

[54] **CONTROL APPARATUS AND METHOD FOR TRANSPORTING SHEETS**

[75] Inventors: **Karl-Heinz Förster**, Dresden;
Lothar Vetter, Radebeul; **Helmut Stange**, Dresden, all of Germany

[73] Assignee: **VEB Polygraph Leipzig**, Leipzig, Germany

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[51] Int. Cl. **B65h 7/04**

[58] Field of Search 271/57, 47; 73/37.7, 37.5; 33/148 H, 147 L, DIG. 13; 340/259

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Primary Examiner—Evon C. Blunk

Assistant Examiner—Bruce H. Stoner, Jr.

Attorney, Agent, or Firm—Michael S. Striker

[57]

ABSTRACT

An apparatus and a method for controlling the correct transport of sheets. The thickness of one or several superimposed sheets is sensed to determine how many sheets are simultaneously transported. Transducer means transform mechanical magnitude signals into signals having a different physical quality, for example electric signals, and the transformed signals are evaluated and supplied by an output selector to different outputs which are, respectively, correlated with different numbers of sensed superimposed sheets.

12 Claims, 10 Drawing Figures

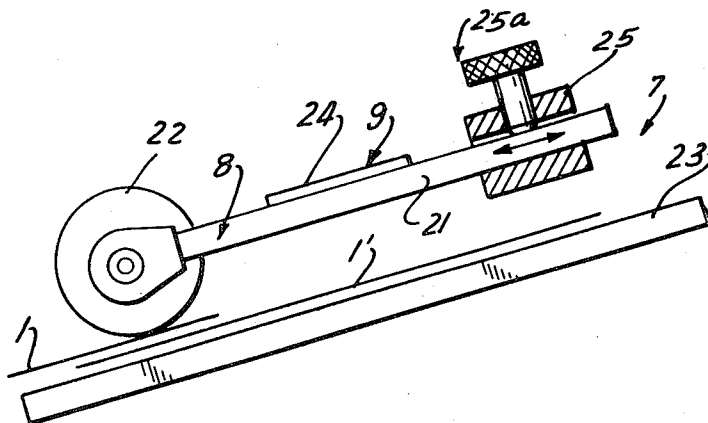


FIG. 1

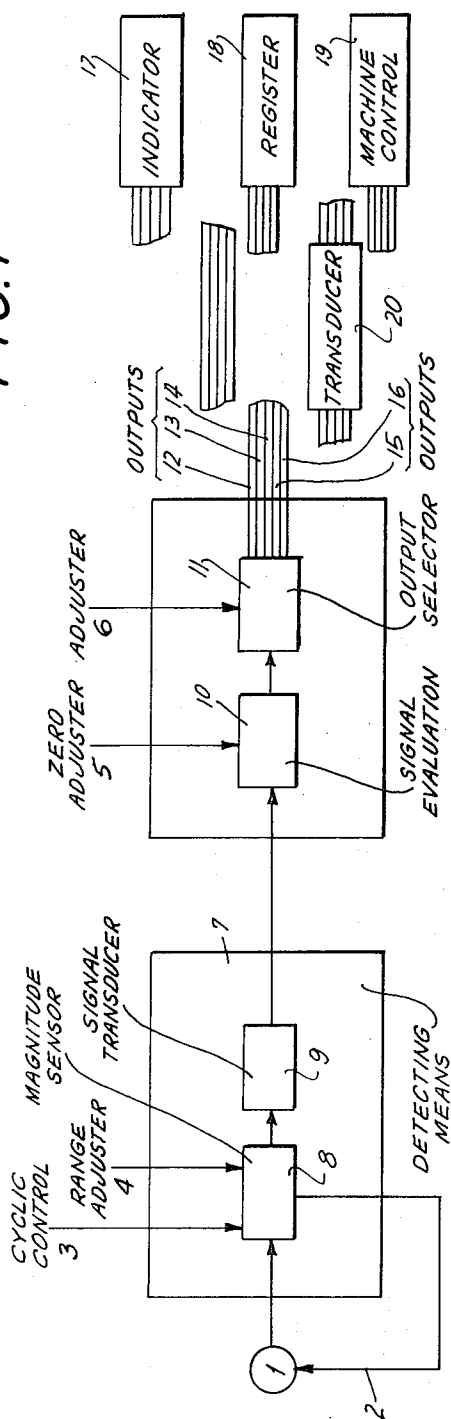


FIG. 2

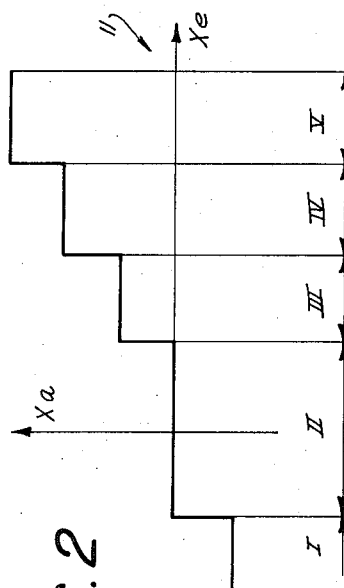


FIG. 8

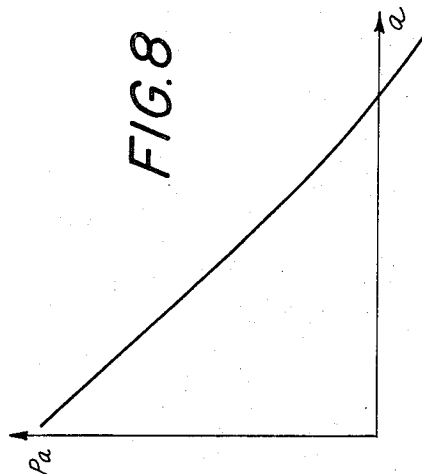


FIG. 7

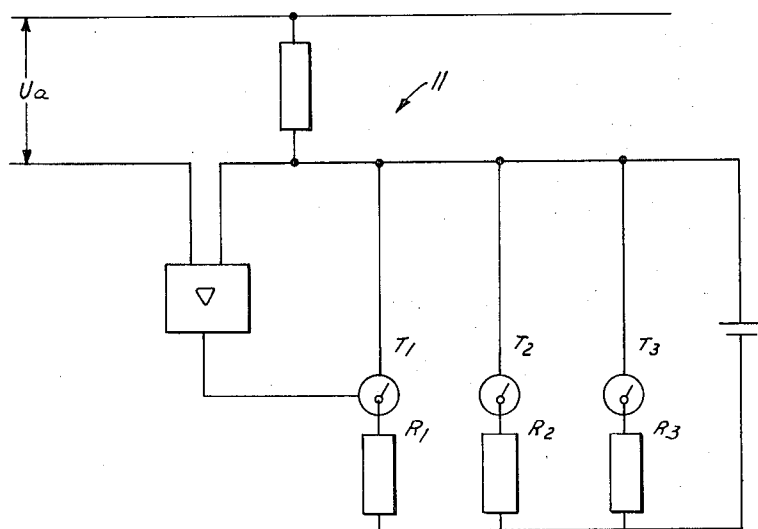
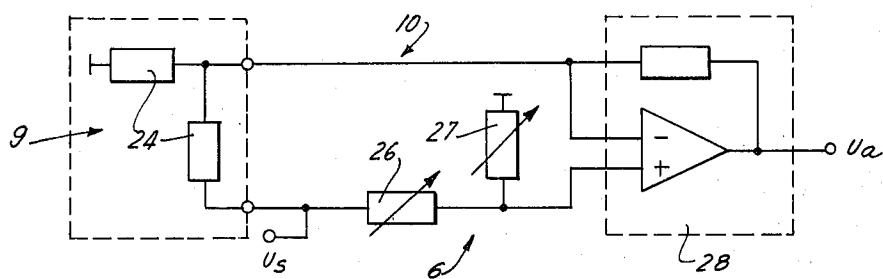
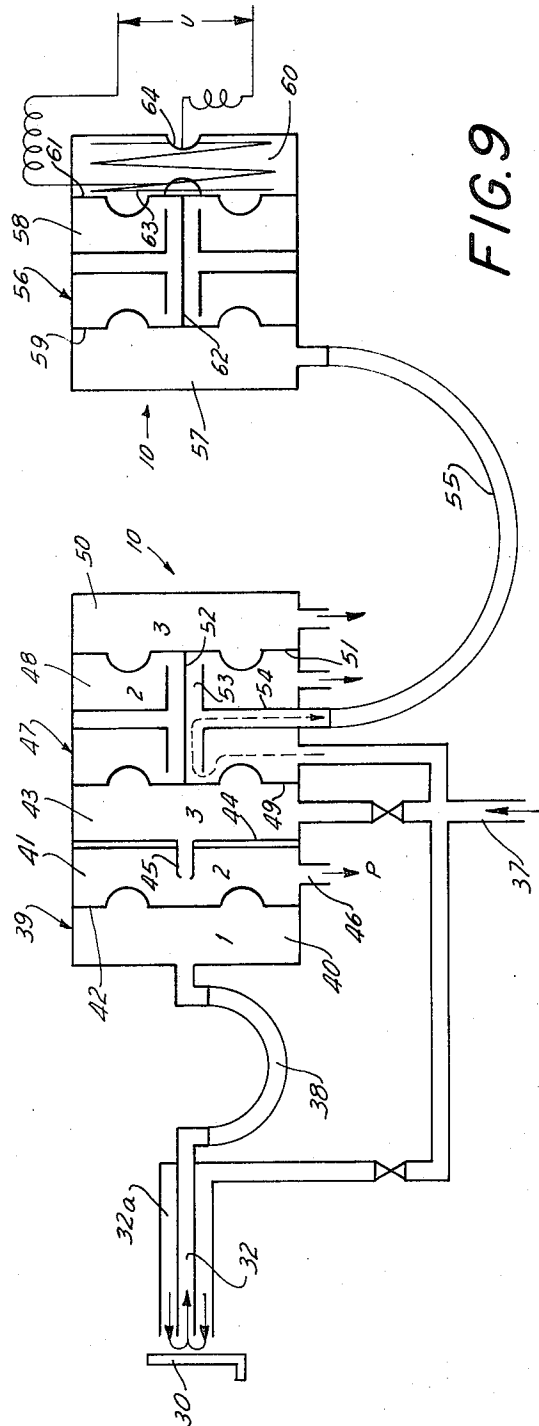


FIG. 10



CONTROL APPARATUS AND METHOD FOR TRANSPORTING SHEETS

BACKGROUND OF THE INVENTION

The present invention relates to an apparatus and method for controlling and indicating the correct transport of sheets for detecting the omission of sheets or multiple sheets which are transported and fed to a sheet processing machine.

Arrangements for the detection of double sheets or missing sheets are known in which the thickness of a sheet is measured at two separate stations, and the difference between the two measured values is recorded. It is a disadvantage of the known arrangements that, at the start of a sheet feeding operation, the sensed value is available only after a period of time corresponding to the time of the travel of the sheet between two sensing or monitoring stations. This causes particular difficulties when the machine is started. Furthermore, difficulties arise regarding equal adjustment when employing two detecting stations.

The BRD-AS 1,204,243 discloses electromechanical apparatus for the sheet control. It is a disadvantage of this apparatus that the exact adjustment of the contact causes difficulty, and that the contacts are subject to wear, and therefore unreliable.

The BRD-AS 1,238,492 and BRD-AS 1,092,438 disclose measuring method requiring electronic signal processing since they have capacitive or inductive detecting devices.

It is one object of the invention to provide a method and apparatus of simple construction capable of detecting improperly fed sheets. A related object of the invention is to detect and indicate omitted sheets and multiple sheets at a point near the sheet separation.

In accordance with the invention, omitted sheets and any number of superimposed sheets sticking together are clearly indicated by specific signals.

It is also an object of the invention, to provide an apparatus having a large measuring range and a small sensing pressure, and being independent of the properties of the transported sheet materials.

It is also an object of the invention to provide an apparatus and method which can be applied to either separately successively fed sheets or to sheets fed in overlapping condition.

In accordance with the invention, the thickness of sheet means transported at a measuring point at a measuring moment is transformed into an amplitude variation of a signal magnitude sensor, the amplitude variation is transformed into a signal having a different physical quality, and the transformed signals are evaluated and supplied to an indicating device and/or registering device, and/or to a machine control device.

An apparatus according to the invention comprises thickness magnitude sensor means for sensing transported sheet means and generating magnitude signals representing the number of sheet portions of the sheet means superimposed at a sensing point; signal transducer means for transforming the magnitude signals into transformed signals having a different physical quality; signal evaluation means for the transformed signals for representing different sensed thicknesses of the sensed sheet means by different electric signals, respectively; a plurality of outputs respectively associated with sheet means of different thickness; and output se-

lector means, such as a multipoint device, receiving the electric signals and supplying different electric output signals to corresponding different outputs.

As a result, signals at different outputs represent a missing sheet means and different numbers of superimposed sheet portions, respectively, whereby omission of a sheet or multiple sheets can be recognized.

In one embodiment of the invention, a flexible sensing arm, whose free length is adjustable, is used as a magnitude sensor means, and has an extensible strip whose resistance is varied when the sensing arm is deflected by sensed sheet means. The extensible strip serves as transducer.

In another embodiment of the invention, a sensing lever is mounted for angular movement, and has a baffle plate cooperating with a pneumatic nozzle of a pneumatic-electric transducer.

In a third embodiment of the invention, photoelectric sensing means are used which indicate displacement of a sensing piston by sheet means of different thickness by electric signals generated by a photoelectric matrix.

The multipoint device or output selector has different adjustable thresholds for omitted sheets, properly fed sheets, and any number of multiple sheets.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic block diagram illustrating the operational principle of an arrangement according to the invention;

FIG. 2 is a diagram illustrating voltage potentials of output selector means shown in FIG. 10;

FIG. 3 is a fragmentary side elevation illustrating parts of a first embodiment of the invention;

FIG. 4 is a fragmentary side elevation illustrating part of the second embodiment of the invention;

FIG. 5 is a fragmentary side elevation, partially in section, illustrating part of a third embodiment of the invention;

FIG. 6 is a fragmentary front view illustrating a detail of the embodiment of FIG. 5 on an enlarged scale;

FIG. 7 is a diagram illustrating a first signal evaluation device for the embodiment of FIG. 3;

FIG. 8 is a diagram graphically illustrating a pressure variation occurring in the embodiment of FIG. 4;

FIG. 9 is a schematic sectional view of a pneumatic-electric transducer for the embodiment of FIG. 4; and

FIG. 10 is a circuit diagram illustrating an output selector means particularly suited for the embodiment of FIGS. 3 and 7.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

When a stream of successive sheets are transported along a guide table, it is possible to transport separate single sheets, or to arrange successive sheets in overlapping position, as shown for sheets 1, 1' in FIGS. 3, 4 and 5. The free end of the sheet 1' again overlaps with

another sheet, not shown. It is possible that a sheet is omitted or that several sheets together are transported as if they were a single sheet.

In accordance with the invention either the separate sheets, or the overlapping portions of successive sheets are sensed and the lack of a sheet and sensed thickness of more than two overlapping portions of two successive sheets, indicates the improper transport of two or more sheets which stick together.

Referring now to FIG. 1, the thickness of a sheet means 1, or 1,1' or of a multiple sheet, is measured at a measuring point by a detector 7 which includes a thickness and magnitude sensor means 8, and a signal transducer means 9. The thickness of the sheet means 1, as schematically indicated in FIG. 1, is determined by the detecting means 7 which rests with a small measuring pressure 2 on the sheet means 1. The magnitude sensor means 8 is placed in the sensing position by a conventional cyclic control device 3 so that the overlapping sheet portions are sensed by sensing rollers 22 or 22' as shown in FIGS. 3 and 4 only at predetermined time intervals.

The magnitude sensor means 8 includes a signal range adjuster 4. The thickness representing magnitude signals of the detecting means 7 and magnitude sensor means 8, are supplied to signal transducer means 9 in which the magnitude signals are transformed into signals having a different physical quality; for example, mechanical displacement of the sensing arm 21 with sensing roller 22 in the embodiment of FIG. 3 is transformed into a resistance change of an expansible strip 9.

The transformed signals (e.g. the resistance changes of strip 9) produced by the signal transducer means 9 are supplied to signal evaluating means 10 which includes a zero point adjusting device 5 which represents a thickness of the sheet means corresponding to a desired correct thickness.

An output selector means or multipoint member 11 receives the signals from the signal evaluation device 10 shown in FIG. 7, for example, and supplies different electric output signals at corresponding outputs 12 to 16 so that the voltage appearing at a particular output represents the thickness of the sensed sheet means 1, 1'. It will be self-evident to persons skilled in the art that multipoint member 11 accordingly constitutes an analog-to-digital converter; this is also clear from FIG. 2 (discussed below) which sets forth in graphical form the operation of the multipoint member 11, this graphical representation being evidently a representation of the conventional operation of a conventional analog-to-digital converter. The output selector means 11 is provided with an adjusting means 6 for setting the device for omitted sheets or multiple sheets in a known manner. The multipoint member or output selector means 11 supplies signals to the outputs 12 to 16, respectively, in accordance with the sensed magnitude, and output 12 may be associated with an omitted sheet, output 13, with a correctly positioned sheet, output 14 with a double sheet, output 15 with a triple sheet, and output 16 for a stack of four sheets. Further outputs for sheets forming stacks may be provided.

Outputs 12 to 16 are connected with an indicating means 17 and the respective output signals are indicated; for instance, one light bulb can be provided for each of outputs 12-16. At the same time the outputs 12 and 16 are connected with a registering device 18

where the output signals are registered for further processing. The outputs 12 to 16 are also connected with a machine control means 19, and used for controlling functions of a sheet transporting and feeding machine, for example, blocking of the transporting movement and the like.

The devices 17 to 19 may be combined with each other in accordance with specific conditions at the machine. If the respective devices are controlled by different power and energy than the output selector 11, a system transducer 20 is connected between the outputs 12-15 and the devices 17 to 19.

FIG. 3 illustrates a first embodiment of the invention. The detector means 7 includes a signal magnitude sensor means 8 including a bendable sensing arm 21 with a sensing roller 22 which rolls on and senses the thickness of the stream of sheets guided along the guide table 23. The arm 21 is secured in a support 25, which after loosening of the adjusting screw 25a, can be displaced in support 25 for varying the length of the sensing arm 21 which corresponds to the measuring range adjuster 4 of FIG. 1, as indicated in FIG. 3 by the double arrow 4. Signal transducer means 9 include an extensible resistor strip 24 mounted on the sensing arm 21, and being preferably a semi-conductor extension measuring strip. As noted with reference to FIG. 1, a cyclic control device 3 places at the sensing moment the sensing roller 22 in the correct sensing position.

A signal evaluation means 10 for the embodiment of FIG. 3 is shown in FIG. 7. When sensing arm 21 is elastically displaced and bent, resistance of strip 24 is varied. Resistance strips of this type are sometimes referred to in the art as "strain gages". As shown in FIG. 7 two strips 24 are provided which are connected by a bridge circuit with two adjustable resistors 26, 27. The bridge outputs form the inlets of the feedback amplifier 28 whose output U_a is connected with the multipoint member or output selector 11, shown in FIG. 10. The voltage U_a varies in accordance with the sensed thickness of the respective sheet means 1,1'.

The multipoint member or output selector 11 shown in FIG. 10 has a zero amplifier V for the voltage U_a supplied from the signal evaluation device 10 shown in FIG. 7. Transistor switches T1, T2, T3 are connected in series with resistors R. Depending on the magnitude of the input voltage U_a , one of the transistor switches T1, T2, T3 is operated. Of course, it is possible to provide a greater number of transistor switches.

FIG. 2 graphically illustrates the function of the multipoint member or output selector 11. The line X_e represents the zero point, which is the output 13 in the region II which is associated with a normal correctly positioned sheet means. Depending on the distance of X_a from the line X_e , each voltage potential is associated with a specific output. The region I is correlated with the output 12 for indicating an omitted sheet, the region III is correlated with a duplicate sheet, the region IV is correlated with a triple sheet, and the region V is correlated with a stack of four sheets, so that regions I to V are respectively associated with the outputs 12 to 16.

It can be assumed that at the measuring point normally only one sheet is located. If the sheets are transported in overlapping condition, the standard normal sensed thickness of the stream of sheets will be a double sheet since portions of two successive sheets 1, 1'

overlap, and consequently a single sheet must be indicated as an omitted sheet.

The embodiment of the invention illustrated in FIGS. 3, 7 and 10 operates as follows: At the sensing moment, a double sheet is pushed under the sensing roller 22, corresponding to two overlapping sheets 1, 1'. The elastic deformation and deflection of the sensing arm 21 is transformed by the extensible strips 24 into a resistance change in the bridge circuit of FIG. 5. By adjusting resistors 26 and 27, the bridge circuit is balanced, and the output voltage U_a of operation amplifier 28 becomes zero. The apparatus is now ready for an operation. If at the sensing moment only one sheet, or a plurality of sheets is located under the sensing roller 22, the resistance of the extensible strips 24 is varied, and the output voltage U_a has a different high voltage potential. The respective voltage potential U_a is supplied to the output selector 11 shown in FIG. 10, which, in accordance with the adjusted characteristic, as shown in FIG. 2, supplies a voltage signal to the respective output 12. The adjustment of different thicknesses of the sensed sheet means is carried out by varying the bridge supply voltage U_s .

The embodiment of FIG. 4 and FIG. 9 provides a signal magnitude sensor means 8' in the form of a lever 29 having at one end an angular baffle or blocking plate 30 and at the other end a sensing roller 22'. Lever 29 carries a slide block 31b mounted in a housing 31a for adjustment of the length of lever 29 by means of a clamping screw 31. Lever 29 is angularly movable about a pivot 31 so that the angular position of the baffle plate 30 is changed when sensing roller 22' senses sheet means of different thickness due to omission or duplication of the sheet.

As also shown in FIG. 9, pressure air is supplied to an annular nozzle 32a so that the stream of air is reflected and reversed to flow to the sensor tube 32, producing pressure as indicated at P_a in FIG. 4. The pressure P_a of the reflected air is of course smaller than the pressure P_e of the pressure air supplied to nozzle 32a. Depending on the sensed thickness of the stream of sheets, lever 29 is angularly displaced so that the position of baffle plate 30 relative to the annular nozzle 32 is varied. The variation of the angle causes also a variation of the pressure P_a which depends on the distance between the baffle plate 30 and the nozzle 32 in accordance with the graph shown in FIG. 8. As shown in FIG. 4, the pressure P_a acts on the pneumatic-electric transducer shown in FIG. 9 to produce a voltage U at the output.

The return flow tube 32 is connected by a hose 38 with a pneumatic limit element 39 which has three air chambers. The first chamber 40 is connected with the hose 38 and return tube 32, and separated by a membrane 42 from the second air chamber 41 which is separated by a rigid wall 44 from a third air chamber 43. Wall 44 has a nozzle 45 projecting into the second air chamber 41 which has an outlet 46 communicating with the ambient air. The third air chamber 43 is at the same time the first air chamber of the following normal pressure-low pressure pneumatic amplifier 47. Air chamber 43 is separated from the second air chamber 48 of the pneumatic amplifier 47 by a membrane 49, while the second air chamber 58 is separated from the third air chamber 50 of the amplifier 47 by a membrane 51. Membranes 49 and 51 are connected by a rigid connector 52.

A conduit system 53 is provided in the second air chamber 48 of the amplifier 47, and extends in the direction of the connector 52, surrounding connector 52. A second conduit system 54 branches off the first conduit system 53, and is connected by the hose 55 with a pneumatic electric transducer 56.

The conduit system 53, 54 divides the air chamber 48 of the amplifier 47 into two chamber parts. The first part of air chamber 58 is connected by conduit 37 with a pressure source, and the second part of air chamber 48 with the ambient air. The third air chamber 50 is also connected with the ambient air.

A pneumatic-electric transducer 56 is constructed similar to the amplifier 47, and has a first air chamber 57 separated from a second air chamber 58 by a membrane 59. The second air chamber is separated from the third air chamber 60 by a membrane 61. Membranes 59, 61 are connected by a rigid connector 62. Membrane 61 carries a contact 63 connected with a voltage source, and on the opposite side of chamber 60, a second contact 64 is provided.

During operation, the baffle plate 30 is impinged by an annular stream of air from nozzle 32a to which pressure air is supplied from pressure inlet 37. Depending on the angular position of the baffle plate 30, which depends on the thickness of the sensed sheet means, the back pressure in the sensor tube 32 varies, and air at this pressure enters through hose 38 into the first chamber 40 of the pneumatic limit element 39.

At low back pressure, corresponding in FIG. 4 to a great distance a of baffle plate 30 from the nozzle 32, the membrane 42 is in the illustrated position, and air supplied to the third chamber 43 can enter through nozzle 45 into the second chamber 41 to flow out of outlet 46. Due to the free flow, the membranes 49 and 51 are in the illustrated position, and the air can flow, as indicated by broken lines and an arrow, through hose 55 to the pneumatic-electric transducer 56. The pressure in chamber 41 deforms membrane 49 so that the conduit system 53 is closed, and the air cannot flow to the pneumatic-electric transducer 56, and the pressure at the outlets of the low pressure-normal pressure amplifier 47 is zero.

Consequently, the membrane 59 of the pneumatic-electric transducer 56 returns to its initial position shown in FIG. 9, and the electric contacts 63, 64 open so that no output voltage signal is produced.

The pneumatic limit element 39 responds only to a predetermined limit pressure so that it can respond to only two signal conditions representing, for example, an omitted sheet and a correctly positioned sheet. If additionally, double sheets and triple sheets are to be evaluated, corresponding pressure limit elements, low pressure-normal pressure amplifiers, and pneumatic-electric transducers are required. The function of a pneumatic-electric transducer is, for example described in the U.S. Pat. No. 3,457,384.

Referring now to the embodiment illustrated in FIGS. 5 and 6, the signal magnitude sensor means 8'' includes a sensing piston 34 which rests on the overlapping portions of two sheets 1 and 1'. The rear portion 34a of sensing piston 34 is located in the light of a source of light 36 which is directed toward a photoelectric matrix 35. Adjusting means 4'' are schematically indicated by an arrow. Portion 34a, source of light 36 and photoelectric matrix 35 constitute a signal transducer 9'' which transforms the mechanical movement of sensing

piston 34 into electric pulses at output wires 35a of the matrix 35. A thickness variation of the sheet means 1, 1' due to the omission of a sheet or the addition of an unwanted sheet, is first transformed into movement of the sensing piston 34, and in accordance with the distance of displacement of piston portion 34a between the source of light 36 and the photoelectric matrix 35, a portion of the photoelectric matrix is covered. The covered portions of the photoelectric matrix 35 produce a different signal voltage than the uncovered portions, and in this embodiment, the signal evaluation and output selection is accomplished by a multiplex device, not shown, of the type described in the publication "Instruments and Control Systems" volume 41, 1968, No. 11, page 50.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of apparatus for controlling transported sheets, differing from the types described above.

While the invention has been illustrated and described as embodied in an apparatus and method for detecting improper feeding of transported sheets, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can, by applying current knowledge readily adapt it for various applications without omitting features, that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

We claim:

1. In combination with an arrangement for transporting a stream of sheets along a predetermined path in a predetermined manner, a system for detecting whether sheets are being transported along said path in said predetermined manner, particularly for detecting the improper absence of a sheet or the improper presence of a plurality of sheets where a single sheet should be provided, the arrangement comprising, in combination, sensing means positioned to sense the thickness of said stream of sheets at least at one location along said path, and operative for generating an analog signal having an analog value indicative of the sensed thickness; and analog-to-digital converter means having an input connected to said sensing means to receive said analog signal and being operative for determining into which of a plurality of predetermined ranges corresponding to the thicknesses of different respective numbers of sheets the analog value of said analog signal falls, and for generating one of a predetermined plurality of corresponding digital output signals indicative of the range into which the analog value of said analog signal falls, to provide an indication when a sheet is improperly absent or when a plurality of sheets are present where only a single sheet should be provided, wherein said sensing means comprises a bendable support arm having a free end, a sensing roller mounted for rotation on said free end and held by said bendable support arm in a position bearing down upon and contacting the sheets

of said stream of sheets, with said sensing roller and said bendable support arm being so oriented with respect to each other and with respect to said stream of sheets that changes in the thickness of said stream effect displacement of said roller in the direction of the thickness of said sheets and result in bending of said bendable support arm to an extent corresponding to the displacement of said roller and corresponding to the change in thickness of said stream of sheets, and at least one strain-gage element mounted on said bendable support arm at such a location as to undergo resistance changes in response to bending of said bendable support arm.

2. A combination as defined in claim 1, and further including means for fixedly mounting the other end of said bendable support arm, said means for fixedly mounting being adjustable for effecting changes in the location along the length of said arm at which said arm is fixedly mounted.

3. A combination as defined in claim 1, wherein said at least one strain-gage element forms part of a bridge circuit having an output and constituting part of said sensing means, and wherein said sensing means further includes an operational amplifier having an input connected across the output of said bridge circuit.

4. A combination as defined in claim 1, wherein said analog-to-digital converter means comprises a circuit having an input connected to receive said analog signal and having plurality of outputs and a plurality of threshold levels, one associated with each of said outputs, with said levels, establishing the limits of respective ones of said ranges and being associated with different multiples of the thickness of one sheet of said stream of sheet, including zero thickness and the thickness of a single sheet.

5. In combination with an arrangement for transporting a stream of sheets along a predetermined path in a predetermined manner, a system for detecting whether sheets are being transported along said path in said predetermined manner, particularly for detecting the improper absence of a sheet or the improper presence of a plurality of sheets where a single sheet should be provided, the arrangement comprising, in combination, sensing means positioned to sense the thickness of said stream of sheets at least at one location along said path, and operative for generating an analog signal having an analog value indicative of the sensed thickness; and analog-to-digital converter means having an input connected to said sensing means to receive said analog signal and being operative for determining into which of a plurality of predetermined ranges corresponding to the thicknesses of different respective numbers of sheets the analog value of said analog signal falls, and for generating one of a predetermined plurality of corresponding digital output signals indicative of the range into which the analog value of said analog signal falls, to provide an indication when a sheet is improperly absent or when a plurality of sheets are present where only a single sheet should be provided, wherein said analog-to-digital converter means comprises a circuit having an input connected to receive said analog signal and having plurality of outputs and a plurality of threshold levels, one associated with each of said outputs, with said levels, establishing the limits of respective ones of said ranges and being associated with different multiples of the thickness of one sheet of said

stream of sheet, including zero thickness and the thickness of a single sheet.

6. A combination as defined in claim 5; and further including a digital indicator device connected to said analog-to-digital converter means for providing a digital indication of the range into which the analog value of said analog signal falls.

7. A combination as defined in claim 5; and further including storage means connected to said analog-to-digital converter means for recording the range into which the analog value of said analog signal falls, whereby to make possible subsequent analysis of the operation of said transporting arrangement.

8. A combination as defined in claim 5; and further including control means for controlling operation of said transporting arrangement in dependence upon which of said predetermined plurality of digital output signals is generated by said analog-to-digital converter means.

9. A combination as defined in claim 8, wherein said control means is operative for terminating the transporting of said sheets in response to generation by said analog-to-digital converter means of a predetermined one of said plurality of digital output signals.

10. A combination as defined in claim 5, wherein said sensing means comprises a mechanical sensor member so mounted with respect to said predetermined path as to contact said stream of sheets and be physically displaced by said stream a displacement distance corresponding to the thickness of said stream, and wherein

said sensing means further comprises transducer means responsive to the displacement of said mechanical sensor member and operative for generating a signal indicative of the extent of such displacement and thereby indicative of the sensed thickness of said stream.

11. A combination as defined in claim 10, wherein said transducer means comprises at least one transducer element responsive to the displacement of said mechanical sensor member and also means for converting the response of said transducer element into said analog signal.

12. A combination as defined in claim 5, wherein said sensing means comprises a bendable support arm having a free end, a sensing roller mounted for rotation on said free end and held by said bendable support arm in a position bearing down upon and contacting the sheets of said stream of sheets, with said sensing roller and said bendable support arm being so oriented with respect to each other and with respect to said stream of sheets that changes in the thickness of said stream effect displacement of said roller in the direction of the thickness of said sheets and result in bending of said bendable support arm to an extent corresponding to the displacement of said roller and corresponding to the change in thickness of said stream of sheets, and at least one strain-gage element mounted on said bendable support arm at such a location as to undergo resistance changes in response to bending of said bendable support arm.

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