur; and as a consequence, the advancement of articles is quickly terminated if a jam-up occurs at either of such locations. Therefore, the severity of the damage that might otherwise be caused by a jam-up is minimized, as is the time required to clear the same. The system as shown in FIGURE 2 also has the advantage of employing a single interrupter **53** for a pair of control units although it is apparent that two separate interrupters in respective association with the two control units could be used since the two inspection units together with their respectively associated control units are functionally distinct and separate.

The systems illustrated and described herein have been found to be particularly successful in policing the spacing between box blanks especially on folder-gluers; and where two inspection units are employed as shown in FIGURE 2, locating one such unit before the first folding arm and the other after the second folding arm affords considerable anti-jam protection although the placement should be tailored to each individual installation. Similarly, the radius of the interrupter will be determined by the requirements of each installation. A minimum of slack or backlash should be provided in the drive for the interrupter in order to achieve best results.

Box blanks are relatively thin articles and the energy beams are capable of passing around the edges thereof. Therefore, the exact location of the inspection units must be adapted to the individual installation in order to properly cover or blank out the active area of the energy beam when it is being interrupted by a box blank and eliminate any wave lengths that may tend to by-pass the edge of the box blanks. It has been found that it is beneficial to transmit the energy beams angularly with respect to the receivers therefor; and as a specific example, an angular disposition of approximately 50° as respects the incidence of the beam upon the receiver therefor is quite effective.

Care should be exercised in each installation to prevent ultrasonic energy from being transmitted from one cable to another either directly or through components of the conveyor apparatus which might result in false responses, and also to prevent the beam from being reflected from unrelated but adjacent surfaces for the same reason. It is best where possible to use separate conduits from each unit to the associated control box, and the distances therebetween should usually be kept close enough to avoid splicing the shielded conductors. A by-pass switch may be included in the circuitry in parallel with the solenoid contacts to permit the conveyor apparatus to be jogged for removal of a misaligned or improperly positioned box blank. Curved tubing can be employed to route the energy beams if space limitations require that the transmitters and/or receivers be remotely located from the transmission path of the energy beam across the conveyor. If the system is used on kicker feed machines running many different sizes of boxes, it will be best to have the inspection energy beams oriented so as to view a space just ahead of each leading edge of a box.

In the event that the motor circuit is not already equipped with indicia means (visual and/or audible signal devices) to signal an interruption therein, such means are readily provided in association with the solenoid **19** (or either of the solenoids **56** and **60**) by having the movable contact thereof close a pair of normally open fixed contacts in series with the power circuit of such indicia means whenever the solenoid is deenergized. Evidently, the solenoid could be wholly removed from the motor circuit and used solely to actuate such indicia means in those instances in which it is not desired to automatically stop the advancement of articles when the paired inspection and control beams are concurrently interrupted.

While in the foregoing specification embodiments of the invention have been set forth in considerable detail for purposes of making an adequate disclosure thereof, it will be apparent to those skilled in the art that numerous changes may be made in such details without departing from the spirit and principles of the invention.

I claim:

1. A method for inspecting the spacing between adjacent articles of a plurality thereof being advanced in spaced-apart succession along a predetermined path to detect any significant change from a predetermined norm in the spacing between such adjacent articles, comprising the steps of measuring the spacing between adjacent articles as they are advanced along such path, comparing such measured spacing between adjacent articles with a predetermined reference standard to determine the existence of any deviation of each such measurement from such standard, and controlling the advancement of the articles in response to such comparisons so as to terminate article advancement whenever there is a significant deviation of a measured spacing between adjacent articles from such reference standard.

2. The method of claim **1** in which the step of comparing a measured spacing with such reference standard is effected concurrently with the making of such measurement.

3. A method of inspecting the spacing between adjacent articles of a plurality thereof being advanced in spaced-apart succession along a predetermined path to detect any significant change from a predetermined norm in the spacing between such articles at each of a plurality of locations along such path, comprising the steps of measuring the spacing between adjacent articles at each of a plurality of locations along such path, comparing each such measured spacing between adjacent articles with a predetermined reference standard to determine the existence of any deviation of each such measurement from such standard, and controlling the advancement of the articles in response to such comparisons so as to terminate the advancement whenever there is a significant deviation of a measured spacing between articles from such reference standard.

4. The method of claim **3** in which the step of comparing each measured spacing with such reference standard is effected concurrently with the making of such measurement.

5. In apparatus for inspecting the spacing between adjacent articles of a plurality thereof being advanced in spaced-apart succession along a predetermined path to detect any significant deviation from a predetermined norm in the spacing between such adjacent articles, an inspection unit comprising means for transmitting a beam of energy across such path so as to be successively interrupted by each article being advanced therealong and thereby provide alternately successive uninterrupted periods each of which represents a definitive measurement of the actual

spacing between adjacent articles, a control unit comprising means for transmitting a beam of energy, an interrupter cyclically movable into such control beam in timed relation with the advancement of articles along said path so as to interrupt the control beam during each interval that such inspection beam should be aligned with a space between properly positioned articles and thereby provide a reference standard representing a predetermined norm for the spacing between adjacent articles, and means for receiving such inspection and control beams to compare the same in determining any concurrent interruption thereof and thereby ascertain the occurrence of any such deviation in the actual spacing from such norm.

6. The apparatus of claim 5 in which said interrupter is a rotatably mounted component having an angular width substantially equal to the normal spacing between adjacent articles.

7. In apparatus for inspecting the spacing between adjacent articles of a plurality thereof being advanced in spaced-apart succession along a predetermined path to detect any significant deviation from a predetermined norm in the spacing between such adjacent articles, an inspection unit comprising means for transmitting a beam of energy across such path so as to be successively interrupted by each article being advanced therealong and thereby provide alternately successive uninterrupted periods each of which represents a definitive measurement of the actual spacing between adjacent articles, said inspection unit further comprising means for receiving such beam of energy, a control unit comprising both means for transmitting a beam of energy and means for receiving such beam, an interrupter cyclically movable into such control beam in timed relation with the advancement of articles along said path so as to interrupt the control beam during each interval that such inspection beam should be aligned with a space between properly positioned articles and thereby provide a reference standard representing a predetermined norm for the spacing between adjacent articles, and means responsive to each of said receiving means to compare such inspection and control beams in determining any concurrent interruption thereof and thereby ascertain the occurrence of any such deviation in the actual spacing from such norm.

8. The apparatus of claim 7 in which said interrupter is a rotatably mounted component having an angular width substantially equal to the normal spacing between adjacent articles.

9. The apparatus of claim 7 in which said last-mentioned means includes control means for terminating the advancement of articles along such path whenever said control beam and inspection beam are simultaneously interrupted.

10. In combination with a conveyor for advancing a succession of box blanks and like articles in spaced-apart relation along a predetermined path, motor means connected with said conveyor for driving the same, an inspection unit comprising an energy transmitter oriented with respect to such path for transmitting an energy beam thereacross so as to be successively interrupted by each article being advanced therealong and thereby provide alternately successive uninterrupted periods each of which represents a definitive measurement of the actual spacing between adjacent articles, said inspection unit further comprising a receiver for such energy beam, a control unit comprising both an energy-beam transmitter and a receiver for such beam, an energy interrupter selectively movable between the transmitter and receiver of said control unit to interrupt such control beam, mechanism for moving said interrupter in timed relation with the advancement of articles along such path so as to interrupt such control beam during each interval that said inspection beam should be aligned with the space between properly positioned articles and thereby provide a reference standard representing a predetermined norm for the spacing between adjacent articles, and control means connected with said motor means and with each of said receivers and being responsive to the outputs of the latter to compare the same and de-energize said motor means to terminate the advancement of articles by said conveyor whenever said control beam and inspection beam are simultaneously interrupted, which interruption is indicative of a deviation of the actual spacing between adjacent articles from such predetermined norm.

11. The combination of claim 10 in which said mechanism drivingly couples said interrupter with said conveyor to synchronize its movements with the conveyor.

12. The combination of claim 11 in which said energy interrupter is rotatably mounted and has an angular width substantially equal to the normal spacing between adjacent articles, and in which said mechanism for moving said interrupter rotatably drives the same.

13. The combination of claim 12 in which each of said transmitters transmits vibratory energy in the range of ultrasonic frequencies and each of said receivers is adapted to receive energy of such frequency.

14. In apparatus for inspecting the spacing between adjacent articles of a plurality thereof being advanced in spaced-apart succession along a predetermined path to detect any significant deviation from a predetermined norm in the spacing between such adjacent articles at a plurality of locations along such path, a plurality of inspection units respectively disposed at such locations and each unit comprising means for transmitting a beam of energy across such path so as to be successively interrupted by each article being advanced therealong and thereby provide alternately successive uninterrupted periods each of which represents a definitive measurement of the actual spacing between adjacent articles, a plurality of control units respectively associated with said inspection units and each comprising means for transmitting a beam of energy, interrupter structure cyclically movable into each such control beam in timed relation with the advancement of articles along said path so as to interrupt each control beam during each interval that the inspection beam of the associated inspection unit should be aligned with a space between properly positioned articles and thereby provide a reference standard representing a predetermined norm for the spacing between adjacent articles, and means for receiving such inspection and control beams to compare the same in determining any concurrent interruption thereof and thereby ascertain the occurrence of any such deviation in the actual spacing from such norm.

15. In apparatus for inspecting the spacing between adjacent articles of a plurality thereof being advanced in spaced-apart succession along a predetermined path to detect any significant deviation from a predetermined norm in the spacing between such adjacent articles at each of a plurality of locations along such path, a plurality of inspection units respectively disposed at such locations and each unit comprising means for transmitting a beam of energy across such path so as to be successively interrupted by each article being advanced therealong and thereby provide alternately successive uninterrupted periods each of which represents a definitive measurement of the actual spacing between adjacent articles, each said inspection unit further comprising means for receiving such beam of energy, a plurality of control units respectively associated with said inspection units and each control unit comprising both means for transmitting a beam of energy and means for receiving such beam, interrupter structure cyclically movable into each such control beam in timed relation with the advancement of articles along said path so as to interrupt each control beam during each interval that the inspection beam of the associated inspection unit should be aligned with a space between properly positioned articles and thereby provide a reference standard representing a predetermined norm for the spacing between adjacent articles, and means responsive to each of said receiving means to

compare such inspection and control beams in determining any concurrent interruption thereof and thereby ascertain the occurrence of any such deviation in the actual spacing from such norm and terminating advancement of such articles should deviation exist.

16. In combination with a conveyor for advancing a succession of boxblanks and like articles in spaced-apart relation along a predetermined path, motor means connected with said conveyor for driving the same, a plurality of inspection units spaced apart along such path and each unit comprising an energy transmitter oriented with respect to such path for transmitting an energy beam thereacross so as to be successively interrupted by each article being advanced therealong and thereby provide alternately successive uninterrupted periods each of which represents a definitive measurement of the actual spacing between adjacent articles, each said inspection unit further comprising a receiver for such energy beam, a plurality of control units respectively associated with said inspection units and each comprising both an energy-beam transmitter and a receiver for such beam, an energy interrupter selectively movable between the transmitter and receiver of each of said control units to interrupt such control beams, mechanism for moving said interrupter in timed relation with the advancement of articles along such path so as to interrupt such control beam during each interval that the associated inspection beam should be aligned with the space between properly positioned articles and thereby provide a reference standard representing a predetermined norm for the spacing between adjacent articles, and control means connected with said motor means and with each of said receivers and being responsive to the outputs of the latter to compare the same and de-energize said motor means to terminate the advancement of articles by said conveyor whenever any one

of said control beams and inspection beam associated therewith are simultaneously interrupted, which interruption is indicative of a deviation of the actual spacing between adjacent articles from such predetermined norm.

17. The combination of claim 16 in which said interrupter is rotatably mounted and has an angular width substantially equal to the normal spacing between adjacent articles, and in which said mechanism for moving said interrupter rotatably drives the same.

18. The combination of claim 17 in which said control units are spaced from each other along the path described by said interrupter by an angular distance substantially equal to the normal spacing between adjacent articles.

19. The combination of claim 18 in which each of said transmitters transmits vibratory energy in the range of ultrasonic frequencies and each of said receivers is adapted to receive energy at the transmitted frequency.

20. The combination of claim 19 in which each inspection transmitter is disposed with respect to the receiver therefor at an angle substantially less than 90°.

References Cited by the Examiner

UNITED STATES PATENTS

2,171,362	8/1939	Gulliksen	198—34 X
2,205,255	6/1940	Gulliksen	250—233 X
2,662,633	12/1953	Kingsley	198—37 X
3,074,631	1/1963	Buysch	250—232 X
3,162,294	12/1964	Dieter	198—34
3,223,964	12/1965	Stadlin	198—37 X

EVON C. BLUNK, *Primary Examiner.*

M. L. AJEMAN, *Assistant Examiner.*