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Melby et al.

[11] **3,806,112**

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[54] **SHEET FEEDING APPARATUS**

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[73] Assignee: **Minnesota Mining and Manufacturing Company,** Saint Paul, Minn.

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[52] **U.S. Cl.** **271/10,** 271/118, 271/121, 271/127, 271/164

[51] **Int. Cl.** **B65h 3/06**

[58] **Field of Search** 271/118, 121, 127, 164, 271/162, 170, 160, 114, 116, 10, 9, 34

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Attorney, Agent, or Firm—Alexander, Sell, Steldt & DeLaHunt

[57] **ABSTRACT**

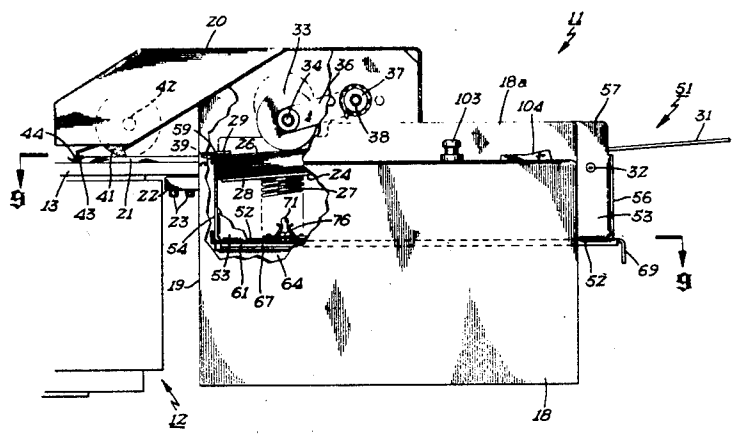
Sheet feeding apparatus is disclosed in which a movably mounted supporting tray supports a stack of sheets at one end of a desired path of feed. The tray has a vertically movable discharge end which is resiliently urged upwardly toward a retaining stop located at a fixed or constant vertical position. Thus the upper surface of the topmost sheet in the stack engages the stop and limits the upward movement of the tray discharge end, so that a common pre-feeding position is defined for the discharge end of each successive topmost sheet. A starting feed roller is mounted above the tray for movement between an upper non-feeding position, in which it is out of engagement with the stack of sheets, and a lower feeding position, in which the roller engages the upper surface of the topmost sheet and starts it along the path. Operating means for moving the starting feed roller from non-feeding to feeding position includes a resilient connection which insures resilient feeding engagement of the roller with the topmost sheet, while the tray discharge edge is urged upwardly with sufficient resilient force to feed the discharge end of each successive topmost sheet from essentially the same vertically located pre-feeding position immediately below the retaining stop.

The sheet-supporting tray is mounted in a removable holder or magazine by pivoting the tray on a horizontal transverse axis spaced substantially rearwardly from the discharge edge, with the axis located vertically to position the tray in a generally horizontal plane when the discharge edge of an empty tray engages the retaining stop. The stop is also part of the magazine, which further includes bottom, side and end walls, with an open-topped discharge end for providing direct feeding engagement of the starting feed roller with the topmost sheet in the magazine, when such roller is moved to feeding position.

The apparatus includes a movable supporting frame for the supply magazine, which can be moved between feeding and loading positions. Magazines with different sizes of sheets can be selectively mounted on the frame with one edge of each such magazine aligned along the same corresponding edge of the path.

An auxiliary feed roller having a foam rubber or other foam-like elastomer peripheral surface is positioned above the path to engage the upper surface of each sheet fed forwardly from the supply stack. The apparatus also includes means for removable attachment at an edge of a processing machine, with the auxiliary feed roller above a bed plate of such machine for feeding the sheets across such bed plate. Sheet detecting means and control means are provided to insure desired sequential feeding of successive topmost sheets with controlled spacings along the path, and to turn off the machine automatically when the supporting tray is empty and whenever a sheet fails for any reason to reach a predetermined point along the path within a desired time interval.

3 Claims, 11 Drawing Figures



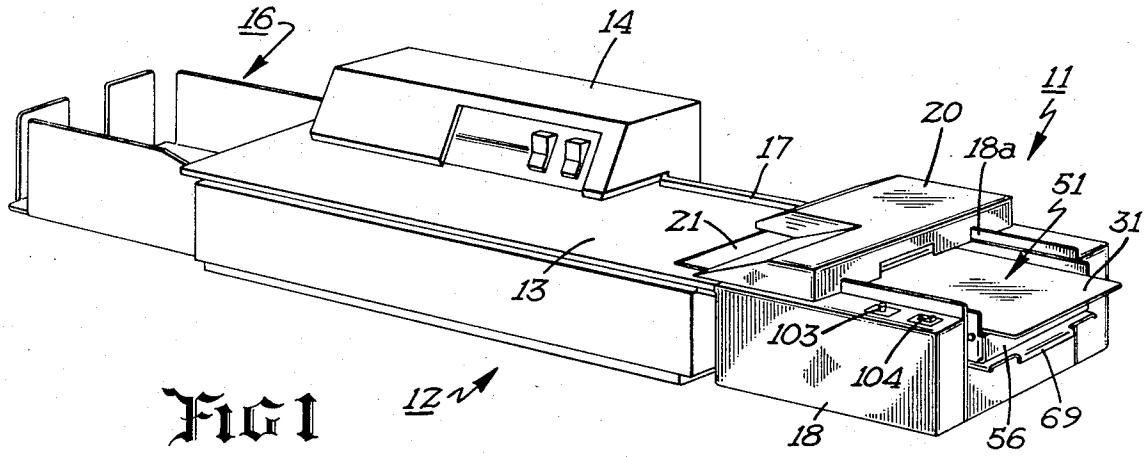


Fig 1

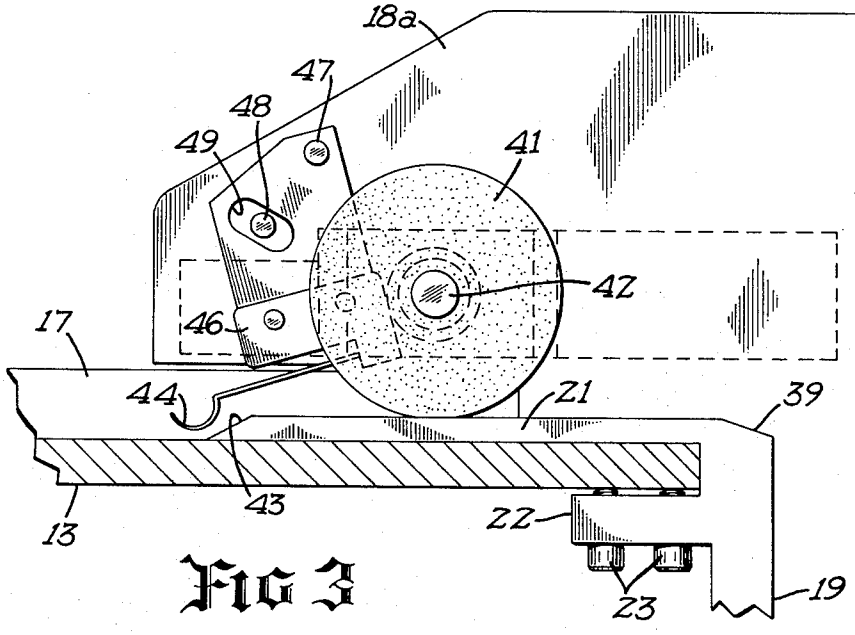


Fig 3

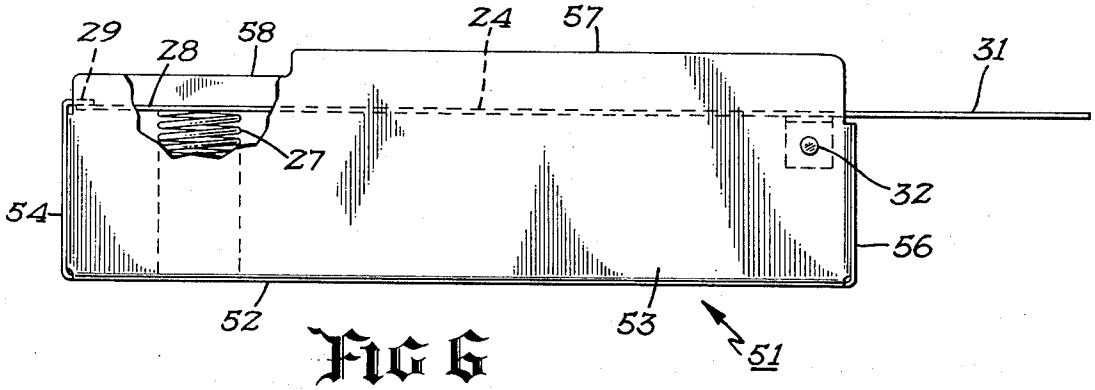


Fig 6

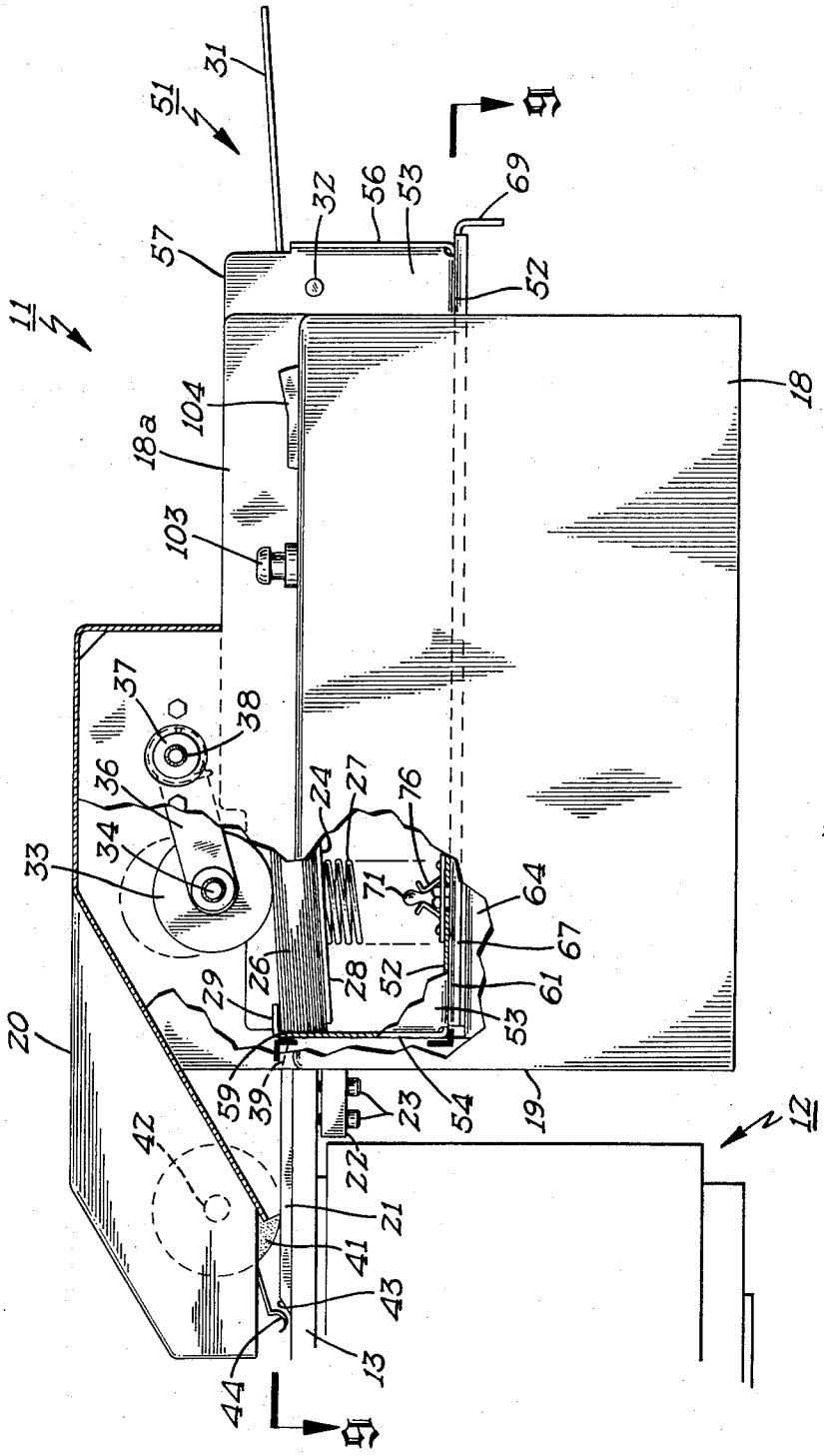

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FIG 2

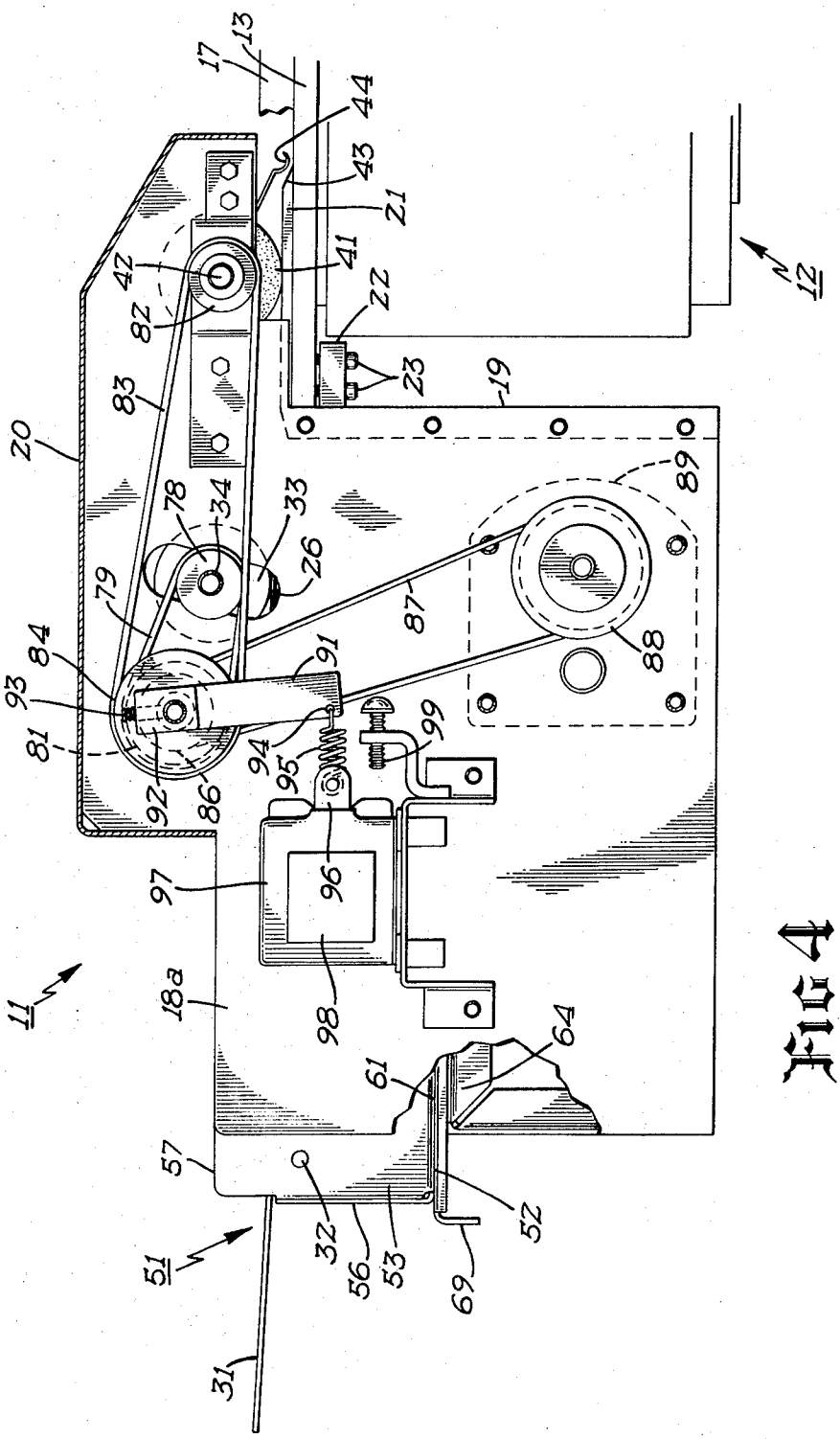

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FIG 4

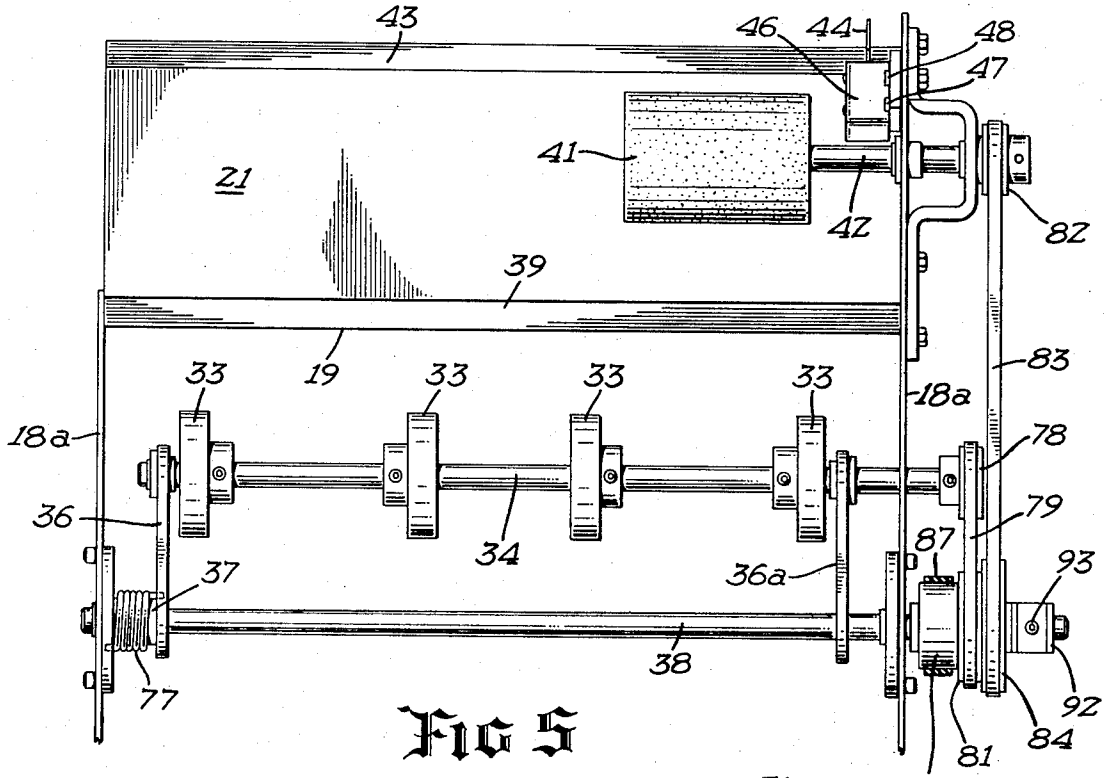


Fig 5

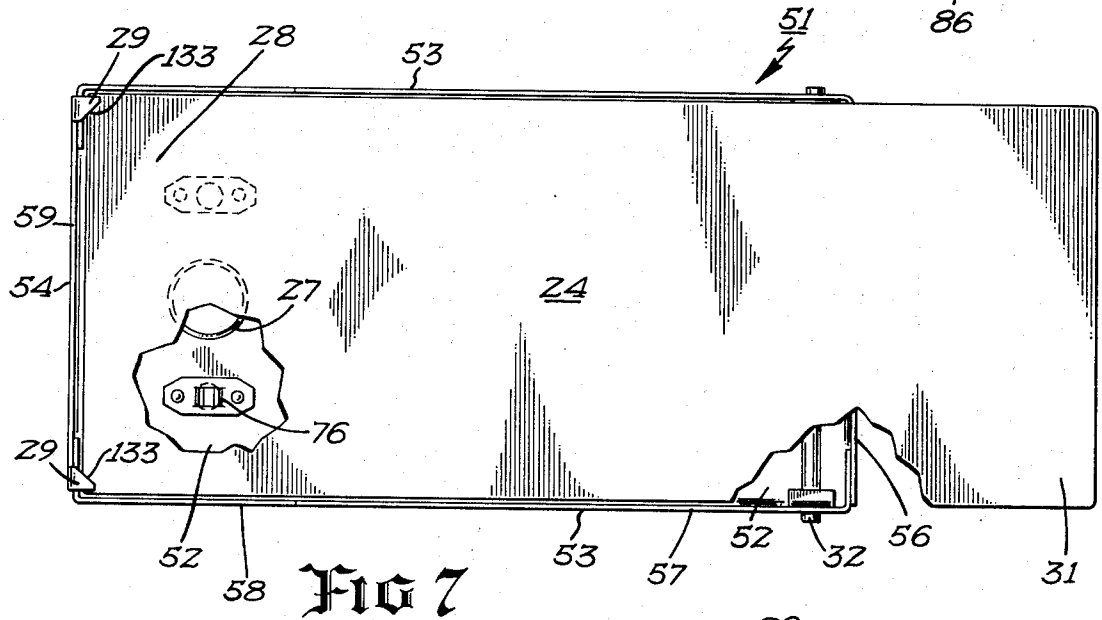


Fig 7

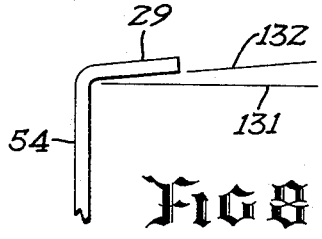


Fig 8

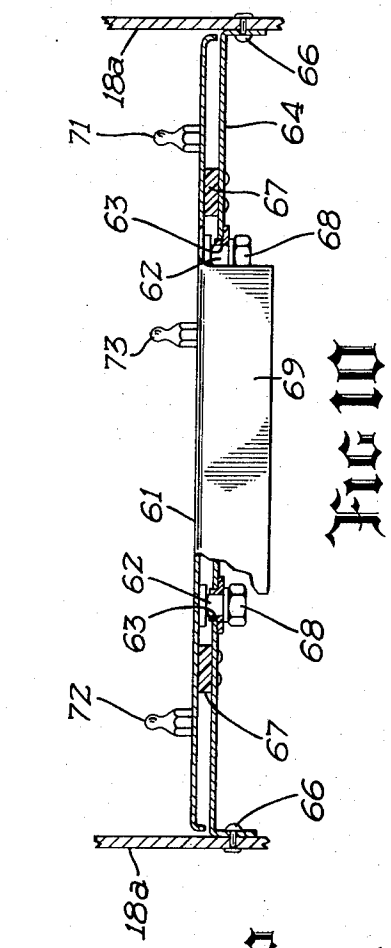


FIG 10

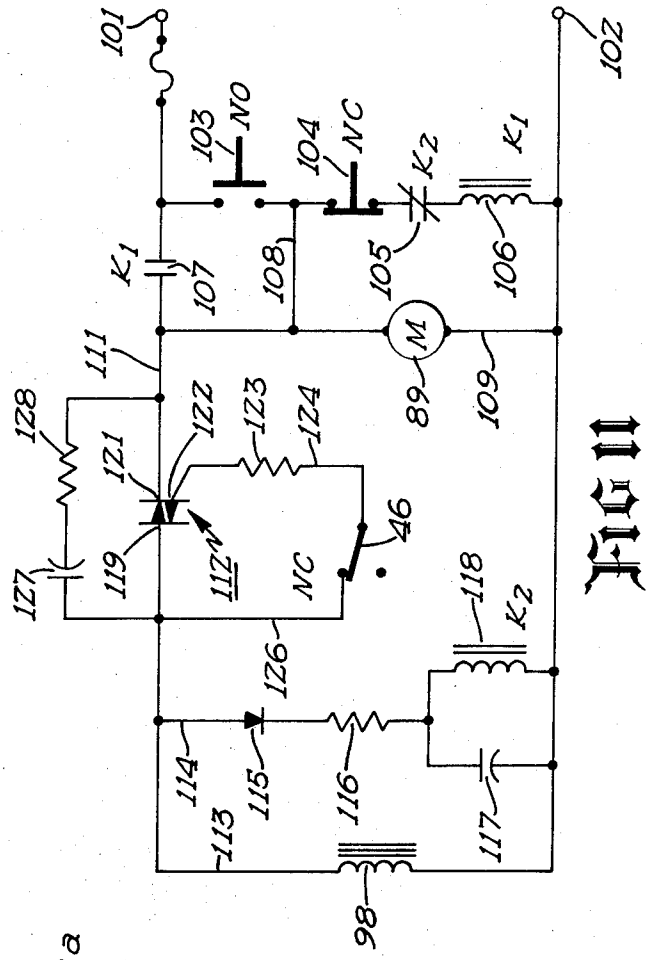


FIG 11

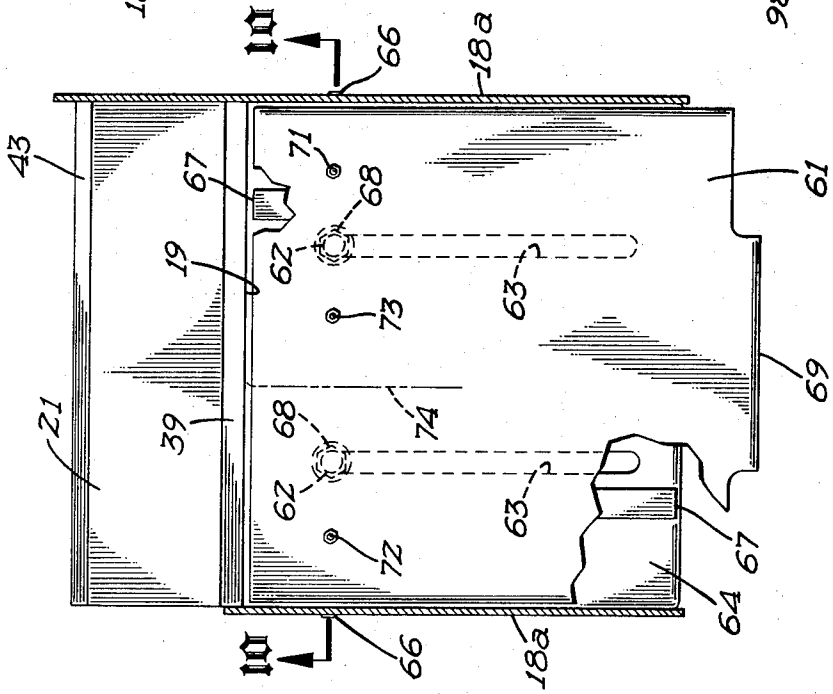


FIG 9

SHEET FEEDING APPARATUS

BACKGROUND OF THE INVENTION

Processing machines are known in which a plurality of individual answer sheets or cards, which have been previously filled out in response to a questionnaire, may be inserted at a reading station in the machine and automatically scanned to provide a total score or other summary of the test results for each applicant. Such a machine is shown, for example, in United States Patent No. 3,518,440 issued June 30, 1970. In connection with such machines, there is a need for an improved sheet feeding apparatus which can receive a supply stack of answer cards or sheets, and feed such sheets one at a time, at pre-determined intervals, along a desired path of feed to and through the processing machine. Presently known sheet feeding devices are constructed in a large variety of different ways. Some of these devices feed sheets from the top of the stack, and others from the bottom. In some cases the supporting means for a supply of such sheets is moved into or out of feeding engagement with a feed roller positioned at a relatively fixed location. In other cases a movable feed roller has been moved into or out of engagement with a stack of sheets supported at a substantially fixed position. In some of these devices the feeding engagement between such a feed roller and a sheet to be fed involve undesired variables which contribute to inefficient or inaccurate feeding, particularly where the depletion of a supply stack results in the feeding of successive sheets from somewhat different relative positions in the apparatus.

SUMMARY OF THE INVENTION

The present invention provides an improved sheet feeding apparatus in which a movably mounted supporting tray supports a stack of sheets at one end of a desired path of feed and has a vertically movable discharge end which is resiliently urged upwardly toward a retaining stop located at a fixed or constant vertical position. Thus the upper surface of the topmost sheet in such a stack engages the stop and limits the upward movement of the tray discharge end, so that a common pre-feeding position is defined for the discharge end of each successive topmost sheet. A starting feed roller mounted above the tray is moved between an upper non-feeding position in which it is out of engagement with the sheet, and a lower feeding position, in which the roller engages the upper surface of the topmost sheet and starts it along the path. Operating means for moving the starting feed roller from non-feeding to feeding position includes a resilient connection which insures resilient feeding engagement of the roller with the topmost sheet, while the tray discharge edge is urged upwardly with sufficient resilient force to feed the discharge end of each successive topmost sheet from essentially the same or a common vertically located pre-feeding position immediately below the retaining stop. The relative strengths of the resilient upward force on the tray discharge edge and the resilient downward force on the starting feed roller provide a suitable balance of forces to insure timely disengagement of the topmost sheet from the stack and movement of that sheet out from under the retaining stop to start its movement along the desired path.

The sheet supporting tray is preferably mounted in a removable holder or magazine which also includes the retaining stop and resilient means for moving the tray discharge edge upwardly toward the retaining stop. The magazine may include enclosing bottom, side, end and top walls, with an open-top discharge end for providing direct feeding engagement of the starting feed roller with the topmost sheet in the magazine, when such roller is moved to feeding position.

The invention further provides a movable supporting frame for the supply magazine, which can be moved between feeding and loading positions. Magazines of different size, i.e., with different sizes of sheets to be fed, are provided with appropriate positioning means for selectively mounting such magazines on the frame with one edge of each such magazine aligned along the same corresponding edge of the desired path of feed.

The invention further provides an auxiliary feed roller positioned above the path of feed to engage the upper surface of each sheet after the sheet has been fed forwardly from the supply stack. The auxiliary feed roller is provided with a foam rubber or other foam-like elastomer peripheral surface for slipping engagement with the surface of a sheet, while the sheet is still being fed by the starting feed roller, and for firm, non-slipping driving engagement with such sheet, after the sheet has been released by the starting feed roller.

The invention also provides sheet detecting means at a predetermined location along the path, preferably close to the auxiliary feed roller, together with control means connected to insure desired sequential feeding of successive topmost sheets with controlled spacings along the path. The control means insures feeding engagement of the starting feed roller with the topmost sheet in the stack until such sheet has reached the auxiliary feed roller, at which point the control means moves the starting feed roller to non-feeding position. When the leading sheet has moved beyond the auxiliary feed roller or has reached a predetermined distance from the supply stack, the detecting and control means causes movement of the starting feed roller back to feeding position to start another topmost sheet along the path. The invention further provides control circuitry which terminates operation of the sheet feeding device whenever a sheet fails, for any reason, to reach a predetermined point along the path within a desired time interval of operation, for example when the supporting tray has become empty and there is no further topmost sheet to be fed, or when the sheet being fed from the stack becomes jammed.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings which form a part of this application and in which like reference characters indicate like parts,

FIG. 1 is a perspective view of a sheet feeding apparatus according to the present invention in combination with a further processing machine;

FIG. 2 is an enlarged view from the front of FIG. 1, with certain parts shown in section and certain parts broken away, to show details of the sheet feeding apparatus according to the invention;

FIG. 3 is an enlarged partial view of an auxiliary feed roller and detector means in the device of FIG. 2;

FIG. 4 is a view of the sheet feeding apparatus of FIG. 1, taken from the rear of that figure, with parts in section and parts broken away for clearness;

FIG. 5 is a partial top view of the device of FIGS. 2 and 4, showing details of the driving and operating connections for the starting feed rollers and auxiliary feed roller;

FIG. 6 is a side view of the removable supply magazine of FIG. 2, with portions broken away;

FIG. 7 is a top view of the device of FIG. 6, with portions broken away to show details of the positioning means for locating the magazine in the apparatus;

FIG. 8 is a partial side view of the retaining stop in the magazine of FIGS. 2, 6 and 7;

FIG. 9 is a partial top view along the section line 9—9 of FIG. 2, with portions broken away;

FIG. 10 is a rear or end view of the movable supporting frame for the supply magazine, with portions broken away and shown in section on line 10—10 of FIG. 9; and

FIG. 11 is a circuit diagram showing the manner in which the various detecting and control means of the invention are interconnected to insure the desired sequence of operation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

As shown in FIGS. 1 to 3, a sheet feeding apparatus 11 embodying features of the present invention is used in combination with a further processing machine 12 of any desired type. The machine shown in FIG. 1 is of the type disclosed in the above mentioned Hanson et al patent, in which cards marked with answers to a questionnaire are positioned on the top or bed plate of the machine where they can be moved beneath a reading head 14 for automatically reading the test answers and providing a suitable scoring summary for each answer sheet. After such answer sheets have been scored, they may be deposited in a receiving bin 16 at the opposite end of the machine. guide 17 is provided to establish the desired path of feed of the cards from the sheet feeding apparatus 11 across the bed plate 12 and under the reading head 14. Thus one edge of each sheet will always be located along the common line of guide 17, whether the individual sheets are of the same width or of different widths, with respect to the path of feed.

As more fully shown in FIG. 2 and 3, the sheet feeding apparatus includes a main body 18 with front and top walls 19 and 20. According to one feature of the invention, an extension 21 of the front wall 19 is adapted to project along the desired path of feed so that it overlaps the starting end of the bed plate 13 of processing machine 12. A cooperating bracket 22 on the front wall 19 carries attaching means 23 for firmly but removably attaching the sheet feeding apparatus 11 at the starting edge of the bed plate 13 of machine 12. Thus sheets fed from apparatus 11 will move across the top of flange 21 above the bed plate 13 at the start of the desired path, and will be guided by the flange or guide 17 to the desired reading position under head 14, or to feeding means (not shown) on machine 12.

The present invention provides a supply assembly for positioning sheets at one end of the path. This includes a sheet-supporting tray 24 on which a stack of sheets 26 can be supported in a pre-feeding or supply position, as shown in FIG. 2. Resilient spring means 27 urges the discharge end 28 of tray 24 upwardly toward a retaining stop 29 which is located in the sheet feeding apparatus at a predetermined constant vertical position. Thus the stop 29 will engage the upper surface of the topmost sheet 26 stacked on tray 24, when such sheets are urged upwardly by spring 27, to limit the upward movement of the discharge end 28 and thereby define a common pre-feeding position for the discharge end of each successive topmost sheet. In the form shown in FIG. 2, supporting tray 24 extends rearwardly so that its rear end 31 projects beyond the rear end of the feeding apparatus in a direction opposite to the desired path of feed of the sheets. This rear or remote end of tray 24 may be supported in a manner permitting the desired vertical movement of the forward discharge end 28 of tray 24. In this embodiment the support for the rear portion 31 of the tray is a substantially horizontal, transversely extending shaft at 32, which provides a pivotal axis for the rear end of tray 24. The vertical location of axis 32 is shown at a point such that, when the last sheet 26 has been fed along the path from tray 24, the discharge end 28 of the tray would engage stop 29 and hold the tray in essentially a horizontal position. When a stack of sheets is placed on the tray, the discharge end of the tray is rocked downwardly so that the topmost sheet can be inserted beneath stop 29. Thus the sheets will be inclined somewhat downwardly and forwardly along the direction of feed to help insure the desired location of each sheet at the common pre-feeding position, with the forward or discharge ends of such sheets immediately adjacent the rear surface of a suitable front wall or stop 54.

The invention further provides a series of starting feed rollers 33 which are secured to a common transverse shaft 34 carried by the vertically movable forwardly extending lever arms 36. These lever arms 36 are fixed at 37 on a pivotally supported cross shaft 38, so that the lever arms can swing up and down to move the starting feed rollers 33 between an upper non-feeding position (shown in dotted outline in FIG. 2) and a lower feeding position (shown in heavy lines in FIG. 2) in which the starting feed rollers engage the upper surface of the topmost sheet and start it along the desired path. As shown in further detail in FIGS. 6 to 8, there are two retaining stops 29 located at opposite front corners of the stack of sheets 26, so that these stops 29 not only limit the upward movement of the topmost sheet, but also provide a forward stop for the extreme lateral edge portions of the topmost sheet. Thus, when starting feed roller 33 is moved to its lower feeding position and engages the topmost sheet, the rotation of rollers 33 will push the top sheet toward the desired path of feed, and the front edge portion of the topmost sheet will buckle slightly in order to permit the sheet to pass between the two retaining stops 29 at the opposite front edges. As shown in FIGS. 7 and 8, the lower surfaces of stops 29 are inclined upwardly and rearwardly from the horizontal (dotted line 131), as shown by dotted extension line 132, at an angle of substantially 10°. The opposite inwardly facing edges of stops 29 are inclined angularly toward each other along the direction of feed, as shown at 133, to facilitate the release of the topmost sheet.

The discharge end of the topmost sheet will then pass above the top edge 59 of front retaining wall 54, and the sheet will successively pass over the inclined leading edge 39 of flange 21, then across flange 21 above bed plate 13, and on across the processing machine 12.

An auxiliary feed roller 41 is spaced forwardly along the path of feed for engaging the upper surface of a

sheet which has been started along the path. This auxiliary feed roller is carried by a rotary transverse shaft **42** and is rotated in a direction to continue the feeding movement of the sheet along the path. The leading edge of each sheet will then pass down over the tapered forward end **43** of flange **21** into direct engagement with the upper surface of bed plate **13.** At this particular location, the invention further provides a detecting means having a movable detecting arm **44** which normally rests in a lower position, but which will be lifted slightly by the engagement of a sheet, when the leading edge of the sheet passes beneath detector **44.**

As shown in FIG. **3,** detector arm **44** is connected to a suitable precision switch **46** which is connected in an appropriate control circuit, as further described herein, to achieve the desired control and sequence of operation. Switch **46** is adjustably mounted in the apparatus by a pivot pin **47** and by a pin and slot connection **48, 49,** so that the switch can be secured in a range of desired positions to provide the desired movement of detector arm **44** for sheets of different thickness or flexibility.

In operation, when the sheet feeding apparatus is loaded with a stack of sheets **26** and is first energized by operation of a starting switch, the starting feed rollers **33** will be rotated in a clockwise direction as viewed in FIG. **4** and will be moved to the lower feeding position shown in that view, so that the topmost sheet will be started along the path. The forward or discharge end of the sheet will reach the auxiliary feed roller **41,** before the rear of the sheet has passed beyond the starting feed rollers **33.** The auxiliary feed roller **41** is preferably made of foam rubber or another foam-like elastomeric material, so that it has a relatively resilient peripheral surface to engage the upper surface of each sheet. Auxiliary feed roller **41** will be driven with a peripheral speed at least as great as that of starting feed roller **33,** and preferably at a greater speed, in order to provide the desired spacing between successive sheets along the path. When the roller **41** moves at higher speed, its periphery will be in resilient slipping engagement with the top of a sheet, as long as the speed of movement of that sheet is limited to the peripheral speed of starting feed rollers **33.**

When the leading edge of the sheet engages the detector arm **44,** however, the control circuitry of the apparatus will cause upward movement of starting feed rollers **33** to their non-feeding position, so that rollers **33** will no longer control the speed of movement of the sheet along the path. At this point, the resilient peripheral engagement of auxiliary feed roller **41** will provide a firm gripping or driving engagement with the sheet and will move the sheet along the path at a speed corresponding essentially to the peripheral speed of roller **41.** Then, as soon as the sheet has progressed into the processing machine **13** and been further fed by that machine along the desired path, the rear or trailing edge of the sheet will pass beyond the detector arm **44,** so that the arm can again drop. The control circuitry will then cause movement of starting feed rollers **33** back to their lower feeding position to start the movement of a following sheet along the path, in the same manner just described.

According to a further feature of the invention, the supporting tray **24** for the supply of sheets **26,** the resilient spring means **27,** and the retaining stops **29** are connected to each other as parts of a removable supply magazine **51,** as shown in detail in FIGS. **2, 6** and **7.** Supply magazine **51** thus includes one or more enclosing walls, such as bottom wall **52,** side walls **53,** front wall **54** and rear wall **56.** A top wall could be provided at **57** over part of the magazine, but at least the forward end of the magazine must be open at the top, as shown in **58,** to provide for direct feeding engagement of the starting feed rollers **33** with the topmost sheet in the magazine, when the starting feed rollers move to feeding position. The height of the front wall **54** must also be limited, so that the upper edge of this wall at **59** is somewhat below the lower surface of the retaining stops or corner nips **29** to permit feeding movement of the topmost sheet forwardly along the path from the magazine **56.**

To facilitate the feeding of sheets of different sizes, and to facilitate loading and unloading of magazines such as **51,** the invention provides a moveable supporting frame on which an individual magazine of desired size can be supported for movement between the feeding position and a magazine loading position. Thus, as shown particularly in FIGS. **9** and **10,** the flat moveable supporting frame **61** is provided with downwardly projecting guide posts **62** which guide the frame **61** for movement longitudinally in slots **63** in a fixed cross frame member **64.** Cross frame member **64** is secured at **66** to the inner supporting sidewalls **18**a of the apparatus. Member **64** also carries longitudinal supporting slides **67** which are made of plastic material which provides a convenient longitudinal slide for the moveable supporting frame **61.** A flange **69** at the rear of frame **61** serves as a handle to move the frame **61** longitudinally from the feeding position shown in FIG. **9** to a rearwardly retracted loading position. Thus a magazine can be placed on the supporting frame **61** when the frame is moved to the rear of the sheet feeding apparatus, out from under the starting feed rollers **33.** When a magazine has been placed on the moveable frame **61** at that point, handle **69** can be pushed to move the frame **61** and the magazine **51** supported thereon forwardly along the path of feed into the initial feeding position.

The invention also provides means for removably supporting magazines of different size on the moveable supporting frame **61.** For this purpose, positioning members **71, 72** and **73** are located transversely across the forward or discharge end of the frame member **61.** These positioning posts are located in such a way that magazines of different size can be engaged with different pairs of the posts, depending on the particular sizes of the sheets which are to be fed for processing in machine **12** at any given time. For example, a magazine **51,** of the type shown in FIGS. **2** and **6,** could have a width transversely of the direction of feed which would substantially cover the entire support frame member **61.** Such a magazine would have interengaging means adapted to fit over all of the positioning posts **71, 72** and **73,** and firmly engage at least two of such posts to make sure the magazine remains in the desired feeding position when the frame member **61** is in its forward position. When a narrower magazine **51** is to be used, it could be engaged with only two of the positioning posts **71** and **73,** so that the right edge of the magazine as viewed in FIGS. **9** and **10** would be in alignment with the right edge of the sheet feeding apparatus and thus in position to be fed along the guide **17** of the processing machine in FIG. **1.** Such a narrow magazine, how-

ever, would extend laterally from the right edge of moveable frame **61** to a position such as that indicated by the dotted line **74** in FIG. **9.** Such a half width magazine is shown in a top enlarged view by way of example in FIG. **7.** The magazine includes appropriately located clips **76** in its bottom wall **52,** and these clips are spaced on each side of the resilient spring means **27** of such a unit at locations adapted to engage posts **71** and **73** in FIGS. **9** and **10.** For a full width magazine, clips such as **76** would be spaced corresponding to posts **71** and **72** in FIGS. **9** and **10,** and the bottom wall of such a magazine could have merely an opening into which post **73** could project, without necessarily being engaged by a retaining clip on the bottom wall. Post **73** is offset from the center line of the moveable frame **61** in order that it will project into the bottom wall of a full-width magazine at a point out of alignment with the centered resilient spring **27** for the supporting tray **24** of such a magazine.

The driving mechanism for the starting feed rollers and auxiliary feed roller, and the operating mechanism for moving the starting feed rollers between non-feeding and feeding position, is shown in detail in FIGS. **4** and **5.** Thus in FIG. **5,** the starting feed rollers **33** are rigidly secured to rotating cross shaft **34** which is rotably mounted in the supporting lever arms **36** and **36A.** These arms are secured to rotate with the supporting shaft **34** which extends transversely between the inner sidewalls **18A** of the apparatus. A coil spring **77,** which engages the frame and one of the lever arms **36,** normally urges the lever arms and rollers **33** upwardly as a unit to their non-feeding position. Shaft **34** has a drive pulley **78** at its right end in FIG. **5,** and this drive pulley is engaged by a drive belt **79** driven from an intermediate roller **81,** which is freely rotatable on the right end of the supporting shaft **34** for lever arms **36** and **36A.** A similar driving pulley **82** on the right hand end of shaft **42** serves to drive the auxilliary feed roller **41** by means of a drive belt **83.** Belt **83** is driven from a slightly larger drive pulley **84** which rotates as a unit with pulley **81.** The pulley assembly **81** and **84** also includes another drive pulley member **86** which rotates as a unit with these parts. Drive pulley **86** is engaged by a drive belt **87** driven from the drive pulley **88** (FIG. **4**) of a driving motor **89.**

In this manner, when the motor **89** is running, it will constantly rotate all of the drive pulley members **81** and **84** through associated pulley **86.** These drive pulleys in turn will constantly rotate the starting feed roller **33** and the auxiliary feed roller **41.** The relative sizes of the respective pulleys are chosen in such a manner that the peripheral speed of the auxiliary speed roller **41** will be at least as high as the peripheral speed of the starting feed rollers **33.** Preferably, as shown by the relative pulley sizes in FIG. **4,** the pulley ratios will be such that the peripheral speed of auxiliary roller **41** will be somewhat higher than the peripheral speed of starting feed rollers **33.** Thus when a leading sheet or card is engaged by auxiliary roller **41** and is released from starting feed rollers **33** by the movement of such rollers to their upper non-feeding position, the auxiliary roller **41** can push the card ahead at a greater rate and thus achieve a greater predetermined spacing between successive sheets or cards. The foam-like peripheral surface of auxiliary roller **41** further permits slipping engagement, as described, so that even before the feed roller **33** releases a sheet, the auxiliary feed roller tends to help pull the leading sheet from the stack due to the resilient frictional slipping engagement between the auxiliary roller **41** and the upper surface of such sheet.

The spring member **77** (FIG. **5**) normally holds the lever arms **36** and **36A** and shaft **34** in the upper non-feeding position of starting feed rollers **33.** The rotation of all the pulleys **81, 84** and **86** in a sheet feeding direction also tends to rotate shaft **34** to the upper non-feeding position of starting feed rollers **33.** Shaft **34** includes at its right hand end an operating lever **91** which is securely keyed to the shaft through a bushing **92** and retaining screw **93.** The lower end of operating lever **91** is secured at **94** to a resilient spring connection **95,** the other end of which is secured to the longitudinally moveable core **96** of a solenoid **97.** When the coil or winding **98** of the solenoid is energized, core **96** will be drawn to the left in FIG. **4,** tensioning the resilient spring connection **95** sufficiently to rock lever arm **91** and starting feed rollers **33** to their feeding position in engagement with the topmost sheet **26** in the supply stack. When the solenoid coil **98** is de-energized, spring **77** on shaft **34** has sufficient resilience to pull the parts to the upper non-feeding position. The extent of such upward retraction is determined by an adjustable stop **99** which may be located at any convenient part of the assembly, but which is illustrated in FIG. **4** as engaging and limiting the forward movement of the solenoid core **96.**

The various parts just described are connected through appropriate electrical circuitry to achieve the desired mode of operation. A suitable circuit diagram is shown in FIG. **11,** in which the circuit is connected to supply lines **101** and **102** of a suitable 110 volt A.C. supply. A normally open starting switch **103** is momentarily closed to start the operation of the unit. When this switch is closed, it completes a circuit from line **101** to line **102** through a normally closed stopping switch **104,** a normally closed relay contact **105** and the energizing coil **106** of a holding relay K-**1.** The holding relay closes contacts **107** to establish a holding circuit and operating circuit from line **101** through contacts **107,** branch line **108,** the closed stopping switch **104,** and contacts **105** and relay coil **106.** Thus coil **106** will continue to hold contacts **107** closed to maintain the circuit during normal operation. This closing of the circuit at contacts **107** also completes a parallel circuit through the motor **89** so that the motor will run continuously and drive the respective feed rolls continuously, until otherwise interrupted. The motor circuit is completed through the line **109** to line **102.**

Supply line **101** is further connected through a branch line **111** and a bidirectional thyristor **112** to another parallel branch line **113** which includes the solenoid winding **98.** A further branch line **114** in parallel with solenoid line **113** includes a diode **115,** in series with a resistance **116,** and parallel branch lines including condensor **117** and the coil **118** of a second relay K-**2** which controls the contacts **105** in the original holding circuit. The values of resistor **116,** condensor **117** and the resistance of coil **118** are chosen to provide a desired time constant. Thus when current is flowing through all of the branches **109, 113** and **114,** condensor **117** will gradually be charged. After the predetermined time, the relay coil **118** will have sufficient voltage drop across it to be energized to open its relay contacts **105** and shut off the apparatus in case a sheet

does not reach the detector arm **44** of control switch **46** within the predetermined time.

The precision switch **46** is connected to control the switching condition of the bidirectional thyristor **112.** For this purpose, the first main terminal **119** of the thyristor is connected to the gate **122** of the thyristor through a resistor **123** and the detecting switch **46** via lines **124** and **126.** Thus when the switch **46** is normally closed and awaiting the arrival of a sheet, the connection between main terminal **119** and gate **122** maintains the thyristor **112** in a current-transmitting or "on" condition to complete the parallel circuits through lines **113** and **114.** When the leading edge of a sheet is fed by the starting feed rollers **33** to the auxiliary feed roller **41,** so that the edge of the sheet moves detector arm **44** and opens switch **46,** the opening of the connection between thyristor terminal **119** and its gate **122** permits the thyristor to switch to a non-conducting or "off" condition, so that no current is transmitted from its second main terminal **121** to its terminal **119** and the parallel branch lines **113** and **114.** At this point, the solenoid coil **98** is deenergized, and the starting feed rollers **33** will move upwardly to their non-feeding position. Also at this time the condensor **117** will have an opportunity to be at least partially discharged through the relay coil **118,** in preparation for another timing cycle.

Once the sheet has passed the detector arm **44,** so that switch **46** can return to its normally closed position, the reconnection through resistor **123** of thyristor terminal **119** and its gate **122** restores the thyristor to a conducting or current transmitting condition. The solenoid winding **98** is thus energized, and the starting feed rollers are pulled down to their feeding position to start the movement of the next topmost sheet from the supply stack. When the last sheet has been fed, the absence of a further sheet will leave the switch **46** in its normally closed position, and the gradual build-up of a charge on condensor **117,** after the pre-selected time interval, will actuate relay coil **118** and open contacts **105** to stop the machine.

The machine can also be stopped manually at any time by operation of the normally-closed stopping switch **104,** which momentarily opens the holding circuit through relay coil **106** and permits its relay contacts **107** to become open to break all of the circuits involved including the holding circuit, the motor circuit, the solenoid circuit and the time delay circuit.

An improved sheet feeding apparatus and control system have accordingly been described in the foregoing specification, together with some of the ways of practicing the invention. The description includes the best mode presently known for putting the invention into practice. A sheet feeding apparatus constructed in the manner herein described offers the indicated operating advantages of smooth and controlled feeding of successive sheets from the top of a supply stack, with desired control over the relative spacing of successive sheets along the path of feed, and with the provision of safety means in the form of a time delay device to shut off the operation of the machine if, for whatever reason, a sheet fails to reach the detecting means at the point where such sheets are being transferred to a suitable processing machine or are otherwise being discharged from the sheet feeding apparatus of this invention.

We claim:

1. Sheet feeding apparatus for successively feeding individual sheets along a desired path comprising, in combination:

a supply assembly for positioning a supply of sheets at one end of the path, the supply assembly including:

a sheet-supporting tray movably mounted in said assembly for supporting a stack of sheets, said tray having a vertically movable forward discharge end from which sheets are to be fed along the path;

a retaining stop on said assembly above the discharge end of the tray, said stop being located at a predetermined constant vertical position for engaging the upper surface of the topmost sheet on the tray and limiting the upward movement of the discharge end, thereby defining a common pre-feeding position for the discharge end of each successive topmost sheet; and

resilient means urging the discharge end of the tray upwardly toward the retaining stop;

a starting feed roller mounted above the supply assembly near the discharge end for movement between an upper non-feeding position and a lower feeding position in which the starting feed roller engages the upper surface of the topmost sheet and starts it along the path;

motor means operatively connected for rotating the starting feed roller in a sheet feeding direction;

operating means for moving the starting feed roller between non-feeding and feeding positions; and

an auxiliary feed roller spaced forwardly along the path for engaging the upper surface of a sheet which has been started along the path, said motor means being operatively connected for rotating the auxiliary feed roller in a sheet feeding direction at a peripheral roller speed at least as high as the peripheral roller speed of the starting feed roller, and said auxiliary feed roller having a foam-like elastomer peripheral surface for resilient slipping engagement with each sheet until such sheet is disengaged from the starting feed roller and for firm driving engagement with each sheet thereafter.

2. Sheet feeding apparatus according to claim **1** in which the peripheral speed of the auxiliary feed roller is greater than that of the starting feed roller, said apparatus also including detector means for detecting the arrival of a sheet in engagement with the auxiliary feed roller, and control means connecting the detector means and operating means for moving the starting feed roller to non-feeding position when a sheet has been engaged by the auxiliary feed roller and for moving the starting feed roller to feeding position when a preceding sheet has passed beyond the auxiliary feed roller.

3. Sheet feeding apparatus for sucessively feeding individual sheets along a desired path comprising, in combination:

a supply assembly for positioning a supply of sheets at one end of the path, the supply assembly including:

a sheet-supporting tray movably mounted in said assembly for supporting a stack of sheets, said tray having a vertically movable forward discharge end from which sheets are to be fed along the path;

a retaining stop on said assembly above the dischrage end of the tray, said stop being located at a predetermined constant vertical position for engaging the upper surface of the topmost sheet on the tray and limiting the upward movement of the discharge end, thereby defining a common pre-feeding position for the discharge end of each successive topmost sheet; and

resilient means urging the discharge end of the tray upwardly toward the retaining stop;

a starting feed roller mounted above the supply assembly near the discharge end for movement between an upper non-feeding position and a lower feeding position in which the starting feed roller engages the upper surface of the topmost sheet and starts it along the path;

motor means operatively connected for rotating the starting feed roller in a sheet feeding direction;

operating means for moving the starting feed roller between non-feeding and feeding positions; and

attaching means for removable connection of the apparatus at an edge of a bed plate of a processing machine in which sheets are to be fed across the bed plate for processing by said machine, the attaching means positioning the sheet feeding apparatus at a location directing sheets fed along said path by the starting roller onto the bed plate, and said apparatus having an auxiliary feed roller spaced forwardly along said path at a location above such bed plate for engaging the upper surface of a sheet which has been started along said path above the bed plate, said motor means being operatively connected for rotating the auxiliary feed roller in a sheet-feeding direction at a peripheral roller speed greater than the peripheral roller speed of the starting feed roller, and said auxiliary feed roller having a resilient peripheral surface for resilient slipping engagement with each sheet until such sheet is disengaged from the starting feed roller and for firm frictional driving engagement with each sheet thereafter.

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