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Wada

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[54] **POSITION DETECTING AND MAINTAINING DEVICE**

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[30] **Foreign Application Priority Data**

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[52] **U.S. Cl.** **318/675,** 318/466, 318/665
[51] **Int. Cl.** **G05b 11/01**
[58] **Field of Search** 318/665, 626, 466, 467, 318/675

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Attorney, Agent, or Firm—Woodhams, Blanchard and Flynn

[57] **ABSTRACT**

A position detecting and maintaining apparatus for use between a movable article and a movable base member. Track means are provided and extend parallel to the direction of movement of the movable article and guide means are provided for guiding the base member along the track means. A shaft is rotatably supported on the base member and has a lever fixed thereto and rotatable therewith and adapted to engage the article to effect a rotation of the shaft means upon a relative movement between the base member and the article. A spring is provided for urging the lever in a direction opposite to the direction of movement of the base member and the article. An electrical potentiometer is provided for converting the rotational movement of the shaft to an electrical output signal, which electrical output signal controls a servo-valve apparatus for maintaining a uniform relative spacing between the base member and the article.

8 Claims, 12 Drawing Figures

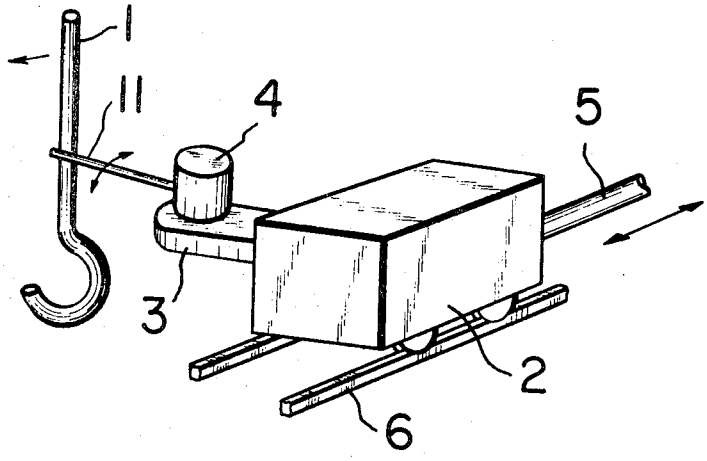


Fig. 1

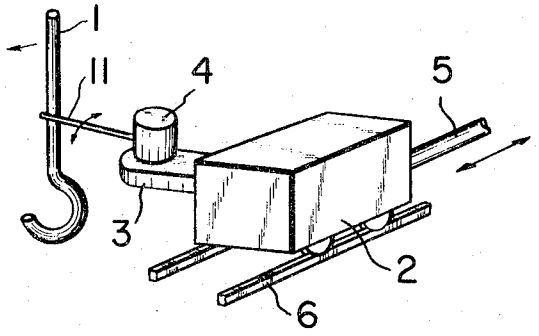


Fig. 2

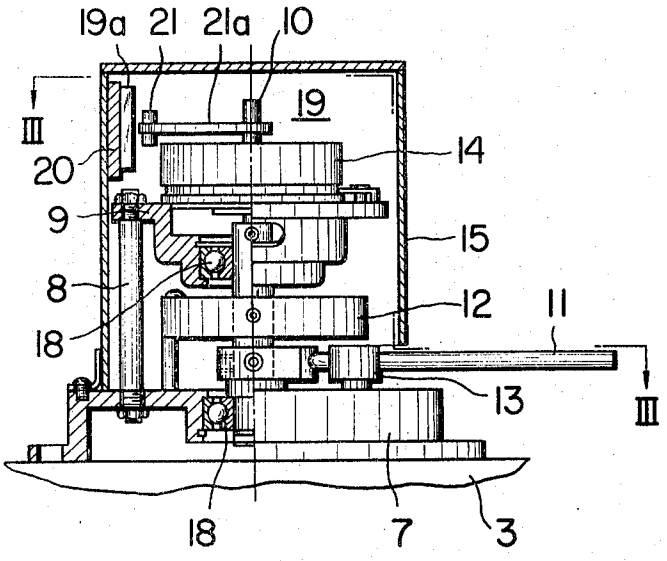


Fig. 3

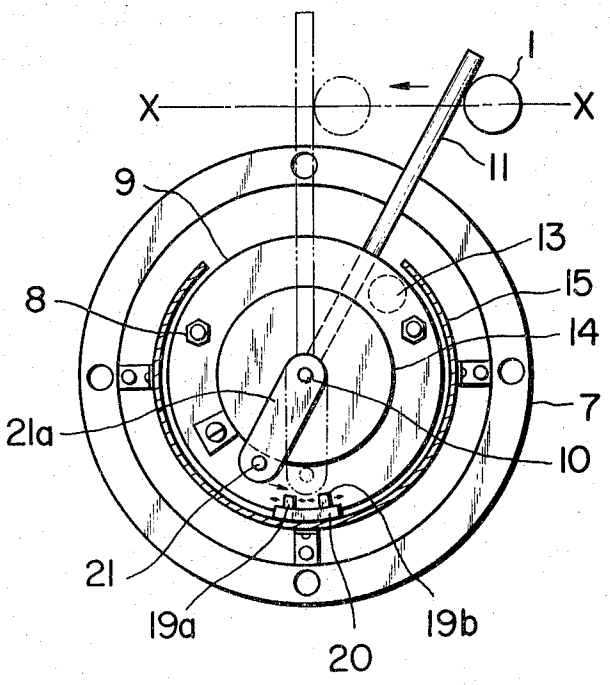


Fig. 4

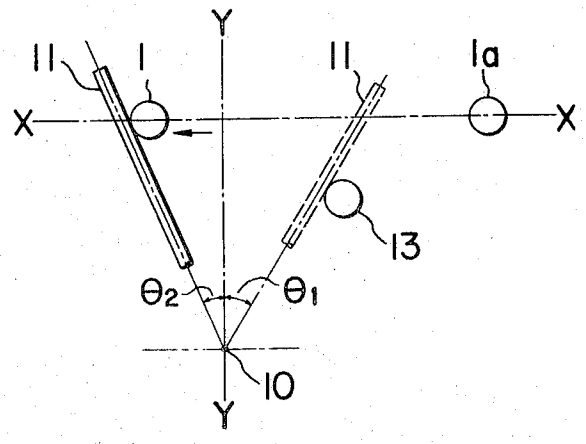


Fig. 5

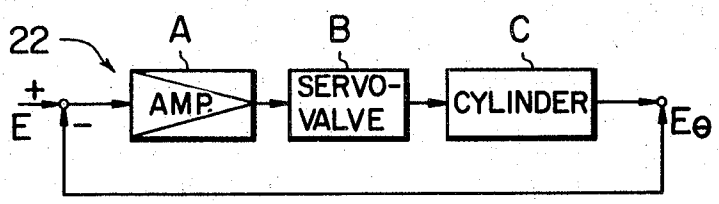


Fig. 6

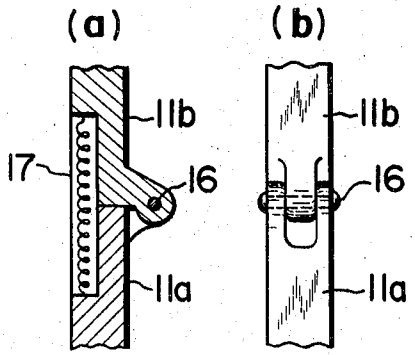


Fig. 7

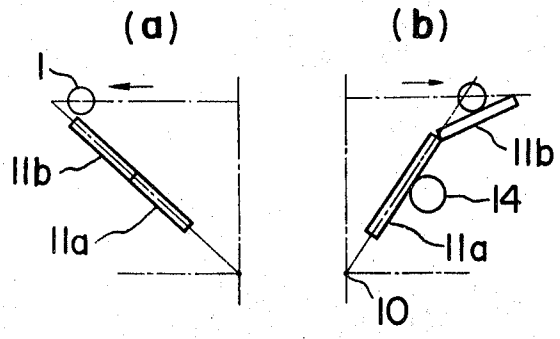


Fig. 8

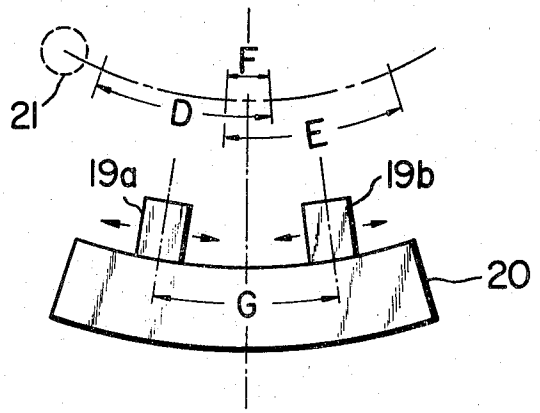


Fig. 9

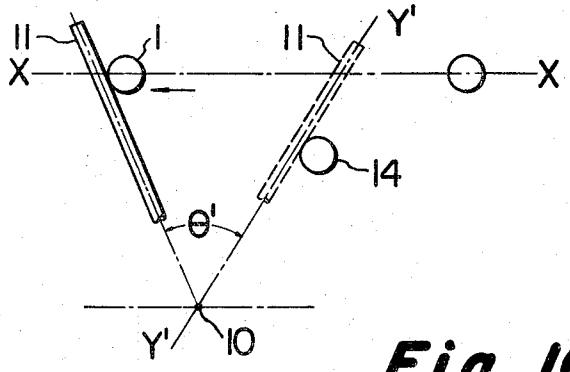
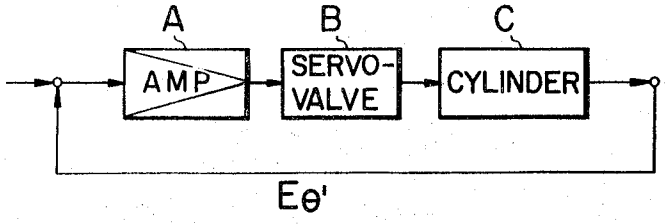


Fig. 10



POSITION DETECTING AND MAINTAINING DEVICE

FIELD OF THE INVENTION

The present invention relates to a position detecting apparatus for detecting a relative position between an auxiliary apparatus and an article conveying apparatus so that a follow-up control can be effected on the auxiliary apparatus. More particularly, the follow-up control will facilitate a movement of transferring or processing equipment in parallel direction with an article conveying apparatus, such as a conveyor, when loading thereonto or unloading therefrom an article or facilitate a processing or inspection of an article conveyed thereby, such being accomplishable by a servomechanism. The present invention also relates to apparatus for generating synchronous follow-up confirmation signals which confirm that a conveying device and another device moving parallel therewith move therealong and are in a synchronous follow-up condition.

BACKGROUND OF THE INVENTION

Conventionally, when an auxiliary apparatus is used to handle an article being conveyed, the apparatus is kept travelling at a desired position relative to the article. However, it has been difficult to move the auxiliary apparatus in a manner to correctly maintain its relative position with respect to the article during the period or in the section of the path of travel in which the handling operation is performed, due to, for example, a change in conveying speed caused by fluctuations of the load or the reaction of a conveyor chain, delay in the start of the auxiliary apparatus, a change in accelerating characteristics and the like.

Further, when an article is loaded onto or unloaded from a conveying device such as the conveyor, or when a transferring device or some other auxiliary device such as the processing or inspecting machine is caused to travel after such conveying device in order to furnish some processing or inspection to the article being conveyed, it is necessary to automatically control the speed of the auxiliary device so as to keep the device in a given relative position with respect to the conveying device. It is further necessary to keep the auxiliary device in a synchronous follow-up condition with respect to the conveying device, that is, a condition in which the former travels at the same speed as and in a given relative position with respect to the latter, at least while the auxiliary device is performing its transferring, processing or other operation.

However, as a matter of fact, the auxiliary device can in many cases perform its operation even if it is not accurately kept in the synchronous follow-up condition. For example, the auxiliary device may be somewhat deflected or permitted to oscillate back and forth in either direction from the desired relative position when the auxiliary device does not move at precisely the same speed as the conveying device. Even then, so far as the amount of deflection or oscillation is within a tolerance, this deflected condition may be regarded as the synchronous follow-up condition and the auxiliary device can be operated.

It is an object of the present invention to provide a position detecting apparatus which is attached to the auxiliary apparatus for detecting the relative position thereof with respect to the article being conveyed,

being engaged with the article or its hanger to thereby cause the servomechanism to operate to keep and maintain a desired position therebetween.

It is a further object of the present invention to provide apparatus for generating synchronous follow-up confirmation signals to confirm that an auxiliary device as mentioned before is in the synchronous follow-up condition. Another object of the invention is to provide apparatus for generating synchronous follow-up confirmation signals combined with a position detecting device for detecting a relative position of the auxiliary device to the conveying device.

Other objects and purposes of this invention will be apparent to persons acquainted with apparatus of this general type upon reading the following specification and inspecting the accompanying drawings, in which:

FIG. **1** is a perspective illustration of a position detecting and maintaining apparatus embodying the invention;

FIG. **2** is a sectional view through the position detecting and maintaining apparatus;

FIG. **3** is a sectional view taken along the line III—III of FIG. **2**;

FIG. **4** is a schematic illustration illustrating the positions of the lever;

FIG. **5** is a block diagram of the drive control mechanism controlling the movement of the carrier;

FIGS. **6**(*a*) and **6**(*b*) are a fragmentary longitudinal section and sideviews, respectively, of a pivoted lever construction;

FIGS. **7**(*a*) and **7**(*b*) illustrate the two part lever in operation;

FIG. **8** is an enlarged illustration of a portion of the position maintaining apparatus;

FIG. **9** is a schematic illustration of the positions of a lever in a modified embodiment; and

FIG. **10** is a modified block diagram of another servo-apparatus utilized for controlling the movement of the carrier.

DETAIL DESCRIPTION

Referring now to the drawings, in FIG. **1** reference numeral **1** designates a hanger associated with an overhead conveyor and movable along a path and reference numeral **2** is a carrier which carries an auxiliary device and is capable of moving along a parallel path with the conveyor. A position detecting device **4** is mounted on an arm **3** projecting from the carrier **2**, which carrier can be moved reciprocatingly on rails **6** either by means of a hydraulic cylinder rod **5** driven by a servomechanism B illustrated in FIG. **5** or the carrier **2** can be driven by an electric motor the speed of which is controlled by the difference signal from the amplifier A.

FIGS. **2** and **3** illustrate details of the detecting device **4**, in which a vertically extending support **8** is mounted on a base **7** which in turn is mounted on the arm **3**. A shaft **10** is vertically supported by ball bearings **18** mounted in a bracket **9** mounted in turn on the support **8** adjacent the upper end thereof. Ball bearings **18** are also mounted in the base **7** and rotatably support the lower end of shaft **10**. One end of a lever **11** is firmly secured to the lower portion of the shaft **10**, which lever extends transversely of the movement paths and is adapted to engage the hanger **1**. The shaft **10** is urged by a spiral spring **12** interposed between the shaft **10**

and base 7 so that the lever 11 is continuously rotatingly urged in a direction opposite to the direction in which the hanger 1 moves. These elements are so arranged that the tip of said lever 11 is in such a position that it permits engagement with the hanger 1 when the lever 11 contacts a stopper 13 mounted on the base 7.

Reference numeral 14 designates a position detecting device comprising, for example, a potentiometer mounted on the bracket 9 and having a sliding piece attached to the shaft 10. The potentiometer 14 converts the rotational angular position of the shaft 10 into an electric signal.

The stopper 13 is provided to limit the rear rotational position of the lever 11 due to the urging of the spring 12. When the lever 11 is engaged with the stopper 13, the tip of the lever 11 is in such a position that it is engagable with an approaching hanger 1. FIG. 4 illustrates a condition in which the lever 11 has been rotated while in engagement with the hanger 1 to the solid line position thereof. If it is assumed that an output voltage from the potentiometer 14 for the time when the lever 11 is at a position perpendicular to the running direction of the hanger 1 (FIG. 4, position Y—Y) is a reference voltage, an output voltage from the potentiometer for the time when said lever 11 has rotated either to the left or to the right from the position Y—Y through an angle of θ_1 or θ_2 degrees will effect a change in the output signal to either above or below the reference voltage depending on the sign of θ_1 or θ_2, namely, the direction of movement of the lever 11 from the position Y—Y. Accordingly, a difference E–E $_\theta$ between the reference voltage E and an output voltage E $_\theta$ of the potentiometer 14 indicates a relative position of the hanger 1 to the carrier 2 and the difference equals zero when the lever is perpendicular to the line X—X. In other words, the carrier 2 is not accelerated or decelerated when $E = E_\theta$. When the lever 11 is on the right of the line Y—Y, or E > E $_\theta$, the carrier 2 decelerates. On the other hand, when the lever 11 is on the left of the line Y—Y, or E < E $_\theta$, the carrier 2 accelerates. In either case, the speed of deceleration and acceleration increases with increasing difference between E and E $_\theta$.

FIG. 5 is a block diagram showing a speed deviation control device 22 for controlling a servomechanism for operating a hydraulic cylinder driving the carrier 2. The operating speed of the rod 5 of a hydraulic cylinder C, that is, the speed of the carrier 2, is automatically controlled by an amplifier A amplifying a difference signal E–E $_\theta$ between the reference voltage E and a potentiometer output voltage E $_\theta$ when said lever 11 lies at an angle θ_1 or θ_2 relative to the line Y—Y to effect an adjusting of the opening or control of a servovalve B according to the amplified voltage. It is understood that the amplifier A could be used to control the speed of an electric motor (not illustrated) which drives the carrier 2.

In other words, and as stated above, when $E = E_\theta$, the carrier 2 travels at a speed equal to the hanger 1; when E > E $_\theta$, the carrier 2 decelerates; and when E <E $_\theta$, the carrier 2 accelerates; with the degree of deceleration and acceleration increasing with increasing difference between E and E $_\theta$.

Now the operational phase of this invention will be described below. It is assumed that when the hanger 1 reaches a position 1*a*, (FIG. 4) having moved from right to left along the line X—X, the carrier 2 starts to move. In this condition (as represented by the broken line showing in FIG. 4), the angle θ_1 is positive and the speed of said carrier is still low. Therefore, the hanger 1 approaches closer to the lever 11 until it touches and then rotates the lever, being kept in close contact therewith by the spiral spring 12. Thus the difference between E and E $_{\theta_1}$ becomes smaller, and the deceleration of the carrier 2 decreases. When the carrier 2 reaches a relative position where $\theta = 0$, the speed of the carrier 2 becomes equal to that of the hanger 1. As the speed of the hanger 1 exceeds that of the carrier 2 and the value of θ_2 increases in the negative direction (as represented by the solid line showing in FIG. 4), the carrier 2 is accelerated to reduce the value of θ_2. When θ becomes 0, that is, corresponding to the position of the lever at Y—Y, acceleration stops and the carrier 2 runs at a speed equal to the hanger 1. As described above, the carrier 2 moves while keeping a given relative position with respect to the hanger 1. Therefore, if auxiliary equipment is operated during such period of time, its operation can be performed at a correct position with respect to the article being conveyed. By stopping the carrier 2 after completion of the operation, the hanger 1 rotates the lever 11 to effect a disengagement therefrom (FIG. 7(*a*)). The carrier 2 may also be so designed as to start its motion when the hanger 1 or the article being conveyed has engaged the lever 11 (See FIGS. 9 and 10 discussed hereinbelow).

Where the direction in which the article is carried changes, the lever 11 may be divided into two lever portions 11*a* and 11*b*, as shown in FIGS. 6(*a*), 6(*b*) and 7(*b*). The two portions are connected by a pivot pin 16. A tension spring 17 is connected to and extends between the lever portion 11*a* and 11*b* so that the lever portion 11*b* is permitted to pivot with respect to the lever portion 11*a*, only in the direction opposite to that in which the article is conveyed. With this arrangement, when the article is moved in a direction in which it is acted on by the auxiliary equipment as illustrated in FIG. 7 (i.e., from right to left in FIG. 7(*a*)), the lever 11 performs a position detecting function as described above. When the article is moved in the opposite direction, the lever 11 will pivot about the axis of the pin 16 on contacting the stopper 13, thereby permitting the passage of the hanger 1 to the right, illustrated in FIG. 7(*b*).

In the foregoing embodiment, a voltage at $\theta = 0$ was used as the reference voltage. But a reference voltage may be selected with reference to any angle θ, in which case the carrier 2 runs at the same speed as the hanger 1 when it reaches a relative position forming a given angle θ.

Referring now to the follow-up control, if the carrier 2 and hanger 1 are not travelling at precisely the same speed, the fluctuation of angle θ will be within limits defined by $\Delta\theta$ for a certain period of time. Therefore, if this period of time and the deflection of plus/minus $\Delta\theta$ do not hamper the operation of the auxiliary device, plus/minus $\Delta\theta$ may be established as a deflection tolerance and the auxiliary device may be operated by having the amplifier A detect only that the relative position of the carrier 2 and the hanger 1 is within the deflection tolerance of plus/minus $\Delta\theta$.

To achieve this detection, a synchronous follow-up confirmation signal generating device 19 (FIGS. 2 and 3) is attached to the detecting device 4. The device 19

has two lead switches **19***a* and **19***b* attached in such a manner that their position on the circumference of a cover **15** is adjustable. More specifically, the switches **19***a* and **19***b* are secured to a mounting seat **20** fixed to the inside of the cover **15.** A permanent magnet **21** is secured to a supporting arm **21***a* which is fixed to the shaft **10.** The center of the permanent magnet **21** lies at a middle angular position between the lead switches **19***a* and **19***b* when the lever **11** is at a position where $\theta = 0$ (position Y—Y). Furthermore, as shown in FIG. **8,** the lead switches **19***a* and **19***b* are closed when the angular position is within the range of D and E, respectively. Consequently, in the range F where the ranges D and E are overlapped, both lead switches **19***a* and **19***b* are closed. By reconciling the range F with the deflection tolerance of plus/minus $\Delta\theta$ through the adjustment of a gap G between the lead switches **19***a* and **19***b* and by arranging that the series-circuit of the lead switches **19***a* and **19***b* are closed to generate a signal when both of them are closed, the signal will become a confirmation signal indicating that the carrier **2** is in the synchronous follow-up condition with respect to the hanger **1.** So long as such confirmation signal is being issued, the auxiliary device can be operated without hindrance.

In the above-described embodiment, two lead switches and a permanent magnet are combined as a synchronous follow-up confirmation signal generating device **19.** They are arranged so that the deflection tolerance of plus/minus $\Delta\theta$ can be adjusted. As compared with this, when a single lead switch is used, the angular position range D or E becomes a deflection tolerance. And this deflection tolerance can be adjusted by changing the properties of and the space between the lead switch and the permanent magnet. In addition, other known non-contact access detecting devices, such as the combination of a light source and two or one phototransistor, may be used as the synchronous follow-up confirmation signal generating device.

Of course, it is also possible to compose the synchronous follow-up confirmation signal generating device **19** on a different rotary shaft from the one utilized for the position detecting device **14.**

As may be evident from the above, this invention makes it possible to readily confirm that the auxiliary device, which is follow-up controlled with respect to the article conveying device, is in the synchronous follow-up condition within a desired deflection tolerance. On top of this, according to this invention, operational control of the auxiliary device can be facilitated and the accuracy of the follow-up control can be increased because the confirmation signal does not change irrespective of the direction in which the auxiliary device comes into the synchronous follow-up condition with respect to the conveying device.

Furthermore, the device of the present invention can freely and readily reduce the time interval of said confirmation signal to a very small value. Also, it assures a long service life against frequently repeated use, owing to the use of a non-contact access detecting device.

Finally, the device according to the invention can be made in a very small size. For example, the position detecting device and a compact follow-up control detecting device convenient for attachment to the auxiliary device can be made.

FIGS. **9** and **10** illustrate another embodiment of a speed control apparatus. In FIG. **9,** the hanger **1** moves along the axis X—X in the direction of the arrow. Until the hanger **1** touches the lever **11,** the lever **11** is kept pressed against the stopper **13** by the spring **12** in the position Y'—Y'. Here it is assumed that, in this condition, the angle θ is 0 (as represented by the broken line showing in FIG. **9**), and the output voltage $E_{\theta'}$ of the potentiometer is also 0. Thus, when the hanger **1** starts to push the lever **11,** the angle θ increases and the output voltage $E_{\theta'}$ of the potentiometer increases accordingly.

The output voltage $E_{\theta'}$ (FIG. **10**) of the potentiometer is amplified by an amplifier A and the opening of a servo-valve B is adjusted according to the amplified output so that the operating speed of the cylinder C, that is, the speed of the carrier **2,** is automatically controlled. Immediately after the hanger **1** starts to push the lever **11,** the output voltage $E_{\theta'}$ is low and, as a result, the speed of said carrier **2** is also low, which causes the hanger **1** to outrun the lever **11.** At such time, the angle θ' or the output voltage $E_{\theta'}$ becomes larger thereby resulting in an increase in the speed of said carrier **2.** Therefore, the speed of the carrier **2** approaches and then becomes equal to the speed of said hanger **1.** It is to be understood that the amplifier A could be used to control the speed of an electric motor (not illustrated) which drives the carrier **2.**

The relative position of the hanger **1** to the carrier **2,** or the value of the angle θ, for the time when the two are running at an equal speed can be freely fixed by changing the amplification rate of the amplifier A.

As may be understood from the above, the position detecting apparatus according to this invention is of very simple and durable construction. Further, it is capable of a follow-up control of auxiliary equipment as set forth above to keep it in a given relative position with respect to an article being conveyed so that the auxiliary equipment can perform its function at an appropriate position on the article being conveyed which travels at varying speeds.

Although particular preferred embodiments of the invention have been disclosed in detail for illustrative purposes, it will be recognized that variations or modifications of the disclosed apparatus, including the rearrangement of parts, lie within the scope of the present invention.

The embodiments of the invention is which an exclusive property or privilege is claimed are defined as follows:

1. A position detecting device for use with an article moving in a first direction along a first path, comprising:

guide means defining a second path which is spaced from but substantially parallel to said first path;

base means coacting with said guide means for movement along said second path in said first direction;

lever means rotatably supported on said base means, said lever means projecting outwardly so as to extend transversely relative to said paths, said lever means having a portion thereof positioned for engagement with said article when same is being moved along said first path to effect rotation of said lever means upon relative movement between said article and said base means;

means coacting with said lever means for urging said lever means to rotate in a direction whereby said portion is moved in a direction opposite to said first direction;

converting means associated with said lever means for converting the rotary angular position thereof to an electric signal; and

control means coacting with said base means and responsive to said electric signal for maintaining a substantially uniform spacing between said base means and said article as they are moved along their respective paths, whereby said base means and said article are moved substantially, in synchronism with one another.

2. A device according to claim **1,** including auxillary means mounted on said base means and adapted to cooperate with said article; and

including follow-up control means for generating synchronous follow-up confirmation signals having predefined limits, said follow-up control means being connected in circuit with said auxillary means to activate same only when the relative position between said article and said base means are within said predefined limits of said follow-up confirmation signals.

3. A device according to claim **2,** wherein said follow-up control means includes a pair of spaced limit switches adjustably mounted on said base means, said spacing defining said predefined limits of said follow-up confirmation signals and limit switch activation means connected to said lever means and being rotatable therewith between said pair of limit switches.

4. A device according to claim **1,** wherein said control means includes motor means drivingly connected to said base means for driving same along said second path in said first direction, said control means also including servo means operatively connected between said converting means and said motor means for accelerating or decelerating said base means responsive to said electric signal for causing said base means to be moved substantially in synchronism with said article.

5. A device according to claim **4,** wherein said servo means includes means defining an electrical reference signal and electrical amplification means responsive to said electric signal and said reference signal to produce an output signal indicative of the relative position between said article and said base means, and said motor means being responsive to said output signal to control the speed of movement of said base means along said guide means.

6. A device according to claim **4,** further including follow-up control means coacting between said lever means and said base means for sensing when the speed of said base means is within predefined limits relative to the speed of the article.

7. A device according to claim **1,** wherein said converting means comprises a potentiometer having a rotatable wiper arm secured to and rotatable with said lever means.

8. A device according to claim **1,** wherein said lever means includes a first lever portion pivotally supported on said base means and a second lever portion pivotally supported on said first lever portion, and spring means coacting between said first and second lever portions for normally maintaining same in a selected positional relationship, said second lever portion being swingable relative to said first lever portion in opposition to the urging of said spring means to permit movement of said article along said first path in the opposite direction.

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