

[54] **WEB EDGE POSITION CONTROLLING DEVICE**

[75] Inventors: **Akira Takagi; Motoharu Kuroki,**
both of Kanagawa, Japan

[73] Assignee: **Fuji Photo Film Co., Ltd.,**
Kanagawa, Japan

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[30] **Foreign Application Priority Data**

Dec. 17, 1969 Japan..... 44-101443

[52] U.S. Cl. **226/22, 226/97**

[51] Int. Cl. **B65h 25/26**

[58] Field of Search 226/3, 21, 22, 23, 97

[56] **References Cited**

UNITED STATES PATENTS

2,291,830	8/1942	Obenshain	226/23 UX
3,079,805	3/1963	Rojecki	226/23
3,127,080	3/1964	Allander	226/97
3,411,683	11/1968	Bartles	226/21

Primary Examiner—Richard A. Schacher
Attorney, Agent, or Firm—Sughrue, Rothwell, Mion, Zinn & Macpeak

[57] **ABSTRACT**

A device for controlling the position of the edge of a moving web in a web feeding apparatus in which a contact feeding station succeeds a noncontact feeding station. This device comprises a contact roller downstream of an air cushion web-feed station, said contact roller being pivoted about an axis not parallel to the surface of the outgoing web.

3 Claims, 5 Drawing Figures

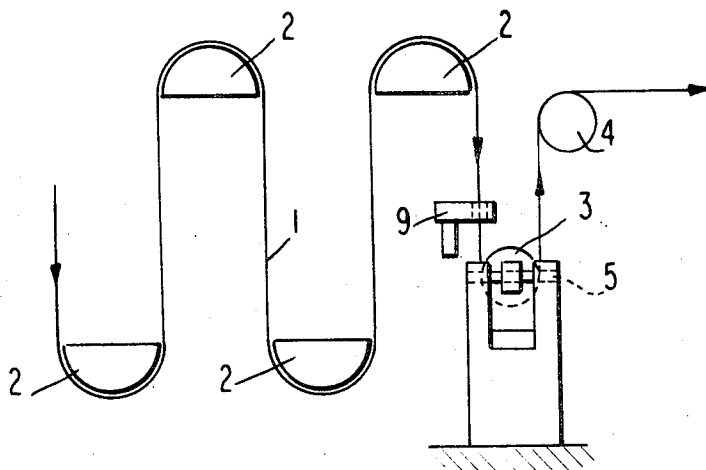


FIG. 1

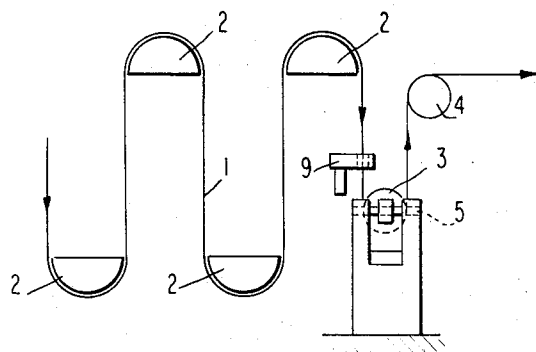


FIG. 2

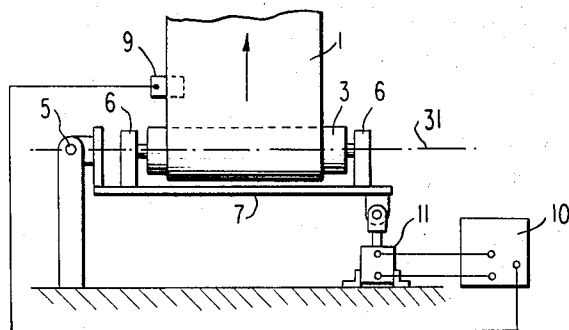
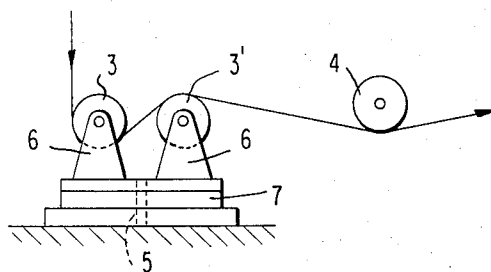


FIG. 3



INVENTORS

AKIRA TAKAGI
MOTOHARU KUROKI

BY *Sughrue, Rothwell, Mion,*
Zinn & Macpeak
ATTORNEYS

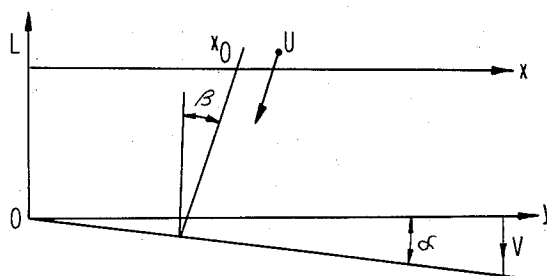


FIG. 4

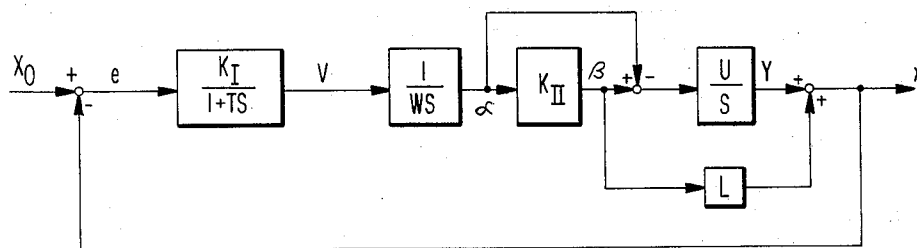


FIG. 5

WEB EDGE POSITION CONTROLLING DEVICE

CROSS-REFERENCE TO A RELATED APPLICATION

This is a continuation in part application of the application of Akira Takagi, et al., filed Dec. 16, 1970, Ser. No. 98,502, for WEB EDGE POSITION CONTROLLING DEVICE.

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

The present invention relates to a device for controlling the edge position of a running web, such as paper, plastic sheet, metallic web and the like, and relates particularly to a device for controlling the edge position of a running web in a web feeding process including web floating and web feeding by the use of rollers subsequent thereto.

2. DESCRIPTION OF THE PRIOR ART

In the web feeding process in which the web is continuously fed, it is often desired to avoid the frictional or mechanical contact of the web with the surface of the roller partly in the process. In order to avoid friction or contact between the web and the roller surface, it has been known to utilize air or liquid cushion to float and feed the web above the guide rollers or guide members. In such a web feeding arrangement, the web is usually also fed by a contact feeding process in which the web is fed by rollers. In the web floating process or station, the web is liable to fluctuate laterally. Accordingly, the web is likely to acquire wrinkles when it comes into the contact feeding apparatus in which it is fed by rollers downstream from the air cushion feeding means. Particularly at the first roller with which the coming web is brought into contact at the first time, the web is remarkably apt to acquire wrinkles due to the lateral fluctuation in the air cushion feeding station.

In order to prevent fluctuation and control the edge position of the web in the web feeding process as described above, prior art edge position control devices were employed as a trial. However, since such prior art edge position control devices are designed to control the edge position of the web in the contact feeding station in which the web is fed by rollers, and further is designed for controlling the edge position of the web at a position downstream of the control device, effective edge position control was not achieved when employed in the station as described above due to its slow response. Moreover, in the special station for feeding the web by an air cushion, it was required to precisely and exactly control the web feeding conditions relevant to the web feeding operation for controlling or regulating the edge position of the running web. In addition, the longer the web feeding length of the non-contact feeding station, the more the web fluctuates, and it has been required to limit the length of the non-contact web feeding station.

SUMMARY OF THE INVENTION

The object of the present invention is to provide an edge position controlling device in a web feeding apparatus in which a contact feeding station succeeds a non-contact feeding station.

Another object of the present invention is to provide an edge position controlling device by which the limitation in the length of the non-contact feeding station is obviated.

Still another object of the present invention is to provide an edge portion controlling device in which the web floating operation of the non-contact feeding means allows the control to have an integrated effect.

As used in this application, the expression "to have an integrated effect" means that the object is achieved without fail and that the object is easily attained because the web is in a floating condition before the web edge position controlling roller.

In accordance with the present invention, there is provided a web edge position controlling device adapted to a web feeding process consisting of a web floating non-contact feeding station followed by a roller contact feeding station. It comprises at least one controlling roller serving as a first roller to contact the web at the contact feeding station. A web edge position detecting means is disposed in the vicinity of the controlling roller on the web approach side of the roller. An operating means swings the controlling roller about an axis which is not parallel with the surface of the outgoing web, thereby making the edge position of the web come back into alignment with the desired standard position at the web edge position detecting means.

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and advantages of the present invention will be made apparent from the following description of the invention taken in conjunction with the accompanying drawings in which:

FIG. 1 is a side elevational view of one embodiment of the device in accordance with the present invention.

FIG. 2 is a front view of the main part of the device shown in FIG. 1.

FIG. 3 is a partial side view of the device in accordance with another embodiment of the present invention.

FIG. 4 is a diagrammatic representation of the relationship of certain quantities discussed in explaining the integrated effect provided by the present invention.

FIG. 5 is a block diagram which will be used in explaining the integrated effect provided by the present invention.

DESCRIPTION OF SPECIFIC EMBODIMENTS

Now referring to the drawings, particularly to FIGS. 1 and 2, a web 1 is supported by a guided along a set of air cushion supports 2 arranged at the positions where the web 1 turns its advancing direction. The web 1 is supported by air cushion formed on the surface of the cushion supports 2. After passing through the air cushion supporting station, the web 1 is fed into a roller feeding station including a controlling roller 3, a guide roller 4 and so forth. The controlling roller 3 should be substantially the first roller to be in contact with the web after the web 1 leaves the cushion or non-contact station and comes into the contact roller feeding station, and is rotatably supported by a pair of bearings 6 secured to a movable base 7. In the vicinity of the controlling roller 3 is disposed a web edge position detecting device 9 of the conventional pneumatic or photoelectric type so that the edge position detector 9 detects the edge position of the web 1 before the web comes into contact with the roller 3. The web edge position detector 9 generates an output signal proportional to the deviation of the edge position of the web from a

standard or regular position. The movable base 7 is connected to an operating device 11 using a hydraulic cylinder, pneumatic cylinder, electric motor or the like, and the controlling roller 3 is pivoted around an axis 5 which is perpendicular to its axis of rotation 31. The axis 5 around which the controlling roller 3 is pivoted is not parallel to the surface of the outgoing web and is preferably perpendicular to the surface of the web 1 on the discharge side of the roller 3 as well as to the axis 31 of rotation thereof. Though the position of the pivot axis 5 is on one side of the roller 3 in FIGS. 1 and 2, it may be on the other side or at the middle of the roller 3. The reference numeral 10 indicates a controlling device which operates in response to the output signal of the detector 9.

Now the operation of the controlling roller 3 will be described in detail. When the controlling roller 3 is swung around the axis 5 in the clockwise direction in FIG. 2, the web 1 is deviated to the right, and in the case that the controlling roller 3 is swung around the axis 5 in a counterclockwise direction, the web 1 is deviated to the left. In accordance with such an effect of the controlling roller 3, the controlling device 10 provides an operating signal to the operating device 11 to effect the regulating of the edge position of the running web 1 utilizing the output signal from the web edge position detector 9.

As well known in the art, the deviation of the web on the roller is due to the inclination of the angle from the right angle made between the web advancing direction and the direction of axis. That is, the web is deviated to the acute angle side of the angle. Therefore, in the case that the web runs apart and the roller axis is seen to be pivoted clockwise, the web deviates to the right, and vice versa. In accordance with the construction of the present invention, the web 1 on the approach side of the controlling roller 3 is easily and quickly deviated laterally by the pivoting of the rotational axis 31 of the roller 3 as the web is in floating condition before the controlling roller. And since the detector 9 is disposed on the web approach side of the controlling roller 3, the deviated edge position of the web 1 can be detected before the web 1 is brought into contact with the roller and the edge position of the web can be quickly regulated. Thus, the edge position of the running web 1 can be effectively and quickly regulated in accordance with the present invention.

Another embodiment of the web edge position controlling device is shown in FIG. 3. In this embodiment, a pair of parallel rollers 3 and 3' are employed as the controlling roller which are substantially brought into contact with the web for the first time at nearly the same time. The front surface and the back surface of the web 1 are alternately brought into contact with the roller surface of the rollers 3 and 3', so that the frictional effect between the roller surface and the web surface is increased to prevent the slip therebetween. It will be noted that the axis 5 is perpendicular to the axes of rotation of the controlling rollers 3, 3' but is not perpendicular to the outgoing web. This is because our experiments and calculations have shown that, while it is preferable to have the axis 5 perpendicular both to the axis of rotation of the controlling rollers and to the outgoing web, the former consideration is more important than the latter.

In FIG. 3, the web edge position controlling mechanism and the web edge position detecting device are

omitted. The function of the construction of the second embodiment shown in FIG. 3 is all the same as of the first embodiment, and accordingly the explanation thereof is omitted.

As previously stated, an important object of the present invention is to provide an edge portion controlling device in which the web floating operation of the non-contact feeding means allows the control to have an integrated effect. The fact that the present invention does so provide will now be demonstrated. To do so, the following quantities are employed:

x_0 is the distance in meters of the web edge at the standard position from some convenient reference line parallel to the axes of the web at the standard position.

x is the distance in meters of the web edge from the same reference line actually measured at the detecting position.

y is the distance in meters of the web edge from the same reference line at the controlling roller(s).

L is the distance in meters between the detecting position and the controlling roller(s).

α is the angle, measured in radians and 0 at the standard position, between a perpendicular to the reference line and the axis of the controlling roller(s). It is the value of the swing of the controlling roller 3 in radians.

β is the angle, measured in radians and 0 at the standard position, between the reference line and the edge of the web. It is the value of the angle between the axis of the machine and the longitudinal center line of the web.

V is the operating speed of the controlling roller in meters per second,

U is the running speed of the web in meters per second.

W is the radius of swing of the controlling roller(s) in meters.

T is the time constant of the operation portion in seconds.

K_I is the gain of the operation portion in/seconds (seconds⁻¹).

K_H is the non-dimensional ratio of β to α .

The results of the mathematical treatment of these quantities are shown in FIGS. 4 and 5. These quantities may be subjected to Laplace transformations in a manner well known in the art. So doing, the open loop transfer function $G(S)$ may be shown to be as follows:

$$G(S) = (K_I K_H L / W) S + [U(K_H - 1) / K_H L] / S^2 (1 + TS) = N(S) / D(S)$$

To determine the stability of the system, applicants used the F lubrits method, which is a known way of judging the stability of automatic edge position control of webs.

$$F(S) = N(S) + D(S) = 0 \quad S^3 + (1/T) S^2 + (K_I K_H L / TW) S + [U(K_H - 1) / TW] = 0$$

Therefore, the necessary and sufficient condition for the state to be stable is as follows:

$$K_H > 1 \quad K_I / TW \{ K_H L / T - U(K_H - 1) \} > 0$$

then, $K_H / K_H - 1 > T / L / U$, $K_H > 1$

From this, it follows that the edge-position controlling devices as disclosed herein operate in a controlled state when $K_H > 1$.

It will be recalled that K_H is the non-dimensional ratio of β to α ; so K_H is larger than one when β is larger

than α . The fact that β is larger than α results from the floating condition before the controlling roller 3, the axis of which is not parallel to the outgoing direction of the web. Therefore, the web-floating operation of the non-contact feeding means is the basis of the integrated effect.

What is claimed is:

1. In a web feeding apparatus including a web floating, noncontact feed station and a roller contact feeding station, a web position controlling device comprising:

1. a first controlling roller serving as substantially the first roller to be in contact with the web at the contact feeding station, said first controlling roller being:
 - a. mounted for rotation about a first axis concentric to the rolling surface of said controlling roller and
 - b. mounted for pivoting about a second axis perpendicular to said first axis and also perpendicular to an imaginary line located in a right section of said controlling roller and connecting the center of said controlling roller to a point on the rolling surface thereof halfway between the point where the web first comes in contact with said controlling roller and the point where the web ceases to be in contact with said controlling roller when the web is in a standard position;

2. a web position detecting means disposed in the vicinity of said first controlling roller on the web approach side; and

3. means for pivoting said first controlling roller about said second axis when said web position detecting means detects that the web has deviated from a standard position relative to said web position detecting means.

2. A web position controlling device as claimed in claim 1 wherein said second axis is perpendicular to the surface of the outgoing web.

3. A web controlling device as claimed in claim 1 and further comprising a second controlling roller:

1. spaced from said first controlling roller;
2. mounted for rotation about a third axis parallel to said first axis; and

3. mounted for pivoting about said second axis, whereby one surface of the web can be brought into contact with the rolling surface of said first controlling roller and the other surface of the web can be brought into contact with the rolling surface of said second controlling roller, thereby providing more frictional contact between the web and the controlling roller means comprising the two controlling rollers than is provided between the web and the first controlling roller only.

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