

- [54] **SUPERPOSED SHEET DETECTION**
 [75] Inventor: **James H. Allen**, Webster, N.Y.
 [73] Assignee: **Xerox Corporation**, Stamford, Conn.
 [22] Filed: **Sept. 16, 1971**
 [21] Appl. No.: **180,973**

- [52] **U.S. Cl.**..... **340/259, 271/57, 340/285**
 [51] **Int. Cl.**..... **B65h 7/12**
 [58] **Field of Search**..... **340/259, 285, 272, 340/213 Q; 271/57 X, 57 R**

[56] **References Cited**
UNITED STATES PATENTS

- 3,287,015 11/1966 Preuss et al. 271/57
 3,182,301 5/1965 Kolb 340/259

OTHER PUBLICATIONS

Dorr, R. L. et al. Document Overlap Detection. IBM Tech. Disclosure Bulletin 14(8): p. 2501-2502, Jan., 1972. TK7800113

Primary Examiner—John W. Caldwell
Assistant Examiner—Glen R. Swann, III
Attorney—James J. Ralabate et al.

[57] **ABSTRACT**

Superposed sheet detecting methods and the apparatus wherein rotatable member disposed in operable location to sheet transport means is adapted to be angularly displaced in accordance with the thickness of sheets transported. Signals representative of the angular displacement of the rotatable member are produced and at the commencement of a detecting cycle, an initially produced signal is utilized as a reference signal. Subsequently produced signals are compared to the reference signal to determine differences therebetween. If the difference between a produced signal and the reference signal exceeds a predetermined level, the sheet associated with said produced signal is deflected from the sheet transport means and the detecting cycle is terminated.

27 Claims, 4 Drawing Figures

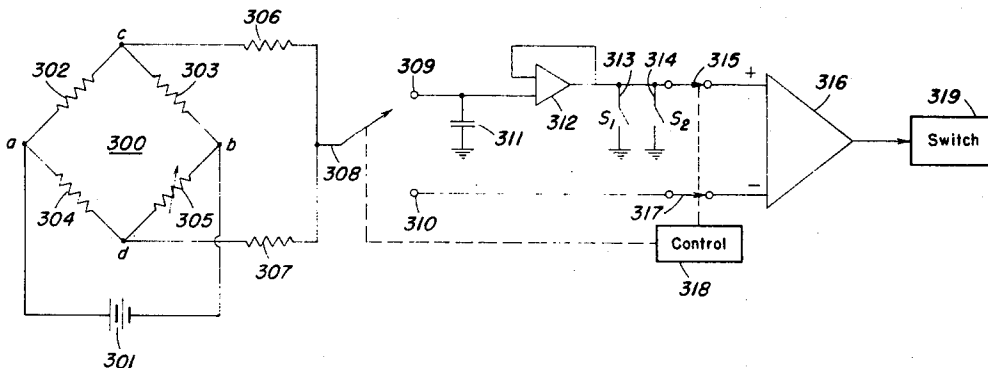
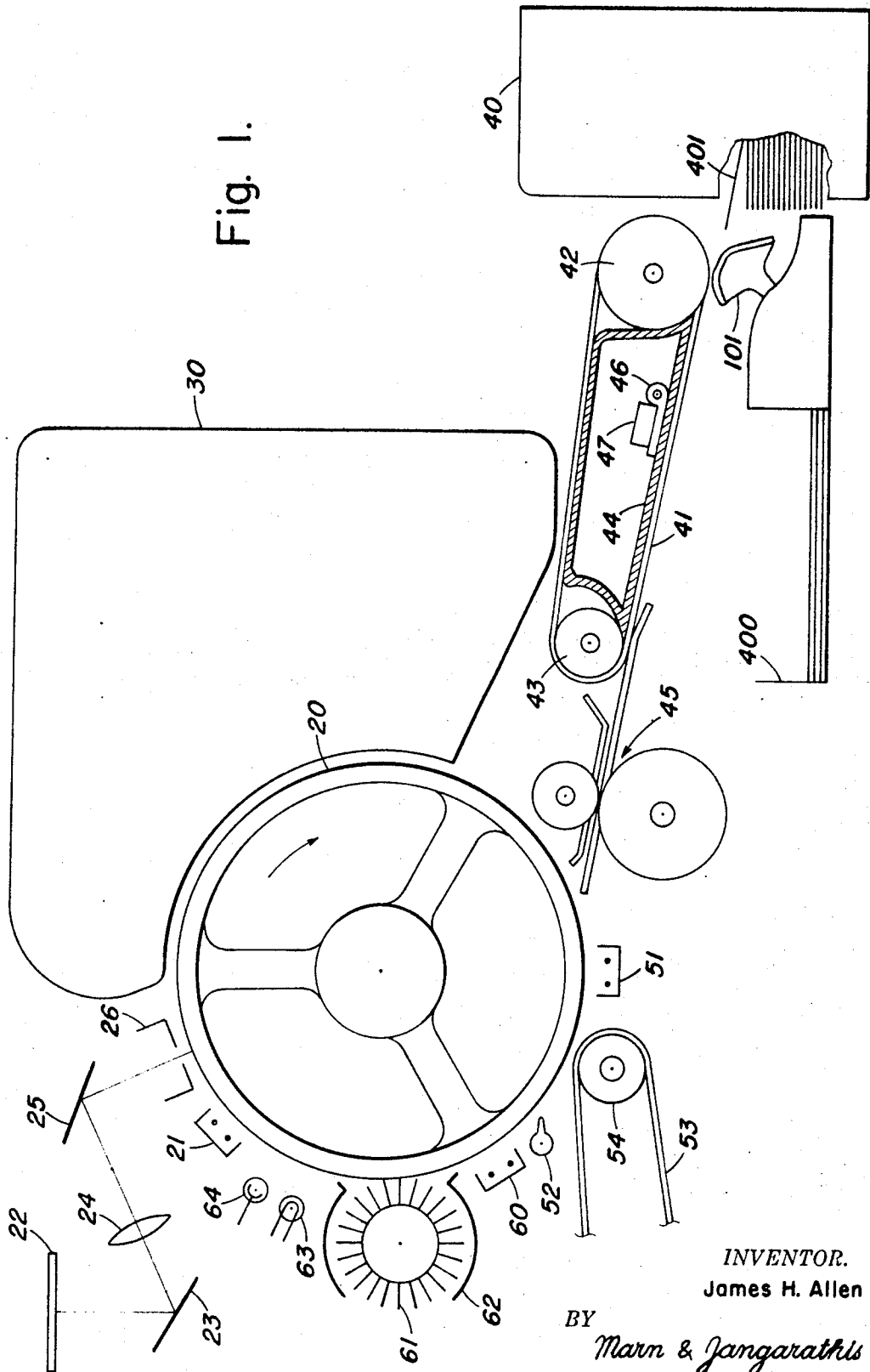


Fig. 1.



INVENTOR.
James H. Allen

BY
Marr & Jangarathis
ATTORNEYS

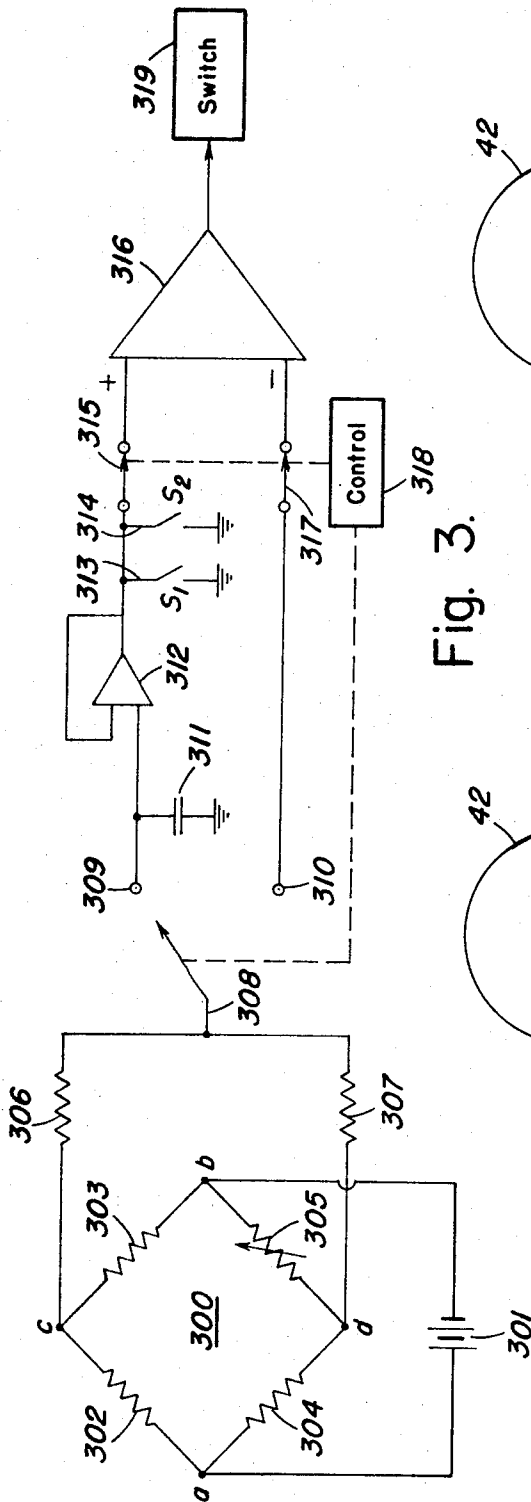


Fig. 3.

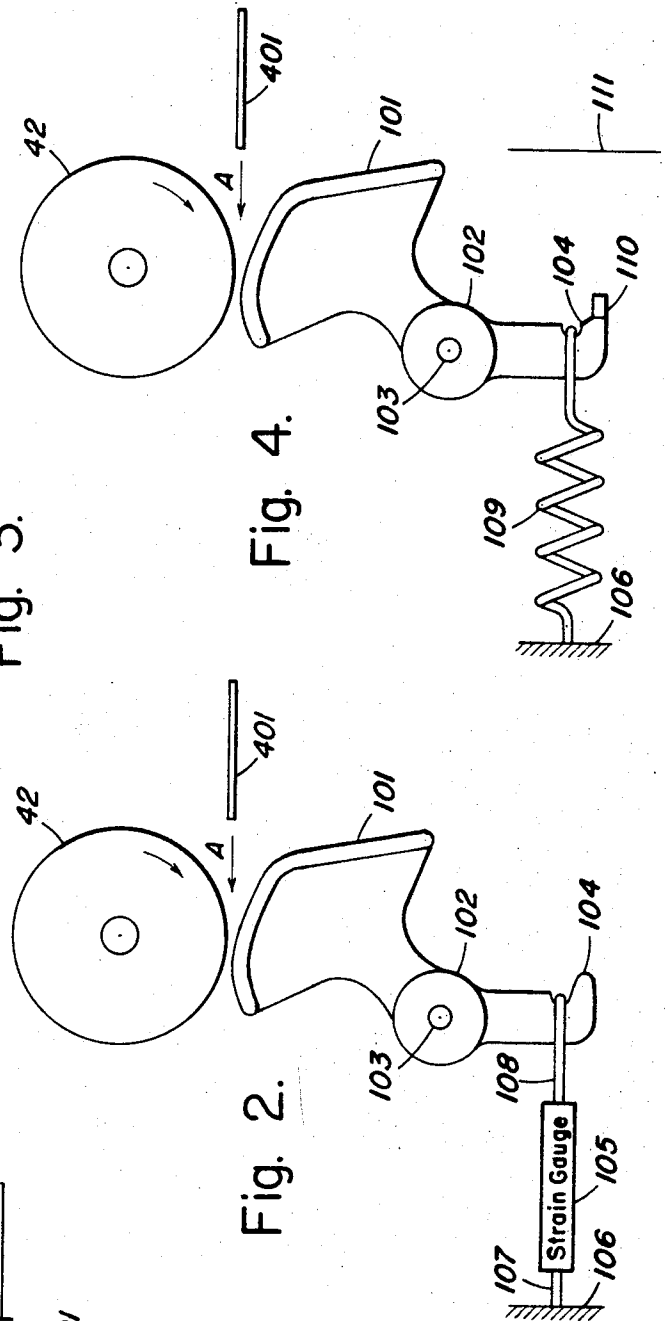


Fig. 4.

Fig. 2.

INVENTOR.
James H. Allen

BY
Marr & Jangarathis
ATTORNEYS

SUPERPOSED SHEET DETECTION

BACKGROUND OF THE INVENTION

This invention relates to a method of determining the thickness of material and the apparatus therefor, and more particularly to a method of and apparatus for detecting the transporting of superposed sheets of material.

Many devices such as printing presses, copy reproducing machines and the like operate upon sheets of material serially fed thereto. Successful operation of these devices is dependent upon the feeding thereto of single sheets of material. Moreover, these devices must be capable of operating upon sheets of material admitting of various thicknesses and weights and, in addition, must be characterized in the rapid switching of the operation thereof from one thickness to another. Although sheet transport means have been developed to convey single sheets of material, it has been found that superposed sheets are frequently transported thereby.

Various superposed sheet detecting means have been employed in cooperation with sheet transport means to insure that only single sheets are conveyed. These detecting means employ settable mechanical members which are effective to establish a specified tolerance wherein only single sheets within one range of thicknesses are passed through the detecting means, and superposed sheets are diverted from the transport path. One disadvantage of the foregoing superposed sheet detecting means is the limitation on the thickness of the material that may be employed therewith. Superposed sheets of relatively thin material may fail to actuate such detecting means whereas single sheets of relatively thick material may be diverted. Although the range of thicknesses may be adjusted by varying the specified tolerance, operation of these superposed sheet detecting means is unreliable when sheets of material admitting of non-uniform thickness is transported thereto.

Another disadvantage of the aforementioned superposed sheet detecting means is the requirement of frequent adjustment by a trained operator in order to maintain a specified tolerance. In addition, frequent adjustments thereof tend to impair reliable operation and cause recurrent mechanical failure.

Therefore, it is an object of the present invention to provide an improved method of determining the thickness of material and the apparatus therefor.

It is another object of the present invention to provide a method of and apparatus for detecting superposed sheets of material of variable thickness.

It is a further object of this invention to provide a method of and apparatus for detecting a multiple of sheets without the alteration of a pre-established tolerance to correspond to the thickness of said sheets.

Still another object of this invention is to provide self-adjusting apparatus for detecting superposed sheets of material admitting of selectively variable thickness without mechanically adjusting the apparatus for each range of thickness.

A further object of the present invention is to prevent the operation of a device upon sheets of material having a thickness without a desired range, which thickness might result in jamming and other malfunctioning of cooperating machinery of the device.

Various other objects and advantages of the invention will become clear from the following detailed de-

scription of embodiments thereof, and the novel features will be particularly pointed out in connection with the appended claims.

SUMMARY

In accordance with this invention, the method of detecting superposed sheets of material conveyed by a sheet transport device and the apparatus therefor are provided wherein the thickness of an initial sheet is represented by a reference signal and the thickness of a subsequently conveyed sheet is represented by a generated signal; the difference between the reference signal and a generated signal is determined, and if said difference exceeds a predetermined amount, the sheet associated with that generated signal is diverted from the sheet transport device and a subsequent reference signal is provided in accordance with the thickness of the next conveyed sheet of material. Alternatively, if said difference exceeds said predetermined amount, continued operation may be suspended until remedial action is taken.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more clearly understood by reference to the following detailed description of exemplary embodiments thereof in conjunction with the accompanying drawings in which:

FIG. 1 schematically illustrates a portion of a reproducing device wherein the superposed sheet detecting means of the present invention may be employed;

FIG. 2 illustrates the mechanical components that may be utilized with the superposed sheet detecting means of the present invention;

FIG. 3 is a schematic diagram of an electrical circuit in accordance with one embodiment of the present invention; and

FIG. 4 illustrates another embodiment of the mechanical components that may be utilized with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings wherein like reference numerals are used throughout and in particular to FIG. 1, there is shown automatic graphic reproducing apparatus such as a xerographic machine which comprises a xerographic plate 20 including a photoconductive layer or light receiving surface on a conductive backing and formed in the shape of a drum adapted to rotate in the direction indicated by the arrow to cause the drum surface sequentially to pass a plurality of processing stations.

The several processing stations in the path of movement of the drum surface are conventional and need only be briefly described. A charging station 21, such as a corona discharge device, is adapted to deposit a uniform electrostatic charge on or in the photoconductive layer of the xerographic drum 20.

An exposure station is provided to dissipate the electrostatic charge on the surface of xerographic drum 20, in accordance with character patterns prerecorded on a document 22. The exposure station may include an object mirror 23 positioned below document 22 to reflect an image of the document through lens 24 onto image mirror 25 which in turn reflects the image onto the xerographic drum through a slit in a fixed light shield 26 positioned adjacent the drum surface. Docu-

ment 22 is illuminated by a source of light (not shown). As is understood, the charge on the surface of the drum 20 is dissipated in accordance with the exposure thereof to form a latent electrostatic image of the document 22.

A conventional developing station 30 is positioned adjacent the exposure station. The developing station 30 may contain xerographic developing material including toner particles having an electrostatic charge opposite to that of the electrostatic image. The toner particles may be adapted to be cascaded over the drum surface whereby they adhere to the electrostatic latent image to form a xerographic powder image in the configuration of the character patterns of document 22. An image transfer station is positioned adjacent to the developing station and includes a sheet feeding mechanism adapted to feed sheets of support material such as paper or the like successively to the xerographic drum 20 in synchronism with the presentation of the developed image on the drum surface at the transfer station. The sheet feeding mechanism includes a sheet feed device 40 adapted to feed the top sheet 401 of a stack of sheets to roller means 42. Endless moveable belt means 41 are deployed about roller means 42 and roller means 43 and serve to transport the sheet fed to roller means 42 to a sheet registration device 45. The sheet transported by endless belt means 41 is adapted to adhere thereto by means of vacuum shoe 44. Vacuum shoe 44 is capable of reducing the air pressure above endless belt means 41 resulting in a force which urges the sheet against the belt means.

The sheet transport device includes sensing means 47 disposed at a predetermined location in said device and adapted to sense the leading edge of a sheet transported by endless belt means 41. Sensing means 47 may comprise a conventional switch including a depending lever interposed in the path of the transported sheets. Contact between the leading edge of a sheet and the depending lever is effective to close the switch. Alternatively, sensing means 47 may include a photoelectric device wherein a light beam may be interrupted by the leading edge of a transported sheet resulting in the closing of a switch or generation of a pulse signal. The sheet transport device further includes reject fingers 46 which are adapted to protrude into the path of a conveyed sheet upon being actuated. The movement of reject fingers 46 into the path of a conveyed sheet is effective to deflect the sheet into an abort or reject tray 400 located beneath the sheet transport device. Further description of reject fingers 46 and sensing means 47 is set forth hereinbelow.

The aforementioned sheet registration device 45 serves to arrest and align each individual sheet of material and then, in timed relation to the movement of the xerographic drum 20, advances the sheet material into contact with the xerographic drum in registration with a previously formed xerographic powder image on the drum 20. The transfer of the xerographic powder image from the surface of drum 20 to the surface of the sheet of material in contact therewith is effected by means of corona transfer device 51. The corona transfer device 51 is adapted to produce an electrostatic field which is capable of attracting the toner particles comprising the xerographic powder image from the surface of the drum 20 and cause them to adhere electrostatically to the surface of the support material.

Stripping apparatus 52 is positioned adjacent to the image transfer station for removing the sheets of support material from the surface of the drum 20. The stripping apparatus 52 may be of the type described by U.S. Pat. No. 3,062,536 which issued to Rutkus et al. and includes a plurality of small diameter orifices supplied with pressurized aeroform fluid by a suitable pulsator or other device. The pulsator is adapted to force jets of pressurized aeroform fluid through the outlet orifices into contact with the surface of the xerographic drum 20 slightly in advance of the sheet of support material to strip the leading edge of the sheet from the drum surface and to direct it on to endless moveable belt means 53 deployed about roller means 54 whereby the sheet material is carried to a fixing station (not shown).

The final station in the illustrated reproducing apparatus is a drum cleaning station having positioned therein corona precleaning means 60, rotating brush 61 and a discharge lamp 63. The rotating brush 61 is adapted to rotate into contact with the surface of drum 20 to remove residual powder therefrom. The powder particles removed from the xerographic drum 20 are collected by dust hood 62. The purpose of discharge lamp 63 is to flood the xerographic drum 20 with light to cause dissipation of any residual electric charge remaining on the surface thereof. In addition, photodetecting means 64 may be disposed in optical communication with the surface of drum 20 so as to be responsive to light emanating from lamp 63 and reflected by the surface of drum 20. It may be observed that if stripping apparatus 52 fails to remove a sheet of support material from the drum surface the intensity of the light reflected to photodetecting means 64 from the sheet adhering to the surface of the drum will be increased. Additional means may be coupled to photodetecting means 64 to detect the increased light intensity for a purpose soon to be described.

Suitable drive means are provided to drive the drum and the various operating stations illustrated in FIG. 1. In addition, the operable components of FIG. 1 may be supported by a rigid frame and mounting apparatus. A more detailed description of a xerographic reproducing device corresponding to that illustrated in FIG. 1 may be found in U.S. Pat. No. 3,301,126 which issued to R. F. Osborn et al. on Jan. 31, 1967, and assigned to the Xerox Corporation, the assignee of the present invention.

Referring now to the subject matter of the present invention, a rotatable member 101 is disposed adjacent roller means 42 to define a spaced relationship therebetween for the reception of a top sheet 401 fed thereto by sheet feed device 40. The rotatable member 101 is one of the mechanical components of the superposed sheet detecting apparatus of the present invention illustrated in more detail in FIG. 2 which comprises rotatable member 101, shaft 103 and strain gage means 105. Rotatable member 101, which may assume the configuration illustrated in FIG. 2, is fixed to sleeve 102 which in turn is secured to shaft 103. Shaft 103 may be journaled for rotation in a support frame (not shown) or, if desired, sleeve 102 may rotate about shaft 103. The rotatable member 101 includes a depending portion thereof which terminates in a spring arm portion 104. Strain gage means 105 may be a conventional resistance strain gage and is coupled to the spring arm portion 104 of rotatable member 101 by suitable fastening

means 108. The strain gage 105 is additionally secured to a rigid support 106 which may be, for example, a support frame for the apparatus of FIG. 1, by fastening means 107. A more detailed illustration of the configuration of rotatable member 101 may be seen in U.S. Pat. No. 3,396,965 which issued to J. K. Dennis et al. on Aug. 18, 1968, assigned to the Xerox Corporation. If desired, rotatable member 101 may assume a cylindrical configuration adapted to rotate about its longitudinal axis and coupled to strain gage means 105 at a radial location thereof. Alternatively, the rotatable member 101 may be a cam or an eccentric coupled to or in mechanical contact with strain gage means 105.

In operation, the rotatable member 101 is disposed at a location adjacent roller means 42 to define an interstice therebetween. The spatial relationship thus defined is determinative of the range of the thicknesses of sheets of material to be utilized with the present invention as will soon be seen. Preferably the spacing should be equal to the thickness of the thinnest sheet of material to be used. As the sheet of material 401 is fed between roller means 42 and rotatable member 101 in the direction indicated by the arrow A, the rotatable member 101 rotates in a counter clockwise direction. The contour of the rotatable member 101 should be such that, as the rotatable member rotates, the spacing between roller means 42 and the rotatable member 101 gradually increases. Accordingly, the rotatable member 101 will be angularly displaced a determinate amount in accordance with the thickness of sheet 401. It is readily apparent that as the thickness of sheet 401 increases or if a multiple of sheets are fed to the rotatable member, the angular displacement of rotatable member 101 is correspondingly increased. As the rotatable member 101 rotates, a strain is exerted thereby on strain gage means 105 resulting in an increase in the resistance of the strain gage means. If desired, the strain gage means 105 may be coupled to the rotatable member 101 such that rotation of the rotatable member 101 decreases the strain exerted on the strain gage means 105, thereby decreasing the resistance thereof. Detent means or slippage means may be provided to limit the strain exerted on strain gage means 105 by the rotation of rotatable member 101.

It is understood that the variation of the resistance of strain gage means 105 is a function of the thickness of sheet 401. This fact is turned to account by the electrical circuit of FIG. 3 which comprises impedance bridge means 300, storage means 311 and comparison means 316. The impedance bridge means 300 may be a conventional Wheatstone bridge including four resistance arms 302-305, respectively, together with a source of current 301. The resistance of each of resistance arms 302-304 is fixed and the resistance of resistance arm 305 is variable and may comprise the resistance of strain gage means 105 of previously described FIG. 2. The source of current 301 is applied to the impedance bridge means 300 via input terminals *a* and *b* as illustrated in FIG. 3. As is understood by those skilled in the art, impedance bridge means 300 admits of a balanced condition when the product of the resistance of resistance arm 302 and the resistance of resistance arm 305 is equal to the product of the resistance of resistance arm 303 and the resistance of resistance arm 304. When bridge balance is obtained, the voltage potential appearing at output terminal *c* is equal to the voltage potential appearing at output terminal *d*. It is clear that

the foregoing conditions maintain if input terminals *a*, *b* and output terminals *c*, *d* are interchanged. Output terminal *c* is coupled to switch means 308 via resistance means 306 and similarly, output terminal *d* is coupled to switch means 308 via resistance means 307. Accordingly, resistance means 306 and 307 comprise an algebraic combining network wherein switch means 308 is provided with a voltage potential indicative of the balance condition of impedance switch means 300. Thus as the variable resistance of resistance arm 305 is adjusted, switch means 308 is supplied with a corresponding voltage potential. It will soon become apparent that if desired switch means 308 may be coupled only to output terminal *d*.

Switch means 308 is controlled by switch control means 318 and is adapted to selectively couple input terminals 309 and 310 to the impedance bridge means 300. Hence, switch means 308 admits of a first state whereby input terminal 309 is coupled to the impedance bridge means 300 and switch means 308 admits of a second state whereby input terminal 310 is coupled to the impedance bridge means 300. Accordingly, switch means 308 may comprise a conventional stepping switch, a relay switch, a transistor switch or the like. Input terminal 309 is coupled to storage means 311 which is adapted to store the reference voltage potential applied to input terminal 309 via switch means 308. The storage means 311 may comprise a conventional capacitance means adapted to maintain a stored potential over a period of time. Alternatively, storage means 311 may comprise a conventional digital storage device such as a buffer register, a magnetic memory core or the like. The storage means 311 is coupled to a first input of comparison means 316 via switch means 315. A conventional voltage follower circuit 312 may be electrically interposed between the storage means 311 and switch means 315 to effectively isolate the storage means 311 from the remaining circuitry to mitigate the deleterious effects on the stored potential. Input terminal 310 is coupled to a second input of comparison means 316 via switch means 317. Comparison means 316 is adapted to compare the voltage potential stored by storage means 311 and the voltage potential supplied to input terminal 310 and in addition to indicate differences therebetween. Accordingly, comparison means 316 may comprise a conventional differential amplifier having first and second input terminals, or comparison means 316 may comprise a conventional operational amplifier having a non-inverting input terminal and an inverting input terminal or the like. The output signal produced by comparison means 316 is a function of the difference between the input signals applied thereto.

Switch means 315 is adapted to interrupt the electrical connection between the storage means 311 and the first input of comparison means 316. Accordingly, switch means 315 may comprise a conventional relay switch, a transistor switch or the like and is controlled by switch control means 318. Switch means 317 is similar to switch means 315 and is adapted for simultaneous operation therewith. The switch means 317 is effective to interrupt the electrical connection between input terminal 310 and the second input of comparison means 316.

As aforescribed, switch control means 318 is adapted to control the switching state of switch means 308 and in addition the switching states of switch

means 315 and 317, respectively. Switch control means 318 is operably coupled to sensing means 47 previously described with respect to FIG. 1 and is responsive to the passage of sheets of material through the sheet sensing station. Switch control means 318 may include a conventional counter means such as a relay counter or the like adapted to be incremented by sensing means 47. Accordingly, the counting means may indicate the number of sheets conveyed by the sheet transport device of FIG. 1. Alternatively, the counting means may indicate the sensing by sensing means 47 of an initial sheet or a subsequent sheet. The sensing of an initial sheet is effective to commence a detecting cycle whereby the switch control means 318 is energized such that switch means 308 couples the impedance bridge means 300 to input terminal 309. The sensing of a subsequent sheet is effective to energize switch control means 318 such that switch means 308 couples the impedance bridge means 300 to input terminal 310. Switch control means 318 additionally includes time delay means responsive to the sensing of a transported sheet of material by sensing means 47 whereby switch means 315 and 317 are closed for a predetermined period of time. In other words, the electrical connections to the first and second inputs of comparison means 316 are normally interrupted except during the intervals determined by the time delay means. Accordingly, the time delay means may comprise a conventional thermal delay relay, a monostable multivibrator or the like. It is understood that the operation of comparison means 316 is interrupted when the electrical connections thereto are interrupted whereby the output signal generated by comparison means 316 is effectively zero.

Switch means 319 is coupled to comparison means 316 and is adapted to be actuated when the output produced by comparison means 316 exceeds a predetermined positive or negative level. Accordingly, switch means 319 may comprise a relay switch, monostable multivibrator, a unijunction transistor circuit, a Schmitt Trigger, a silicon control switching circuit or the like. The actuation of switch means 319 is effective to close switch means 313, the latter being connected in shunt relationship with respect to storage means 311, and to terminate the detecting cycle. Switch means 313 serves as a reset switch for the storage means 311 whereby the contents of said storage means are erased therefrom. If storage means 311 comprises a capacitance means, the closure of switch means 313 provides a discharge path for the stored potential. The switch means 313 may comprise a conventional relay, a transistor switch or the like. An additional switch means 314, which may be similar to aforementioned switch means 313, is connected in parallel with and performs the same function as the switch means 313. However, the closure of switch means 314 is controlled by the actuation of photodetecting means 64, previously described with respect to FIG. 1. It is recalled that the photodetecting means 64 is adapted to detect the adherence of a sheet of material to the xerographic drum 20.

The operation of the electrical circuit illustrated in FIG. 3 will now be described in conjunction with FIGS. 1 and 2. When operation of the apparatus employing the sheets of material is initiated, the top sheet 401 is fed to the sheet transport device by sheet feeding means 40. The rotatable member 101 is angularly displaced in accordance with the feeding of sheet 401 to the space between roller means 42 and the rotatable

member 101. Consequently, a strain is exerted on the strain gage 105 to modify the resistance thereof in a corresponding manner. The modification of the resistance of the strain gage means 105 produces a corresponding modification in the resistance of resistance arm 305 which is detected in the well-known manner by the impedance bridge means 300. Accordingly, the balanced condition of the impedance bridge means 300 is disturbed and a voltage potential appears across the output terminals c, d. As is understood if the resistance of the strain gage means 105 is increased, the resistance of resistance arm 305 increases such that the voltage potential at output terminal d exceeds the voltage potential at output terminal c. Consequently, switch means 308 is provided with a positive potential. It is readily apparent that if the resistance of strain gage means 105 is caused to decrease by the angular displacement of rotatable member 101, switch means 308 will be provided with a negative voltage potential.

It will be assumed that when the operation of the apparatus of FIG. 1 commences, the electrical circuit of FIG. 3 exhibits a quiescent condition. That is, storage means 311 has been reset so that no signal is stored thereby, switch means 313 and 314 are open, the electrical connections to comparison means 316 are interrupted, and the switch means 319 is not actuated. When endless belt 41 transports a sheet of material to the sensing station, sensing means 47 detects the passage of the initial sheet to commence the detecting cycle. Switch control means 318 responds to the sensing of the initial sheet by sensing means 47 to energize switch means 308 such that the impedance bridge means 300 is coupled to the input terminal 309. Storage means 311 stores the voltage potential supplied thereto by the switch means 308, which voltage potential is a function of the thickness of the initial sheet of material transported by the sheet transport device of FIG. 1. At this time switch means 315 and 317 may be considered to be open so that the operation of the comparison means 316 is interrupted.

When the leading edge of the next sheet of material to be transported is detected by the sensing means 47, switch control means 318 is responsive to activate the switch means 308 whereby the impedance bridge means 300 is now coupled to input terminal 310. Rotatable member 101 is angularly displaced in accordance with the thickness of this next sheet of material, and the resistance of the strain gage means 105 is correspondingly varied. Accordingly, the resistance of resistance arm 305 is modified and impedance bridge means 300 provides a voltage potential across output terminals c, d that is a function of the thickness of the sheet of material.

The sensing of this sheet of material by sensing means 47 energizes the time delay means included in switch control means 318 so that switch means 315 and 317 close to complete the electrical connections to the inputs of comparison means 316. Comparison means 316 operates to compare the thickness of the initially transported sheet of material represented by the signal stored by storage means 311 to the thickness of the presently transported sheet of material represented by the signal supplied to input terminal 310. If the thicknesses of the respective sheets of material are identical, it is clear that the signals supplied to the respective input terminals of comparison means 316 will also be identical, and comparison means 316 will provide a

zero output signal. It is recognized, however, that the thickness of each sheet of material may vary within allowed limits. Consequently, comparison means 316 may provide an output signal indicating that the thickness of the initial sheet of material is not equal to the thickness of the presently detected sheet of material. If the output signal provided by comparison means 316 does not exceed a predetermined threshold, it may be assumed that the initial sheet of material and the presently detected sheet of material are comprised of single sheets respectively. Accordingly switch means 319 is not activated.

At the terminal of the time delay, switch means 315 and 317 open to interrupt the electrical connections to the inputs of comparison means 316. The apparatus of FIG. 3 is now prepared to respond to the next transported sheet of material. When sensing means 47 senses a leading edge of the next transported sheet of material, switch control means 318 operates to maintain switch means 308 in position to couple the impedance bridge means 300 to input terminal 310. The angular displacement of rotatable member 101 in response to the thickness of this sheet of material is detected by the impedance bridge means 300 which produces a voltage potential across the output terminals *c, d* representative thereof. The time delay means included in switch control means 318 is again energized by sensing means 47 to close switch means 315 and 317 for a predetermined interval of time. Comparison means 316 then compares the thickness of the initially transported sheet of material, which thickness is represented by the voltage potential stored by storage means 311, with the thickness of the presently detected sheet of material, which thickness is represented by the voltage potential applied to input terminal 310. If the signal provided by comparison means 316 does not exceed the predetermined threshold, switch means 319 is not activated. At the termination of the predetermined delay time interval, switch means 315 and 317 open, and the foregoing operation is repeated. If however the output signal provided by comparison means 316 exceeds the negative predetermined threshold, it may be assumed that the presently detected sheet of material is comprised of superposed sheets. Accordingly, switch means 319 is actuated by the signal supplied thereto by comparison means 316. Actuation of switch means 319 energizes a solenoid (not shown) or other means to project reject fingers 46 into the path of travel of the transported sheets of material. Hence the presently detected superposed sheets of material are deflected from the sheet transport device into reject tray 400. The actuation of switch means 319 additionally results in the closure of switch means 313 whereby the contents of storage means 311 are erased. Furthermore, the counting means of switch control means 318 is reset and the detecting cycle is terminated. After a suitable delay the electrical apparatus of FIG. 3 resumes the aforescribed quiescent condition. It is here noted that, if desired, switch means 313 may be closed and switch control means 318 may be reset automatically upon transporting a pre-set number of sheets of material having the proper thickness. In this case, if desired, the contents of storage means 311 need not be erased upon actuation of switch means 319. Hence, the stored reference thickness may be retained for subsequent comparisons. It should also be noted that if the presently detected sheet of material is undesirably thin, comparison

means 316 provides an output signal that exceeds the positive predetermined threshold. Accordingly, switch means 319 is actuated. Thus, a minimum thickness reference is provided by the present invention to provide upper and lower limits on the thickness of subsequently transported sheets of material.

The transporting of the next sheet of material by the sheet transport device of FIG. 1 is effective to initiate another detecting cycle. Accordingly, the sensing of the leading edge of the next transported sheet of material by sensing means 47 energizes switch control means 318 whereby switch means 308 couples the impedance bridge means 300 to input terminal 309. The storage means 311 stores the voltage potential provided across output terminals *c, d* of the impedance bridge means 300 which voltage potential is a function of the thickness of material fed to rotatable member 101. The leading edge of a subsequently transported sheet of material is sensed by sensing means 47 to energize switch control means 318 such that switch means 308 couples the impedance bridge means 300 to input terminal 310. It is now readily apparent that the electrical circuit illustrated in FIG. 3 is effective to compare the thickness of an initially transported sheet of material to the thickness of each subsequently transported sheet of material during a detecting cycle. If the thickness of a transported sheet of material exceeds the thickness of an initially transported sheet of material, the transported sheet of material is deflected from the sheet transport device, and the detecting cycle is terminated. The sheet of material that is next provided by sheet feed means 40 is effective to commence a subsequent detecting cycle.

The present invention provides for the possibility that an initially transported sheet of material is comprised of superposed sheets. If the voltage potential stored by storage means 311 is representative of the thickness of superposed sheets of material, the thickness of each subsequently transported single sheet of material will be such that comparison means 316 will provide an output signal that exceeds the predetermined threshold. It will be observed however that, if the initial sheet of material is comprised of superposed sheets, stripping apparatus 52 will remove only the overlying sheet. Consequently the underlying sheet of material adhering to the surface of the xerographic drum 20 will rotate to and will be detected by photodetecting means 64. The change in the intensity of light reflected to photodetecting means 64 from lamp means 63 by the adherent sheet of material is effective to close switch means 314 thereby resetting the electrical apparatus of FIG. 3 to the aforementioned quiescent condition. Alternatively, photodetecting means 64 may be coupled to switch means 319 so that a detected change in the intensity of reflected light is effective to actuate switch means 319.

It should now be readily apparent that the apparatus in accordance with the present invention is self-adjusting to detect superposed sheets of material of selectively variable thickness. For example if the thickness of the sheets of material transported by the sheet transport device is three mils, the signal stored by storage means 311 will represent a 3 mil thickness. The thickness of each subsequently transported sheet of material will be compared to the stored three mil thickness, and superposed sheets will be detected and deflected to reject tray 400. If now the thickness of sheets transported by the sheet transport device is 6 mils, then

the signal stored by storage means 311 represents a 6 mil thickness. The thickness of each subsequently transported sheet of material is then compared to a six mil thickness. It is apparent that the reference thickness, i.e., the signal stored by storage means 311, may be readily established by an operator of a machine wherein the present invention is to be utilized, merely by feeding a sample sheet to the transport device, which sample sheet represents the desired thickness of subsequently transported sheets. The remaining apparatus illustrated in FIG. 1 may assume an inoperative condition during this operation. One skilled in the art will recognize that the sensitivity of the apparatus in accordance with the present invention to variations of thickness within a range is determined by the aforescribed predetermined threshold. Therefore, the predetermined threshold should be established in accordance with the contemplated application of the present invention.

The present invention, as has been described, advantageously utilized the angular displacement of rotatable member 101 to vary the effective resistance of strain gage means 105. It should be readily apparent that a variable resistance means such as a potentiometer, a rheostat or the like may be substituted for the strain gage means 105 depicted herein. Accordingly, the movable contact of a potentiometer, which may comprise a rotatable shaft, may be mechanically coupled to shaft 103 of FIG. 2 whereby angular displacement of rotatable member 101 causes the shaft 103 to rotate which, in turn, imparts a displacement to the movable contact of the potentiometer resulting in a corresponding change in the effective resistance of the potentiometer. It is, of course, understood that if shaft 103 is adapted to be rigidly secure, thereby precluding any rotation thereof, the movable contact of the potentiometer may be mechanically coupled to sleeve 102. Moreover, the use of a strain gage to vary the resistance in one resistance arm of the impedance bridge means 300 of FIG. 3 does not necessarily require the use of the illustrated rotatable member 101. In general, any device that responds to the thickness of a sheet 401 to apply a corresponding force to the strain gage, may be satisfactorily employed. For example, a flexing member, such as a spring member, that is mechanically coupled to a strain gage, or is provided with a strain gage mounted thereon, may be properly positioned to detect the thickness of a sheet 401 fed to roller 42.

Although one embodiment that may be utilized to indicate the angular displacement of rotatable member 101 has previously been described, another embodiment is illustrated in FIG. 4 which comprises a light emissive element 110 and photoresistance means 111. The spring arm 104 of rotatable member 101 is fastened to a spring 109 which biases the rotatable member 101 in a clockwise direction. Light emissive element 110 is mounted on rotatable member 101 in a radially outward direction from shaft 103 and is adapted to transmit a beam of light of constant intensity. Photoresistance means 111 is disposed in spaced relation from light emissive element 110 and exhibits a resistive characteristic that varies with the relative position of light impinging thereon. Accordingly, photoresistance means 111 may comprise conventional bicells or quadcells conventionally utilized in position sensing applications, such as described at page 58 of the Feb. 15, 1969 issue of "Electronic Engineers Design Magazine," pub-

lished by Cahners Publications. Thus photoresistance means 111 may comprise the variable resistance of resistance arm 305 of the impedance bridge means 300. As the rotatable member 101 rotates in a counterclockwise direction in response to the positioning of sheet 401 intermittent rotatable member and roller means 42, the light emissive element 110 is angularly displaced in a corresponding manner. Accordingly, the position at which the light transmitted to photoresistance means 111 impinges thereon is vertically displaced, and the resistance of the photoresistance means 111 is correspondingly varied.

It should be apparent to those of ordinary skill in the art that the instant invention admits of a plurality of alternations and modifications which in no way change the basic teachings thereof. For example, as has previously been described, the rotatable member 101 may be mechanically coupled to the rotatable shaft of a potentiometer or rheostat whereby angular displacement of the rotatable member 101 produces a corresponding displacement of the adjustable contact of the potentiometer or rheostat. Accordingly, said potentiometer or rheostat may comprise the variable resistance of resistance arm 305 of impedance bridge means 300. In addition the adjustable resistance means to which rotatable member 101 is mechanically coupled may be replaced by adjustable impedance means such as a variable capacitance means or a variable inductance means. A typical example of the former comprises a rotatable air capacitor conventionally utilized in radio receivers. A typical example of the latter may comprise an adjustable core inductance coil whereby the inductance of said coil varies with the positioning of a magnetic core therein. Accordingly, impedance bridge means 300 may comprise an A.C. impedance bridge and source of current 301 may comprise an A.C. source. If desired, the resistance of the adjustable resistance means may be varied by means other than a rotatable member, such as by a compressible means or other aforescribed means.

A further modification of the present invention may comprise the addition of a storage means to input terminal 310 of FIG. 3. The added storage means may be similar to storage means 311. In addition a further unconnected input terminal may be provided intermittent input terminals 309 and 310 to which switch means 308 may be coupled after each sheet of material is fed by sheet feed means 40 to the sheet transport device of FIG. 1.

While the invention has been particularly shown and described with reference to printing presses and to xerographic reproducing machines, it will be obvious to those skilled in the art that this invention may be utilized with any device wherein the thickness of material or detection of superposed sheets is desirable. Consequently, it is apparent that the foregoing and various other changes and modifications in form and details may be made without departing from the spirit and scope of the invention. It is therefore intended that the appended claims be interpreted as including all such changes and modifications.

What is claimed is:

1. Apparatus for determining the thickness of material, comprising:

means for varying the impedance of variable impedance means in accordance with the thickness of said material;

detecting means connected to said variable impedance means for detecting variations of impedance and for generating signals representative of said variations;

means for comparing an initial one of said generated signals with each of subsequent ones of said generated signals and for indicating the results of said comparison;

means for coupling said means for comparing to said detecting means; and

means for resetting said means for comparing to a quiescent condition.

2. The apparatus of claim 1 wherein said means for varying the impedance of variable impedance means comprises a rotatable member disposed adjacent reference means to define a spaced relationship between said rotatable member and said reference means, said rotatable member being adapted to rotate in response to the positioning of material in said spaced relationship such that the angular displacement of said rotatable member is determined by the thickness of said material.

3. The apparatus of claim 2 wherein said variable impedance means comprises variable resistance means operably coupled to said rotatable member whereby the resistance of said variable resistance means is varied in accordance with the angular displacement of said rotatable member.

4. The apparatus of claim 3 wherein said variable resistance means comprises a strain gage mechanically coupled to said rotatable member.

5. The apparatus of claim 3 wherein said variable resistance means comprises:

a surface of photoresistive material having a resistance dependent upon the position of light impinging thereon; and

a light emissive element optically coupled to said surface of photoresistive material and mechanically coupled to said rotatable member such that the position of light transmitted to said surface of photoresistive material from said light emissive element is adapted to vary in accordance with the angular displacement of said rotatable member.

6. The apparatus of claim 1 wherein said detecting means comprises impedance bridge means including said variable impedance means in an arm thereof.

7. The apparatus of claim 1 wherein said means for comparing comprises:

storage means adapted to store said initial one of said generated signals; and

difference means having a first input coupled to said storage means and a second input, said difference means adapted to produce an output signal proportional to the difference between the signals supplied to the inputs thereof.

8. The apparatus of claim 7 wherein said means for coupling comprises:

switch means admitting of a first state whereby said storage means is supplied with an initial one of said generated signals and a second state whereby said second input of said difference means is supplied with subsequent ones of said generated signals; and switch control means coupled to said switch means for controlling the state of said switch means.

9. The apparatus of claim 8 wherein said means for resetting said means for comparing to a quiescent condition comprises:

means for erasing the contents of said storage means; and

activating means coupled to said difference means for activating said means for erasing when said output signal exceeds a predetermined threshold, said activating means being adapted to activate further means.

10. The apparatus of claim 9 wherein said means for comparing includes interrupt means adapted to interrupt the operation of said difference means for desired intervals.

11. Self-adjusting apparatus for detecting a multiple of sheets of material conveyed by a sheet transport device, comprising:

sensing means disposed at a predetermined location in said sheet transport device for sensing the passage sheets of material;

means for producing modifications of the impedance of variable impedance means in accordance with the thickness of said sheets of material;

detecting means controlled by said sensing means for detecting differences between an initial modification of said variable impedance means and subsequent modifications of said variable impedance means; and

further means coupled to said detecting means for producing an output signal in response to detected differences that exceed a predetermined threshold.

12. The apparatus of claim 11 wherein said detecting means comprises:

signal generating means for generating signals that are a function of the impedance of said variable impedance means;

storage means for storing an initial one of said generated signals;

comparison means coupled to said storage means for comparing the signal stored by said storage means with subsequent signals generated by said signal generating means; and

means controlled by said sensing means for selectively coupling said signal generating means to said storage means and said comparison means.

13. The apparatus of claim 12 wherein said means for producing modifications of the impedance of variable impedance means comprises a rotatable member operably coupled to said variable impedance means and disposed adjacent reference means to define a spaced relationship between said rotatable member and said reference means, said rotatable member being adapted to rotate in response to the transport of sheets of material through said spaced relationship such that the angular displacement of said rotatable member is determined by the thickness of said sheets of material.

14. The apparatus of claim 13 wherein said variable impedance means comprises a strain gage mechanically coupled to said rotatable member whereby the resistance of said strain gage is determined by the angular displacement of said rotatable member.

15. The apparatus of claim 13 wherein said variable impedance means comprises:

photoresistive material having a resistance dependent upon the relative position of radiant energy impinging on the surface thereof; and

a source of radiant energy mechanically coupled to said rotatable member such that the relative position of radiant energy transmitted to said surface of photoresistive material, by said source of radiant

energy is adapted to vary in accordance with the angular displacement of said rotatable member.

16. The apparatus of claim 13 wherein said further means comprises:

deflecting means adapted to be interposed in the path of said sheets of material conveyed by said sheet transport device for deflecting the sheets of material away from said sheet transport device; and actuating means coupled to said comparison means for actuating said deflecting means when the difference between the signals compared by said comparison means exceeds a predetermined threshold.

17. The apparatus of claim 16 further including reset means adapted to be actuated by said actuating means for erasing the contents of said storage means.

18. The apparatus of claim 17 wherein said means for selectively coupling comprises switch means responsive to said sensing means to couple said storage means to said signal generating means when an initial sheet of material is conveyed by said sheet transport device and to couple said comparison means to said signal generating means when subsequent sheets of material are conveyed by said sheet transport device.

19. The apparatus of claim 18 further including interrupt means responsive to said sensing means for interrupting the operation of said comparison means for determined intervals of time.

20. The apparatus of claim 13 wherein said signal generating means comprises:

impedance bridge means including said variable impedance means in an arm thereof; and means for applying energy to said impedance bridge means.

21. The apparatus of claim 20 wherein said storage means comprises capacitance means adapted to store a signal generated by said impedance bridge means.

22. The apparatus of claim 21 wherein said comparison means comprises differential amplifier means including a first input terminal adapted to be supplied with the signal stored by said capacitance means and a second input terminal adapted to be supplied with a signal generated by said impedance bridge means.

23. The apparatus of claim 22 wherein said means for selectively coupling comprises:

switch means admitting of a first state whereby said capacitance means is supplied with a signal generated by said impedance bridge means and a second state whereby said differential amplifier means is enabled to compare said stored signal with a signal generated by said impedance bridge means; and switch control means coupled to said switch means and responsive to said sensing means for controlling the state of said switch means.

24. Superposed sheet detecting apparatus for use in a sheet feeding mechanism wherein the thickness of the sheets may be selectively variable, comprising:

sensing means disposed at a predetermined location in said sheet feeding mechanism for sensing the transporting of sheets past said predetermined location and for initiating a detecting cycle;

a rotatable member positioned in cooperative relationship with respect to reference means and adapted to receive sheets transported thereto, said rotatable member being adapted for angular displacement in accordance with the thickness of said sheets;

signal generating means operably coupled to said rotatable member for generating signals representative of the thickness of said sheets;

reference signal means coupled to said signal generating means for providing a reference signal representative of the thickness of an initial sheet sensed by said sensing means;

comparison means coupled to said reference signal means and said signal generating means for comparing said reference signal to generated signals;

actuating means coupled to said comparison means and adapted to be energized when the difference between the thickness of an initial sheet and the thickness of a subsequent sheet exceeds a predetermined amount; and

means responsive to said actuating means for terminating said detecting cycle.

25. Superposed sheet detecting apparatus for use in a sheet feeding mechanism wherein the thickness of the sheets may be selectively variable, comprising:

means for receiving sheets transported thereto and for producing signals representative of the thickness of said sheets;

storage means selectively coupled to said means for producing signals for storing signals representative of the thickness of an initially transported sheet;

comparison means coupled to said storage means and said means for producing signals for comparing said stored signals to said produced signals; and

means coupled to said comparison means for providing an output signal to indicate when the difference between the thickness of an initial sheet and the thickness of a subsequently transported sheet exceeds a predetermined amount.

26. A method of detecting superposed sheets of material of variable thickness successively conveyed by a sheet transport device, comprising the steps of:

initiating a detecting cycle;

providing signals having magnitudes each of which is representative of the thickness of a corresponding one of said successively conveyed sheets of material;

comparing an initial one of said signals with each of subsequent ones of said signals during a detecting cycle;

producing an output signal to indicate when the difference between an initial signal and a subsequent signal exceeds a predetermined level;

deflecting the sheet of material conveyed by said sheet transport device when said indication is obtained; and terminating the detecting cycle.

27. A method of detecting superposed sheets of material of selectively variable thickness conveyed by a sheet transport device, comprising the steps of:

a. generating a reference signal representative of the thickness of an initially conveyed sheet material;

b. providing signals representative of the thickness of subsequently conveyed sheets of material;

c. producing an output signal to indicate when the difference between said reference signal and a provided signal exceeds a predetermined level;

d. deflecting the sheet of material associated with said provided signal;

e. discarding said generated reference signal;

f. repeating steps (a) through (e).

* * * * *