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⑤④ **Apparatus for monitoring the thickness of an object.**

⑤⑦ A thickness monitoring device wherein a linear variable differential transformer (LVDT) device is operatively coupled with a pinch roller mechanism so that variations in thickness which are detected as an object passes through the pinch roller mechanism are converted, by the LVDT device, to electrical signals which may be digitally processed to yield an accurate indication of thickness, and content. Such processed signals are used to control various machine functions in accordance with the thickness or content of the object which has passed through the pinch roller mechanism.

Such a thickness monitoring device finds particular utility in connection with mail extraction equipment in that such a device enables the envelopes being processed to be accurately monitored so that the mail extraction operation can proceed in accordance with specific performance parameters.

Description**APPARATUS FOR MONITORING THE THICKNESS OF AN OBJECT**Background of the Invention

The present invention relates generally to an apparatus for monitoring the thickness of an object, an in particular, to the use of such an apparatus in connection with mail extraction equipment.

A variety of applications require the careful monitoring of an object in terms of thickness so as to properly regulate the equipment which is being used to handle such articles. One such application, to which the present description is primarily directed, involves the regulation of equipment which is presently conventionally used for the bulk processing of mail, particularly the bulk processing of mail for the extraction of contents. Many facets of the mail extraction process call for monitoring of the envelopes being opened, in terms of thickness, either to make sure that the envelopes can be successfully processed through the apparatus, or to "outsort" envelopes which are not to be processed for any of a number of reasons (e.g., mail which is not to be opened by the operator for reasons of security, mail which is not to be opened by the operator because of its lesser importance).

In the bulk processing of mail for the extraction of contents, it has recently become important to pre-sort mail which is to undergo the extraction process so that only desired envelopes are processed through the mail extraction equipment. For example, such pre-sorting may be accomplished so as to make sure that only envelopes which are believed to contain invoices and checks for payment are immediately processed, leaving other envelopes of lesser importance for subsequent processing. Such an operation may be accomplished by passing the envelopes which are to be opened through a sorting mechanism which monitors each envelope in terms of the thickness, whereupon envelopes of the desired thickness are passed through the sorting mechanism to the extraction apparatus, while all other envelopes are diverted from the processing stream. A similar pre-sorting operation may be used to outsort mail which is not to be handled by the operator for purposes of security. For example, it may be desirable to make sure that envelopes containing returned or otherwise processed credit cards are diverted from the ordinary mail extraction operation, to avoid theft or loss. In such case, the diverted envelopes are preferably delivered to a secured container or the like, while all other envelopes are passed through the sorting mechanism to the extraction apparatus.

Irrespective of the particular sorting operation which is to take place, the critical parameter to be monitored is thickness, i.e. the thickness of the envelope to be processed through the apparatus. For example, in the processing of envelopes which contain only invoices and checks for payment, the decision as to whether or not to process an envelope will depend upon whether or not the envelope, together with its contents, is less than a

desired thickness. The presumption is made that thicker envelopes do not contain the desired contents, and should not be processed. In the outsorting of envelopes containing credit cards and the like, the decision as to whether or not to process an envelope will depend upon whether or not the envelope, together with its contents, exceeds a desired thickness. The presumption is made that the thicker envelopes contain a credit card or the like, and should be diverted to the secured container. Thus, the means which are used to monitor envelope thickness are pivotal in assuring that the mail extraction process proceeds in accordance with its desired parameters.

Mechanical sensors such as pressure rollers appropriately coupled with microswitches or the like, have traditionally been used for the purpose of monitoring envelope thickness. One such example of an apparatus which makes use of mechanical means to monitor the thickness of envelopes in the course of their processing may be had with reference to U.S. patent application Serial No. 630,955, filed July 16, 1984 and entitled "Envelope Sorting Apparatus". While such mechanical sensing devices have proved adequate in connection with the more traditional mail sorting operations, recent trends toward more complicated sorting routines have led to the need for more accurate and versatile sensing devices. For example, in some cases it may be desirable to sort envelopes based upon a specified range of thicknesses, and not just based upon a single threshold value. In other cases, it may be desirable to sort envelopes based upon the actual number of articles which they contain. In still other cases, the difference in thickness between an envelope which is to be processed and an envelope which is not to be processed may be so small as to prevent reliable sorting by available mechanical sensing devices.

Summary of the Invention

It is therefore the primary object of the present invention to provide an improved means for monitoring the thickness of an object.

It is also an object of the present invention to provide an improved means for monitoring the thickness of an object such as an envelope which is being processed for the removal of its contents in a mail extraction operation.

It is also an object of the present invention to provide an improved means for monitoring envelope thickness which exhibits improved accuracy and sensitivity over available mechanical thickness sensing devices.

It is also an object of the present invention to provide an improved means for monitoring envelope thickness which is sufficiently versatile to meet the various needs of a mail extraction operation, and which is adaptable to different mail extraction devices.

These and other objects are achieved in accord-

ance with the present invention by providing a thickness monitoring device wherein a linear variable differential transformer (hereinafter LVDT) device is operatively coupled with a pinch roller mechanism so that variations in thickness which are detected by means of the pinch roller mechanism are converted, by means of the LVDT device, to electrical signals which may be processed to yield an accurate indication of thickness. Such processed signals may then be used to control various machine functions in accordance with the thickness of the object which is passing through the pinch roller mechanism, as desired in a particular application.

Such a thickness monitoring device finds particular utility in connection with mail extraction equipment in that such a device enables the envelopes being processed to be accurately monitored so that the mail extraction operation can proceed in accordance with relatively specific performance parameters. Due to the improved sensitivity of the LVDT sensor, and the availability of subsequent signal processing, the thickness monitoring device of the present invention is sufficiently versatile to enable an accurate determination to be made as to the number of articles which are contained in the envelope, and whether the contents are in appropriate condition to proceed to extraction. For example, certain contents of the envelope may have been folded to mailing, or the contents may be attached together with clips or staples. The thickness monitoring device according to the present invention is sufficiently versatile to enable such conditions to be detected.

For further details regarding an apparatus for monitoring thickness in accordance with the present invention, reference is made to the description which is provided below, taken in conjunction with the following illustrations.

Brief Description of the Drawings

Figure 1 is a fragmented, elevational view of an envelope sorting apparatus which incorporates a thickness monitoring device in accordance with the present invention, with portions broken away to reveal internal construction detail.

Figure 2 is an enlarged, sectional view of those portions of the apparatus of Figure 1 which are shown at II.

Figure 3 is a block diagram of a circuit for processing the signals which are produced by the thickness monitoring device shown in Figures 1 and 2.

Figure 4 is a graph illustrating characteristic curves developed at the output of the LVDT sensor, prior to digital conversion and subsequent processing.

In the several views provided, like reference numerals denote similar structure.

Detailed Description of the Preferred Embodiment

Although specific forms of the invention have been selected for illustration in the drawings, and the following description is drawn in specific terms for the purpose of describing these forms of the invention, this description is not intended to limit the

scope of the invention which is defined in the appended claims.

Figure 1 illustrates a thickness monitoring device 1 in operative association with an envelope sorting apparatus 10. In terms of mechanics, the thickness monitoring device 1 generally comprises a pinch roller assembly 2 which includes a stationary roller or series of rollers 3, and a moveable roller or series of rollers 4, which tangentially contact one another at the interface 5. The number of stationary rollers 3 and moveable rollers 4 which are used in a particular application will depend upon the nature of the sorting which is to be accomplished, and the articles which are to be sorted. In any event, a spring 6 is provided to urge the moveable rollers 4 into contact with the stationary rollers 3 so as to maintain the integrity of the interface 5 during operation of the thickness monitoring device 1.

A connecting rod 7 operatively connects the moveable rollers 4 with the pole or slug 8 of a linear variable differential transformer (LVDT) device 9 so that movement of the rollers 4 with respect to the rollers 3 will cause reciprocation of the slug 8 within the LVDT device 9.

The specifics of the interface between the pinch roller assembly 2 and the LVDT device 9 will depend upon the apparatus with which the thickness monitoring device 1 is associated. For the purposes of description, Figure 1 illustrates use of the thickness monitoring device 1 in connection with an envelope sorting apparatus 10 such as is disclosed in U.S. patent application Serial No. 630,955, filed July 16, 1984, the subject matter of which is incorporated by reference as if fully set forth herein. However, it is to be understood that the thickness monitoring device 1 according to the present invention will find equal utility in connection with other envelope sorting devices, and well as other devices which can be used in the processing of envelopes. It is also to be understood that the thickness monitoring device 1 according to the present invention will find utility in connection with applications other than the processing of envelopes, which may call for the accurate monitoring of thicknesses in the course of their operation.

The envelope sorting apparatus 10 generally comprises an enclosure 11, the top 12 of which serves as a bin for receiving a series of envelopes for processing, and the interior 13 of which serves as a storage area for receiving envelopes which have been diverted from the stream of envelopes to be processed through the mail extraction device, as will be described more fully below. In operation, a reciprocating suction cup 14 is provided to sequentially engage each of a series of envelopes positioned on the top 12 of the enclosure 11, and to withdraw the engaged envelope 15 from the series for eventual contact with a vertical guide 16. From this position, the envelope 15 proceeds downwardly as a consequence of gravity, entering a pinch roll assembly 2 wherein the stationary rollers 3 are operatively associated with the vertical guide 16 and the moveable rollers 4 are operatively associated with a pivot 17. In this manner, the envelope 15 is caused to proceed through the pinch roller assem-

bly 2, preferably in response to rotation of the stationary rollers 3, eventually passing between the vertical guide 16 and a stationary guide 18 for delivery to a deflector 19.

Positioning of the deflector 19 is regulated by a connecting rod 20 which is reciprocated by a motor 21 in accordance with parameters which will be described more fully below. Consequently, the envelope 15 is capable of being monitored in terms of thickness as it is drawn through the pinch roller assembly 2 by rotation of the stationary rollers 3. The deflector 19 is then capable of being regulated in accordance with the monitored thickness of the envelope 15 so that it assumes either of two positions including a first position at 22 which passes the envelope 15 to the mail extraction device (not shown) for subsequent processing, or a second position at 23 which diverts the envelope 15 from the normal processing stream, for storage in the interior 13 of the enclosure 11. The interior 13 may be secured or unsecured, depending upon the nature of the envelopes which are being processed.

Any of a number of mechanical expedients may be used to interface the pinch roller assembly 2 with the LVDT device 9. With reference to Figure 2 of the drawings, in connection with the envelope sorting apparatus 10, it is particularly preferred that this interface be accomplished by attaching the connecting rod 7 to the pivot 17 by means of a ball and socket joint 24, which is preferably attached to the uppermost end 25 of the pivot 17, near the moveable rollers 4. Such a ball and socket joint 24 is preferred in that the amount of play between the pivot 17 and the connecting rod 7 can be kept to a minimum, particularly if the ball and socket joint 24 is formed of an appropriate (e.g. self-lubricating, resilient) plastic material.

In operatively connecting the thickness monitoring device 1 and the envelope sorting apparatus 10, it is important for the LVDT device 9 to be kept as separated as possible from the other electrical components which are associated with the envelope sorting apparatus 10, to reduce noise and other deleterious effects. This is simply accomplished by lengthening the connecting rod 7 so that the LVDT device 9 is appropriately placed within the interior 13 of the enclosure 11, away from the electrical equipment which regulates its operation.

Irrespective of the placement of the LVDT device 9 within the enclosure 11, the slug 8 is free to reciprocate according to changes in thickness which are sensed at the pinch roller assembly 2, responsive to reciprocation of the connecting rod 7. Consequently, the thickness of an envelope proceeding through the pinch roller assembly 2 is converted to an electrical signal which is developed at the output of the LVDT device 9. Such an electrical signal is capable of being processed in accordance with the present invention by the circuit 26 which is illustrated in Figure 3.

To this end, an LVDT driver circuit 27 is operatively coupled to the LVDT device 9 so that reciprocation of the slug 8 within the LVDT device 9 responsive to reciprocation of the connecting rod 7 will provide an appropriate output at 28. This output is then applied

to an LVDT signal conditioner 29, which places the output of the LVDT device 9 in proper condition for subsequent processing.

In this regard, the LVDT device 9 is in essence a transformer wherein the primary and secondary windings of the transformer are variably coupled in accordance with positioning of the slug 8. Consequently, the LVDT device 9 is preferably driven with a sine wave, of appropriate frequency and amplitude to match the electrical characteristics of the LVDT device 9 selected for use. This signal is developed by the LVDT driver circuit 27, and serves to provide optimum performance in terms of sensitivity and speed.

In practice, the output 28 of the LVDT device 9 is generally not yet appropriate for subsequent processing. Consequently, the output 28 is subjected to conditioning by the LVDT signal conditioner 29. For example, the signals delivered from the LVDT device 9 will be small in amplitude, and will therefore have to be amplified. Moreover, as a consequence of the input to the LVDT device 9 (a sine wave), the output 28 will be a full-wave rectified signal. As this signal will contain both a DC and an AC component, filtering of the signal is required so as to remove the non-DC components. A number of filters may be used in this regard, preferably an active two-pole low-pass filter. As a consequence of this conditioning, the output 30 of the LVDT signal conditioner 29 will be a DC voltage which varies in proportion to the separation at the pinch roller assembly 2, and which is appropriate for subsequent processing as follows.

The output 30 is applied to an analog-to-digital (A/D) converter 31. Digital conversion is preferred in that the resulting signal can be processed by a software oriented system, which serves to improved both the accuracy and the versatility of the resulting system. Such analog-to-digital conversion can proceed in either of two ways.

One way is to make use of any of the special purpose A/D converters which are conventionally available in the industry. While these devices are relatively fast, they are also relatively expensive. Such devices will therefore find utility in connection with thickness sensing operations wherein speed is of primary importance. However, in connection with the processing of envelopes in a mail extraction operation, the speed of such special purpose A/D converters far exceeds that which is necessary, and therefore does not justify the cost of such devices.

The other way in which analog-to-digital conversion may be accomplished, which is preferred in connection with relatively slow speed operations such as mail extraction, makes use of a convention digital-to-analog (D/A) converter in combination with a software controlled routine known as successive approximation. In such case, and with reference to Figure 3, a D/A converter is operatively coupled with a microcontroller 32 which contains the necessary software routines. Such a system has the added advantage that the microcontroller 32 is also capable of containing software routines for controlling various machine functions, either responsive to the thickness monitoring device 1 or other control elements of the envelope sorting apparatus 10, or

responsive to other portions of the mail extraction device with which it is associated. Some of these interfaces will be described more fully below. Any conventionally available, general purpose microcontroller having an integral program store, a data store and appropriate input/output ports may be used in this regard.

Successive approximation in essence calls for interactive communication between the D/A converter and the associated software routines provided in the microcontroller 32 to develop an analog-to-digital conversion by iterative techniques. To this end, the D/A converter receives a digital sequence from the microcontroller 32, which it converts to an analog signal. This analog signal is compared to the DC output 30 of the LVDT device 9, and the digital sequence developed within the microcontroller 32 is accordingly increased or decreased. Successive comparisons are made until such time as the output of the microcontroller 32 compares with the output 30 of the LVDT device 9. At that time, the digital sequence residing in the microcontroller 32 is the digital representation of the analog output of the LVDT device 9. This digital sequence is then available for subsequent processing in the other software routines which are present in the microcontroller 32 to regulate operation of the apparatus with which the thickness monitoring device 1 is associated, in this case the envelope sorting apparatus 10. It will be understood that such an iterative process requires significantly more processing time than would a conventionally available A/D converter. However, this increase in processing time is well within the design limitations of an envelope sorting scheme, and can be accomplished at considerably less cost.

It will be understood that in connection with the foregoing processes, certain variations will present themselves due to variations in the mechanics of the system (wear, adjustment, backlash, etc.), with corresponding changes in the signals which are produced by the LVDT device 9. To effectively match the signals which are produced by the LVDT device 9 to those portions of the circuit 26 which are used to interpret such signals, and to thereby take advantage of the maximum digital range of the foregoing system, a scaling circuit 33 is provided which is operatively coupled to the LVDT signal conditioner 29. By modifying the signals which are received from the LVDT device 9, adjustment of the scaling circuit 33 enables calibration between the mechanical input to the LVDT device 9 and the ultimate digital output of the microcontroller 32, in accordance with the actual conditions of operation of the system in a particular application.

As previously indicated, the microcontroller 32 not only serves to provide the calculations which are necessary for the operation of the thickness monitoring device 1, but also to control other aspects of the apparatus with which the thickness monitoring device 1 is associated. Consequently, the thickness monitoring device 1, through the microcontroller 32, will have access to those signals which are used to interface the microcontroller 32 with the associated apparatus.

For example, in connection with an envelope processing operation, a number of sensors 34 will be provided to indicate the status of the envelopes as they progress along the transport path which conveys the envelopes through the apparatus. These position sensors 34 serve as a convenient means for indicating when the thickness monitoring device 1 is to commence operation.

Upon operation of the thickness monitoring device 1 as previously described, the microcontroller 32 is then in a position to control various aspects of the envelope processing apparatus by controlling the various motors 35 which are used to perform the mechanical functions of the extraction process. For example, in terms of the present discussion, such motor control may be used to regulate positioning of the deflector 19 by controlling operation of the motor 21. Consequently, the routing of an envelope either to the mail extraction device, or to separate storage, is automatically controlled in accordance with the measurements which are made at the pinch roller assembly 2 of the thickness monitoring device 1. Other operational controls are equally possible since the microcontroller 32 serves as a centralized means for controlling the entire extraction process.

It will therefore be seen that the foregoing system serves well to satisfy each of the objectives previously set forth. It will also be understood that such a system is capable of variation in accordance with the present invention, as well as certain enhancement.

For example, since all of the information which is necessary to the control of an apparatus according to the thickness of a monitored article is capable of being stored within the microcontroller 32, the microcontroller 32 may be addressed to provide various diagnostic/calibration functions which are useful during set-up and servicing of the apparatus in its various modes. A test/diagnostics circuit 36 is therefore provided which is operatively coupled to the microcontroller 32, and which is capable of interfacing with an operator or service technician by means of an appropriate display so as to provide the information which is needed for factory set-up, field service and/or operator diagnostics.

Another advantage of microprocessor-based thickness sensing is that more complicated sensing schemes are capable of being developed simply by varying the software, without attendant variations in hardware. This leads to a number of advantages regarding system versatility.

For example, by appropriately initializing the system, it is possible for the microcontroller 32 to establish a base line before each envelope is measured for thickness, as the series of envelopes are being processed. Since this will tend to account for mechanical variations and electrical drift, less expensive components may be used. Moreover, set-up of the system is greatly simplified, if not virtually eliminated. These enhancements are advantageously achieved by taking a thickness measurement just prior to the introduction of an envelope between the rollers 3,4, to establish a zero base line, and by accordingly initializing the microcontroller 32. Thickness measurement will then

proceed as previously described, with this zero base line serving to account for system variations.

The microcontroller 32 is also capable of selectively monitoring thickness in accordance with a pre-established pattern, if desired. Selective monitoring permits an accurate measurement of thickness to be made by avoiding portions of the envelope which are characterized by special features such as envelope folds, seams or glue lines. By proper strobing of the microcontroller 32, it is possible to make sure that thickness measurements only take place along the more predictable, planer portions of the envelope surface.

Figure 4 graphically illustrates several characteristic curves which are typically developed at the output 30 of the LVDT signal conditioner 29, in an exemplary operation of the thickness monitoring device 1 according to the present invention. It will be noted that in progressing from left to right, a sudden initial increase in output voltage occurs at 37, which corresponds to the leading edge of an envelope being drawn through the pinch roller assembly 2. Prior to this occurrence, the system would preferably be initialized as previously described. As the leading edge passes the pinch roller assembly 2, the output voltage proceeds to level off, at 38. It will be noted that in the region 38, which represents passage of the face of the envelope through the pinch roller assembly 2, a number of different voltage levels are developed. These correspond to different thicknesses representative of the number of items contained in the envelope. For example, accounting for the anticipated thickness of an empty envelope, these levels correspond to a curve 39 which represents an envelope containing a single sheet of paper, a curve 40 which represents an envelope containing two sheets of paper, a curve 41 which represents an envelope containing three sheets of paper, and a curve 42 which represents an envelope containing four sheets of paper.

In analyzing the curves 39, 40, 41, 42, it will be noted that clear and distinct voltage levels are developed in accordance with the present invention. In a typical system according to the present invention, this separation will be on the order of 0.2V, which is more than sufficient for an accurate determination to be made as to the number of contents within the envelope. Of course, these voltage levels will vary in accordance with the thickness of the expected contents of a particular series of envelopes, as well as the envelopes themselves. However, in such case, level variations which are appropriate for accurate detection may be developed with proper scaling as previously described. Even greater, and more easily detected variations in voltage will occur in connection with relatively thick items such as credit cards and the like.

It will be noted that in connection with the curve 40, a sudden increase in voltage is detected at 43 which increases virtually to the same level as the curve 41 and then returns to the curve 40. Such a variation is characteristic of folded contents which are present in the envelope being emptied. Similar, although much larger variations are characteristic of

clipped or stapled contents which are present in the envelope. This enables the microcontroller 32 to detect the presence of folded, clipped or stapled contents, and to sort the envelope accordingly. Testing for these and other phenomena can be accomplished by appropriately programming the microcontroller 32 to detect such phenomena.

After passing the region 38, it will be noted that each of the curves 39, 40, 41, 42 departs from the relatively planar configuration at 38, and undergoes a sudden increase in voltage, at 44. This region represents the passage of the closure flap of the envelope 15 through the pinch roller assembly 2. Thereafter, the trailing edge of the envelope 15 passes from the pinch roller assembly 2, at 45. In view of the irregularities in voltage which are encountered in the regions 37, 44, 45, it is clearly preferable to take thickness measurements only in the region 38. This accomplished by strobing the thickness monitoring device 1 so as to regulate the timing of such thickness measurements. This is readily accomplished by varying the software in the microcontroller 32. Similar techniques may be used to avoid other predictable surface irregularities such as fold lines, seams, glue lines, etc.

In the above discussion, different thickness measurements are described in the alternative. However, the thickness measurement system of the present invention is also capable of compound operations if desired. For example, after initializing the system, it may be desirable to perform a "gross" sorting operation, to outsort undersirable envelopes (e.g., those containing credit cards), and to thereafter make a thickness measurement in the region 38 of each envelope which will enable the microcontroller 32 to make a subsequent determination as to the number of articles contained in the envelope, to assist in further processing. Other variations are also clearly possible.

It will therefore be understood that various changes in the details, materials and arrangement of parts which have been herein described and illustrated in order to explain the nature of this invention may be made by those skilled in the art within the principle and scope of the invention as expressed in the following claims.

Provided below is a computer program listing which is suitable for operating the microcontroller 32 in accordance with the present invention. This program listing is made with reference to a circuit 26 which is comprised of the following specific components.

LVDT driver circuit 27 - NE5520

LVDT device 9 - Model 100HR (Schaevitz)

LVDT signal conditioner 29 - Op-amp OP01

A/D converter 31 - DAC08 (D/A Converter) and CMP01 (Comparator)

Microcontroller 32 - 8748 (Microcontroller) and 8243 (I/O expander).

The program listing itself now follows.

Claims

1. An apparatus for monitoring the thickness of an object, comprising:

first roller means in fixed association with a reference surface,

second roller means in operative association with said first roller means so that said second roller means is adapted for movement toward and away from said first roller means;

means for normally biasing said second roller means into tangential contact with said first roller means;

a linear variable differential transformer operatively connected to said second roller means; and

circuit means operatively associated with said linear variable differential transformer, for receiving electrical signals from said linear variable differential transformer and for providing an electrical signal representative of the thickness of said object as said object passes between said first roller means and said second roller means.

2. The apparatus of claim 1 wherein said monitoring apparatus is operatively associated with an instrumentality which is to be controlled in accordance with the thickness of said object.

3. The apparatus of claim 2 wherein said instrumentality is operatively associated with said circuit means so that said electrical signal representative of thickness is capable of controlling said instrumentality.

4. The apparatus of claim 1 wherein the thickness of said object varies over its length, and wherein said electrical signal representative of thickness correspondingly varies as said object passes between said first roller means and said second roller means.

5. The apparatus of claim 4 wherein said object is an envelope, and wherein said monitoring apparatus is operatively associated with a device for extracting contents from said envelope.

6. The apparatus of claim 5 wherein said extracting device is operatively associated with said circuit means so that said electrical signal representative of envelope thickness is capable of controlling said extracting device.

7. The apparatus of claim 6 wherein said controlling includes the processing of envelopes for the extraction of contents, or the diversion of envelopes from said extracting device, in accordance with the thickness of said envelopes.

8. The apparatus of claim 7 wherein said envelopes are processed or diverted based upon the detection of a thickness of a specific threshold value.

9. The apparatus of claim 7 wherein said envelopes are processed or diverted based upon the number of articles which are con-

tained within said envelopes.

10. The apparatus of claim 7 wherein said envelopes have irregular features associated therewith, and wherein said monitoring apparatus includes control means for performing said thickness monitoring only in regions of said envelopes which do not have said irregular features.

11. The apparatus of claim 10 wherein said control means selectively strobes said circuit means to perform said thickness monitoring only in said regions.

12. The apparatus of claim 7 wherein said monitoring apparatus includes means for initializing said apparatus prior to monitoring one of said envelopes, thereby establishing a zero base line prior to said monitoring.

13. The apparatus of claim 7 wherein said envelopes contain articles which have irregular surface characteristics, and wherein said monitoring apparatus includes means for detecting said irregularities.

14. The apparatus of claim 1 wherein said circuit means comprises microprocessor means for digitally processing the electrical signals from said linear variable differential transformer.

15. The apparatus of claim 14 wherein said circuit means comprises analog-to-digital conversion means for operatively connecting said linear variable differential transformer and said microprocessor means.

16. The apparatus of claim 15 wherein said analog-to-digital conversion means comprises: digital-to-analog conversion means for receiving digital sequences from said microprocessor and for converting said sequences to an analog representation;

comparison means for comparing said analog representation and electrical signals from said linear variable differential transformer; and means for incrementing said digital sequences until the analog representation of the digital sequence from said microprocessor compares with the electrical signal from said linear variable differential transformer.

17. The apparatus of claim 15 wherein said linear variable differential transformer communicates with said analog-to-digital conversion means by conditioning means for preparing the electrical signals received from said linear variable differential transformer for digital conversion.

18. The apparatus of claim 17 wherein said circuit means comprises scaling means for matching the output of said linear variable differential transformer to the digital range of said analog-to-digital conversion means.

19. The apparatus of claim 18 wherein said circuit means comprises means for initializing said monitoring apparatus before the object is introduced between said first roller means and said second roller means.

20. The apparatus of claim 19 wherein said initializing means includes means for adjusting

said scaling means.

21. The apparatus of claim 14 wherein said circuit means comprises means for accessing said microprocessor means and the data contained therein.

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22. The apparatus of claim 14 wherein said circuit means comprises means for strobing said microprocessor means, to monitor the thickness of only selected portions of said object.

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23. The apparatus of claim 22 wherein said object is an envelope, and wherein said strobing means operates said microprocessor means only along substantially planar surface portions of said envelope.

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24. The apparatus of claim 23 wherein said strobing means operates said microprocessor means so as to avoid predictable surface irregularities in said envelope.

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FIG. 2

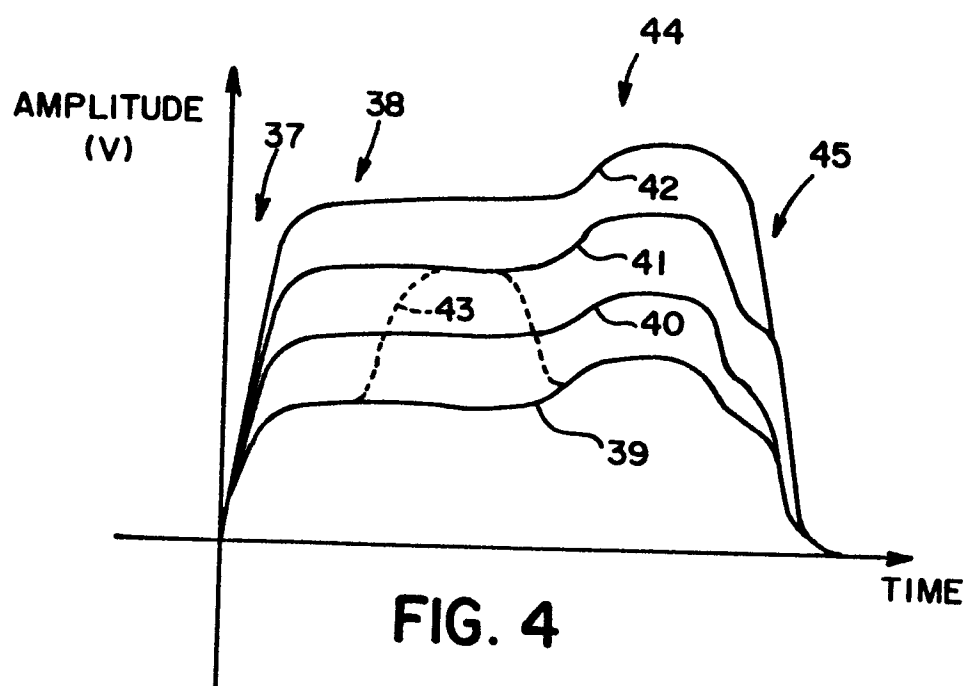
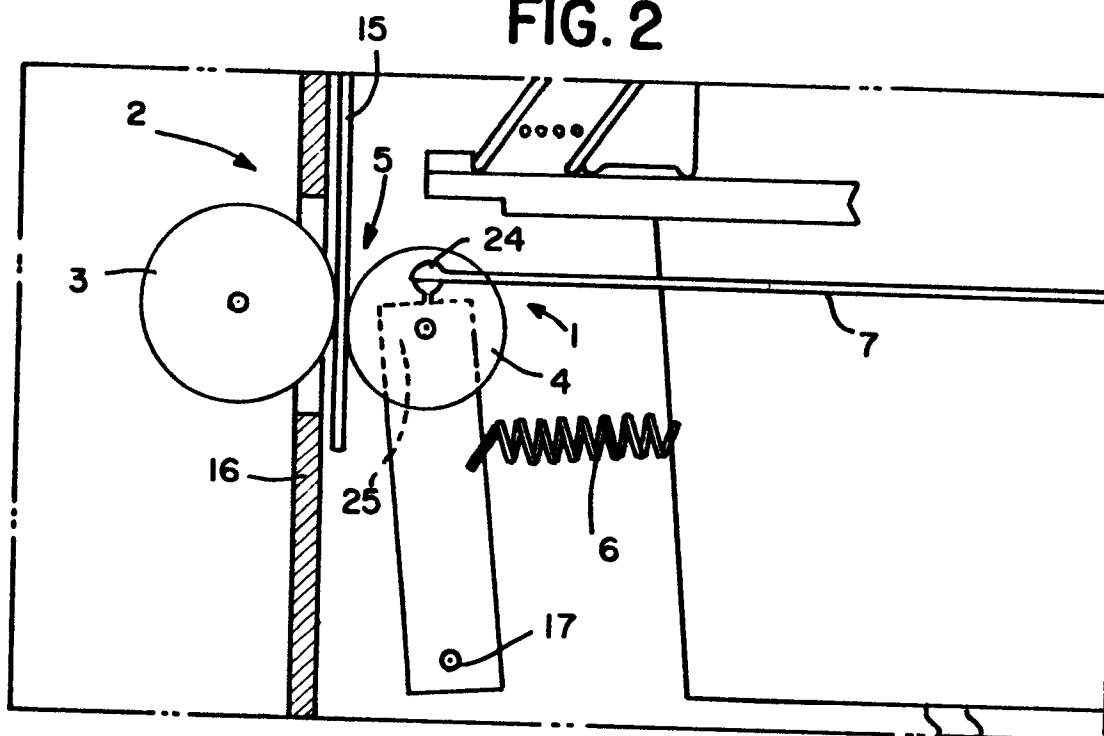


FIG. 4

FIG. 3

