April 13, 1965 P. G. KALMAN 3,178,173

SHEET-FEEDING APPARATUS

Filed March 9, 1964 6 Sheets-Sheet 1

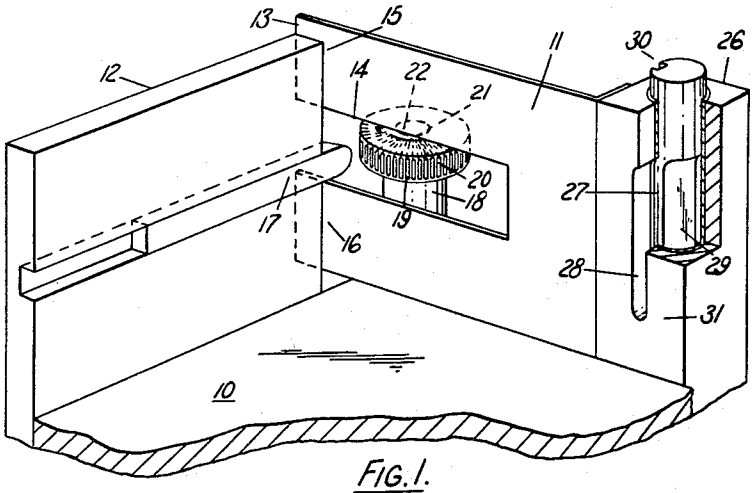


FIG. 1.

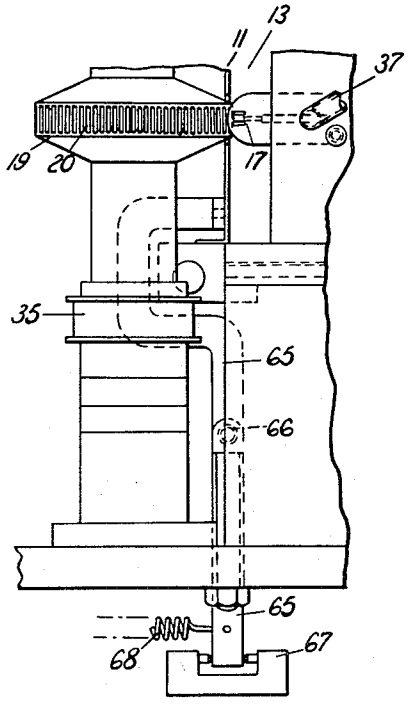


FIG. 4.

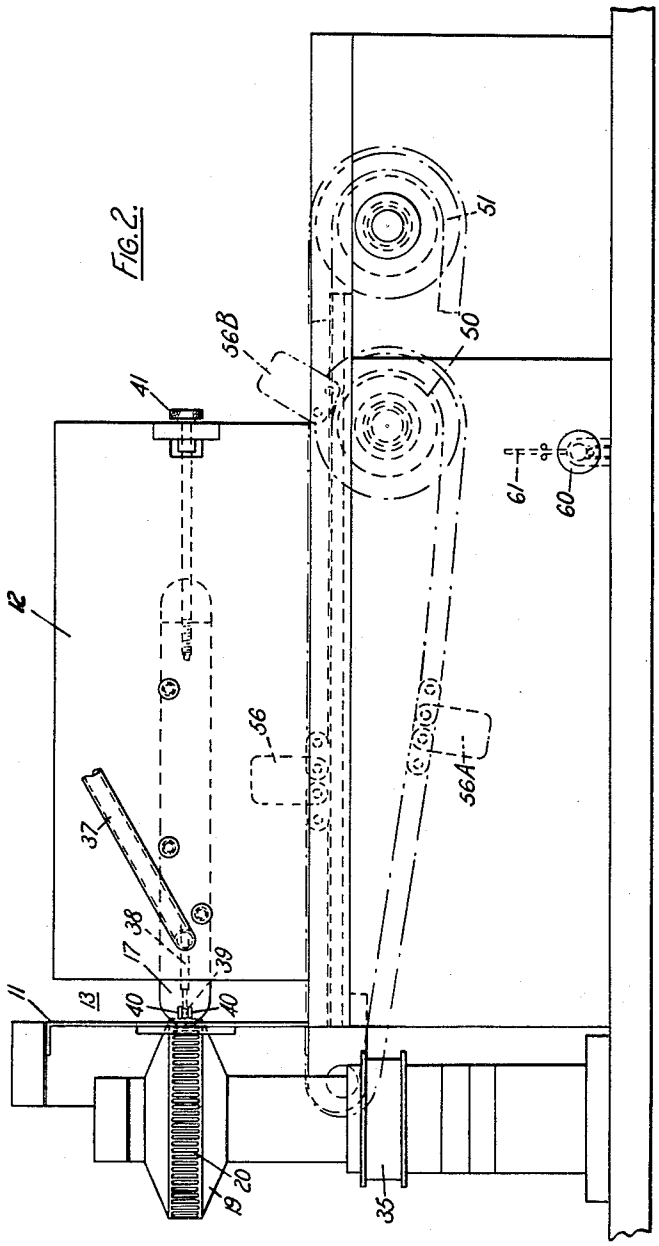
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SHEET-FEEDING APPARATUS

Filed March 9, 1964 6 Sheets-Sheet 2

FIG. 2.



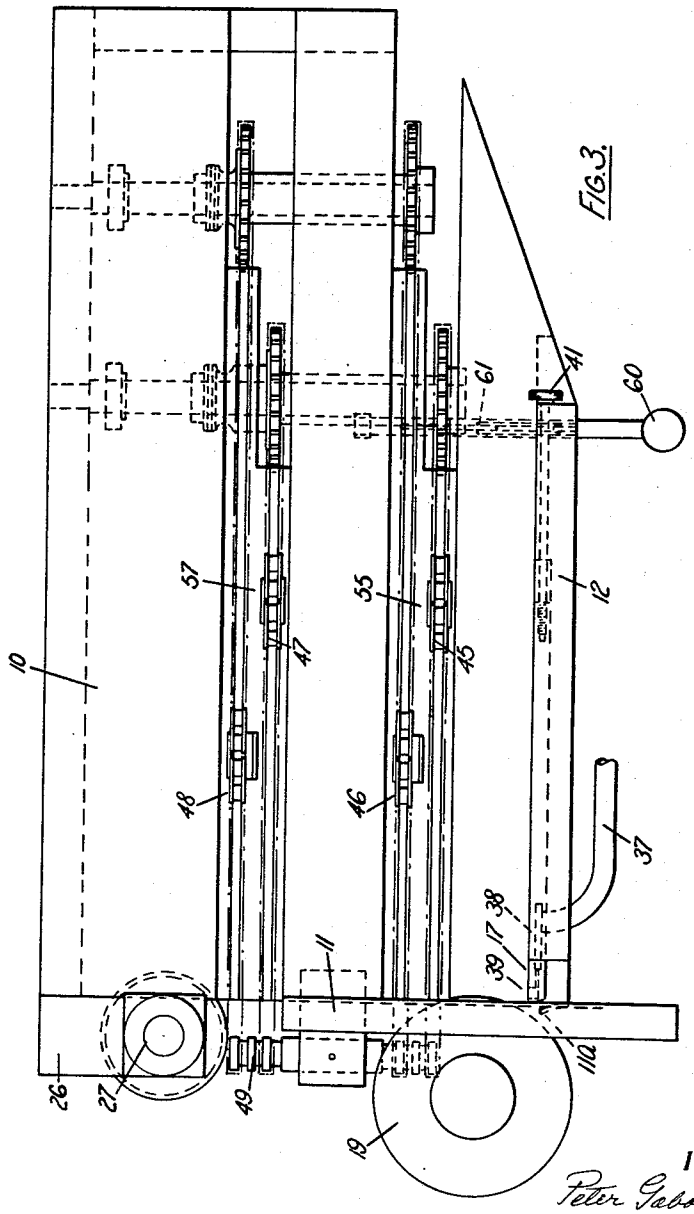
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SHEET-FEEDING APPARATUS

Filed March 9, 1964 6 Sheets-Sheet 3

FIG. 3.



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April 13, 1965 P. G. KALMAN 3,178,173

SHEET-FEEDING APPARATUS

Filed March 9, 1964 6 Sheets-Sheet 4

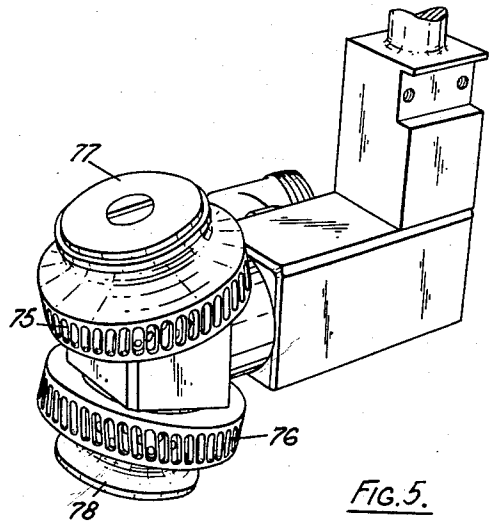


FIG. 5.

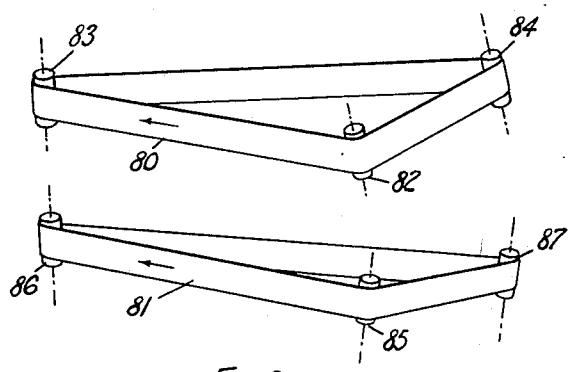


FIG. 6.

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April 13, 1965 P. G. KALMAN 3,178,173

SHEET-FEEDING APPARATUS

Filed March 9, 1964 6 Sheets-Sheet 5

Fig. 7.

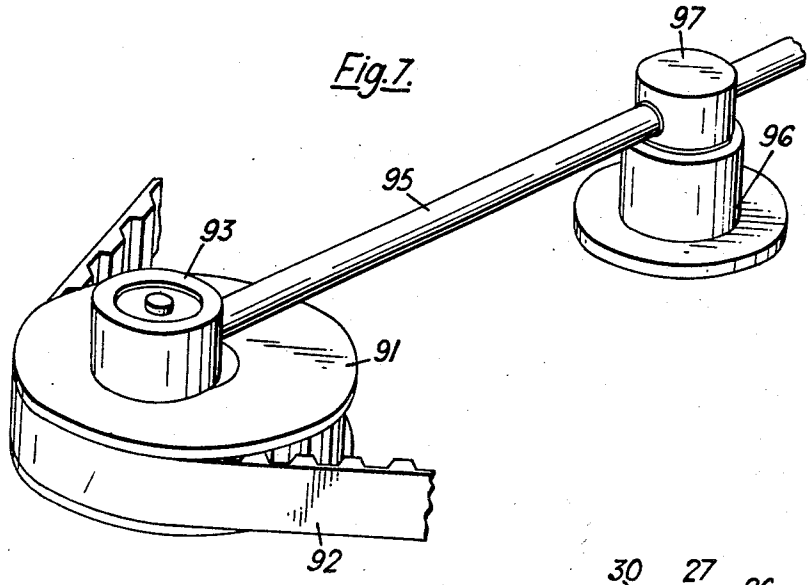
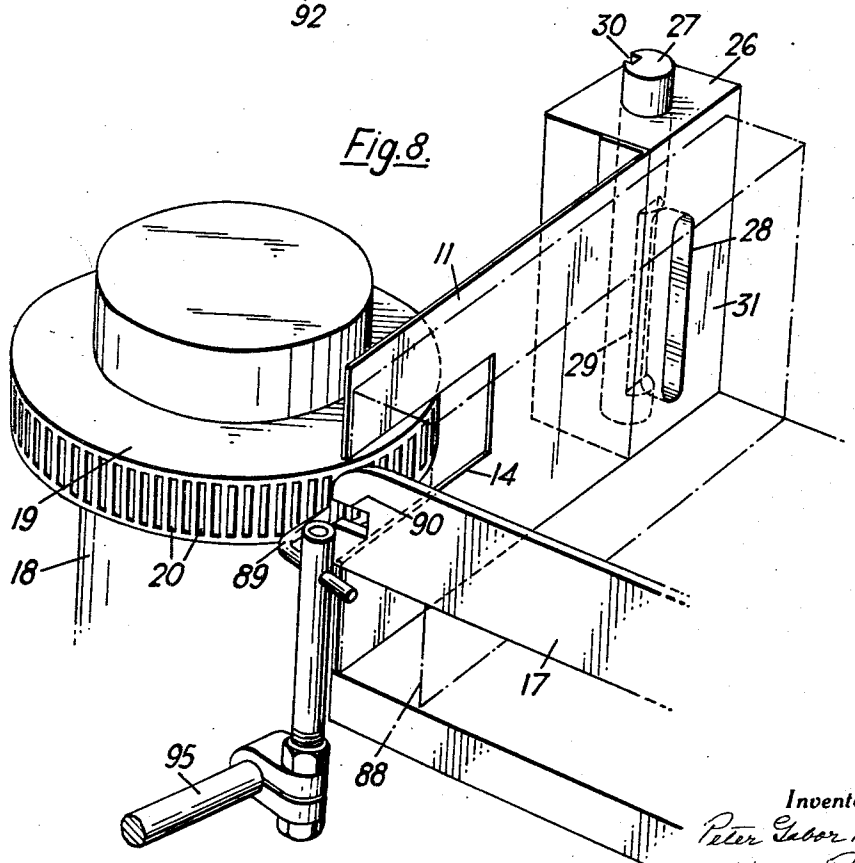


Fig. 8.



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April 13, 1965 P. G. KALMAN 3,178,173

SHEET-FEEDING APPARATUS

Filed March 9, 1964 6 Sheets-Sheet 6

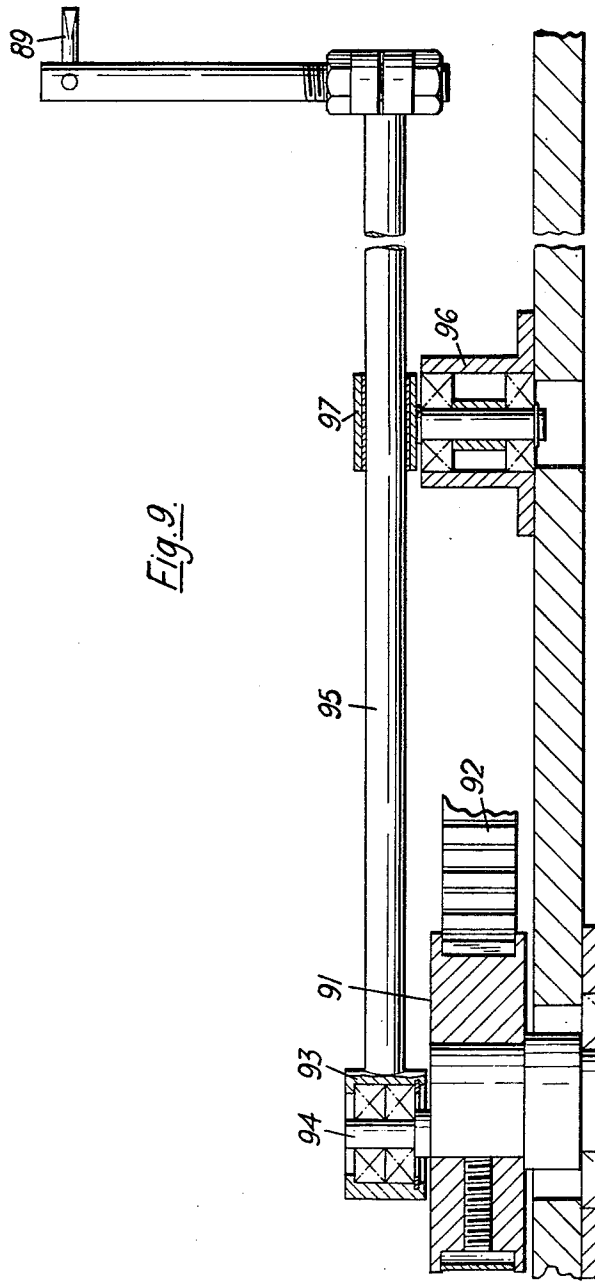


Fig. 9.

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United States Patent Office 3,178,173 Patented Apr. 13, 1965

3,178,173
SHEET-FEEDING APPARATUS

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Filed Mar. 9, 1964, Ser. No. 350,495
Claims priority, application Great Britain, May 10, 1963, 18,638/63
15 Claims. (Cl. 271—28)

This application is a continuation-in-part of United States patent application Serial No. 165,406, and relates to the feeding of sheets from a stack singly and at a high speed. The sheets may, for example, take the form of cheques, postal orders or banknotes, and may be of mixed sizes.

The apparatus according to the invention includes a stackholder in which the stack of sheets is arranged to lie or stand flat with the leading edges of the sheets adjacent an outlet opening in the stackholder, means for moving the first sheet of the stack through the outlet opening, a first restraining means arranged in register with at least a portion of the leading edges of all the sheets to prevent their passage through the outlet opening, and suction means for imparting to the first sheet a curvature in a direction such that the said sheet is no longer subject to the effect of the first restraining means; and a second restraining means operable to restrain the first sheet from moving out of the stackholder in spite of its curvature, the second restraining means being rendered temporarily inoperative at intervals to enable the sheets to be fed at regular intervals. The sheet may also be given a curvature in a direction perpendicular to the first direction of curvature, for example, by making the suction means act through a slot extending in the first direction and of such a width that only a central portion of the first sheet, which portion is in register with a slot, is subjected to the suction.

In one form of apparatus, a blade undergoes a repeated movement in the vicinity of the first restraining means, the path of the blade being such and its movement being so synchronised with the operation of the second restraining means that when the front sheet has its leading edge drawn by the suction means away from the remainder of the stack and is awaiting removal, the blade enters the space between the leading edges of the front sheet and the next sheet to ensure that the latter remains subject to the effect of the first restraining means for the required period and to increase the separation between the front sheet and the next. The means for producing a curvature of the sheet in the second direction may also be used in this form of apparatus. With the blade described above, the sheet separator will operate at high speed even with relatively stiff paper which deflects only slightly under the influence of the suction means.

In order that the invention may be better understood an example will now be described with reference to the accompanying drawings, in which:

FIGURE 1 is a diagrammatic perspective view of a sheet separator embodying the invention;

FIGURE 2 is a side elevation of a practical form of the sheet separator;

FIGURE 3 is a plan view of the apparatus of FIGURE 2;

FIGURE 4 illustrates in side view a modified form of the apparatus of FIGURE 2;

FIGURE 5 illustrates a modified form of the suction wheel device;

FIGURE 6 illustrates the use of belts in place of the suction wheels of FIGURE 5;

FIGURE 7 is a perspective view of the driving mechanism for the blade in a modification of the apparatus of FIGURE 1;

FIGURE 8 shows the manner in which the blade is arranged in relation to the stackholder; and

FIGURE 9 is a section through the blade drive assembly in the apparatus of FIGURES 7 and 8.

Referring firstly to FIGURE 1, the stackholder consists of a horizontal baseplate 10 fastened to which are two vertical mutually perpendicular side plates 11 and 12 between which an opening 13 is left. The side plate 11 has a wide horizontal slot 14 leading to an opening at the end of the plate which is adjacent the side plate 12, the portions 15 and 16 of the plate 11 forming projections which extend beyond the side plate 12. The cheques comprising the stack are placed into the stackholder so as to lie parallel with the side plate 11, the edge of the cheque which is to become the leading edge on removal being parallel with the opening 13 through which the cheque will be fed.

The side plate 12 has a groove which carries a horizontally adjustable finger 17 which protrudes into the opening 13 at the level of the slot 14 in the side plate 11 and which acts as a stop member.

A flanged support disposed in the vicinity of the side plate 11 carries a vertical hollow stubshaft 18 on which a belt-driven wheel 19 revolves at the level of the horizontal slot 14. The wheel is lined internally with a suitable dry bearing material, for example a sintered bronze matrix impregnated with polytetrafluoroethylene, and is provided with vertical slots 20 at its periphery. Each of these slots is provided with a radial passage 21 connecting it with the bore of the wheel. The hollow stubshaft is connected at one end to a vacuum supply and is provided with a lateral window 22, i.e. an aperture through which the vacuum acts, in register with the bore of the wheel.

As the wheel rotates, the slots 20 momentarily situated along the part of the periphery subtended by the window 22 in the stubshaft are continuously evacuated through the stubshaft, so that the central portion near its leading edge of a cheque situated against the side plate 11 is drawn into the opening constituted by the horizontally extending slot 14 in the side plate.

Adjacent the trailing end of the cheque which is next to be separated, the base plate 10 carries also a bearing block 26 which forms an extension of the first side plate and which houses a vertical spindle 27 which is located axially by a ring and by a toothed pulley situated on either side of block 26, both fastened to the spindle by means of grub screws. The pulley is driven by means of a driving belt profiled at its inner surface so as to conform with the teeth of the pulley. The block is provided, at the side facing the stack, with a long slit 28 which communicates with the internal bearing surface and thus with the spindle. A part 29 of the surface of the spindle conforming in height with the slit 28, is relieved and communicates by means of a passage with an annular groove which is continuously evacuated through a tube connected to a vacuum supply. The outer face 31 of the block surrounding the slit is made of a material of high friction coefficient, e.g. rubber.

It will be seen that as the spindle 27 rotates the slit 28 facing the stack is evacuated through the relieved part 29 of the spindle, blocked by the unrelieved part, opened to the atmosphere through the slot 30 and then blocked again, this cycle being repeated continuously. When the slit is evacuated the trailing portion of the cheque nearest to the window is held filmly against the surface 31, while the slotted suction wheel 19, the continuously evacuated part of the periphery of which contacts the same cheque near its leading edge, brushes the cheque. The suction through the peripheral slots 20 causes the central part of the cheque near its leading edge to be drawn into the slot 14 and at the same time to con-

form with the curvature of the wheel 19 so that its leading edge takes up a position at a slight distance away from the tip of the retaining finger 17. The cheque is thus held stationary against the side plate 11 with the upper and lower ends of its leading edge resting on the two projections 15 and 16 of the side plate, while the central part of the cheque, corresponding with the cut-away part of the side plate, assumes a saddle surface of a slight double curvature. The curvature assumed by this part of the cheque is not a surface of development, and the resultant shear stresses between this cheque and the next cheque facilitate its separation from the stack. The rotation of the suction wheel 19 against the leading edge of the stationary cheque also serves to smooth and straighten out the leading portion of the cheque if it was curled up or folded over initially. When, in the course of the rotation of the spindle 27 at the trailing edge of the cheque, the vacuum in the slit 28 is momentarily released and the slit is vented to the atmosphere, the slotted suction wheel 19 carries ahe cheque out of the stackholder, distorting it continuously and enabling it to pass at the side of the finger 17 whilst all the other cheques in the stack are retained by the finger. During the passage of the cheque out of the stackholder, vacuum in the slit 28 is re-established so that the next cheque is immobilised near its trailing edge and is already held firm when the suction wheel 19 contacts it in turn.

Accordingly cheques are fed singly from the stack at times determined by the timing of the rotation of the spindle 27. It is obviously also possible to employ the apparatus described as a continuous feeder, and in this case the block 26 and spindle 27 constituting the secondary retaining means may be removed. The extensions 15 and 16 of plate 11 may be joined past the finger 17 by a curved guide plate thus terminating aperture 14; such an arrangement facilitates the return of the cheques to a flat surface after their emergence from the feeder.

In the embodiments shown in FIGURES 2 and 3, the metal plate 11 has a rectangular aperture instead of the open slot 14 and the upper and lower edges of the aperture are continued at their leading edges to form a tongue 11*a* which is bent slightly inwards and acts as a guide for the cheques leaving the feeder. The vacuum wheel 19, which projects through this aperture, is driven by a pulley 35 and the spindle 27 in the rear vacuum block is driven by a pulley 36. The slot 30 of FIGURE 1 terminates in an annular groove cut into the shaft 27 which is vented through a radial hole in block 26, and a starting valve may be inserted into the venting line. To assist the separation of the documents, which is brought about by the double curvature imparted to the leading cheque, the retaining finger 17 is provided with an air passage 38 which is connected at one end to a compressed air line 37 and leads at its other end to an aperture 39 adjacent the leading edges of the cheques in front of the stack to be separated. Apertures 40 are provided above and below the aperture 39 and extend right through the retaining finger 17. The provision of ports at atmospheric pressure above and below the aperture 39 is found to give a better collimated emergent jet of air which strikes the leading edges of the cheques. If desired, the compressed air may be directed on to the upper edges of the sheets as well as leading edges.

An adjustable screw 41 is provided for varying the extent to which the retaining finger 17 projects into the path of the cheques.

To urge the cheques against the wall 11 of the sheet separator chains 45, 46, 47 and 48 are provided to carry the cheques. The chains pass over a guide member 49 adjacent the plate 11. At their other ends the chains 45 and 47 pass over a pair of driven sprocket wheels 50 fastened to a tubular distance member (FIGURE 2) and the chains 46 and 48 pass over a similar pair of driven sprocket wheels 51. The chains 45, 46, 47 and 48 carry pegs 55, 56, 57 and 58 which engage behind the batches

of cheques which are placed into the separator. As an example, when the first batch of cheques is placed into the separator the sprockets 51 will drive the pegs 56 and 58 forward until they engage behind the cheques. A slipping drive is provided for the sprocket wheels and so the pegs slow down once they have engaged the rear cheque of the batch. At this time the pegs 55 and 57 will be stationary. When a further batch of cheques is to be placed into the separator behind the first batch the further batch is placed on the chains in front of the pegs 55 and 57 and the pair of sprockets 50 is then set in motion. As a result, the pegs 55 and 57 move forward until they engage the rear cheque of the further batch after which the further batch is carried forward until it is immediately behind the pegs 56 and 58.

Windows are provided in the plate 11 to permit the passage of the pegs through the plate when the batch of cheques which was being urged forward by that set of pegs has been fed out of the stackholder. Positions of the pegs during their cycle of travel are illustrated at 56*a* and 56*b* in FIGURE 2.

To enable one set of pegs to be stopped while another set continues its forward motion a feed selector is provided. This feed selector is controlled from the handle 60 and consists of a slotted plate 61. When the slot in the plate 61 is in register with the peg 55 motion of the chain 45 is permitted since the peg can pass through the slot and chain 47 which is coupled to the chain 45 by means of the sprockets 50 will undergo a corresponding movement. However, peg 56 is not in register with the slot and consequently when the peg 56 reaches the plate 61 its motion, together with that of the peg 58 coupled to the peg 56 through the sprockets 51, will be arrested. By pushing in the selector arm 60 it can be arranged that the plate 61 obstructs the peg 55, the peg 56 being then in register with the slot.

We have found it to be advantageous to ensure that the cheques which are to be fed from the stack are subjected to a substantially uniform pressure from the stack. This is brought about in the embodiment shown in FIGURE 4 by sensing the pressure which acts on the plate 11 and regulating the rate at which the stack is urged against this plate.

In this embodiment, the cheques are urged forward by the sprockets and pegs through the medium of an electric motor and a pair of clutches, each operated by an air cylinder, one driving the sprockets 50 and the other driving the sprockets 51. A portion of the plate 11 is mounted on the end of a lever 65 pivoted at 66, the other end of which lies in a position-sensing means 67. When the pressure of a stack is such that the upper end of the lever 65 is pushed back towards wheel 19, against the force of the spring 68, the position-sensing means operates to render the air cylinder momentarily operative in such a manner that the clutch controlled by it through which the stack is driven forward is allowed to slip. When the pressure of the stack is less than a predetermined amount the lower end of the lever 65 will move to the left in FIGURE 4 under the influence of the spring 68 and the position-sensing means will operate to actuate the operative air cylinder in the opposite sense so as to increase the frictional engagement in the clutch which it controls. As a result the stack will be driven forward until the pressure reaches the predetermined value. The lever 65, the position-sensing means 67, the operative air cylinder and its associated clutch, chains and pegs constitute a servo-mechanism which ensures that the stack of cheques is urged against the plate 11 at a predetermined pressure which has been found to be advantageous in ensuring optimal operation of the feeder. The feed selector in this embodiment is an air valve (not shown) which provides one or the other cylinder with compressed air at will.

In some cases the sheet material will be too stiff to be given the required curvature by a single suction wheel

of the kind described above. In such a case, the single suction wheel acting on the front cheque through the slotted side plate may be replaced by two suction wheels, at least one of which is arranged at an angle to the direction of the stub-shaft of the original suction wheel. This is illustrated in FIGURE 5 in which the suction wheels **75** and **76** are arranged to rotate on oblique shafts **77** and **78**. It will be seen that the spacing between the wheels **75** and **76** varies from point to point around their periphery. The angular disposition of the wheels with respect to the stackholder and the direction of rotation of the wheels are such that suction is applied to the front sheet by portions of the wheels which will reach their minimum separation only after a further rotation of about 90°. As a result, the rotation of the two wheels tends to decrease the spacing between the two portions of a sheet which are drawn to the wheels through the opening in the side plate.

The apertures in the peripheries of the wheels are arranged to be substantially parallel with the deformed leading edge of the cheque within the area of contact between the wheels and the cheque so as to minimise leakage of air and hence provide a better grip.

An alternative arrangement employing twisted belts instead of the two oblique suction wheels is illustrated diagrammatically in FIGURE 6. In this figure, two perforated belts **80** and **81** are arranged to pass round two sets of pulleys, **82**, **83** and **84**, and **85**, **86** and **87**, respectively, one of which is a mirror image of the other. The pair of pulleys **82** and **84** have parallel axes and are obliquely arranged in relation to the pair of pulleys **85** and **87** which also have parallel axes. The pulleys **82** and **85** are formed as suction pulleys acting through the perforated belts. The belts are driven by means of the pulleys **83** and **86**, which are mounted on the same shaft. The belts travel in the direction in which the cheque is to be fed and the arrangement of the two sets of pulleys is such that there is a variation of the relative angular positions and relative spacing of the belts as they proceed after receiving the cheques at the suction pulleys so as to remove the curvature which is applied to the cheque where it is drawn round a portion of the periphery of the suction pulleys.

To increase the separation between the front sheet and the remainder of the stack, as may be required when relatively stiff sheets are to be fed at high speed, and to reduce the effect of friction between these two sheets, the arrangement shown in FIGURES 7 to 9 may be employed. In this arrangement, a blade **89** is caused to undergo a repeated movement which is synchronised with the rotation of the spindle **27**. The blade **89** is in register with a notch **90** formed in the end of the finger **17** and passes through this notch during its cyclic movement. In doing so, it enters the space created between the first and second sheets by the suction wheel **19** and increases the separation of the sheets owing to the lateral movement which takes place after it has penetrated between the sheets. At the same time, the penetration of the blade ensures that the second sheet remains subject to the first restraining means for a minimum period determined by the nature of the blade movement. After withdrawal of the first sheet the blade withdraws from the notch **19** and the sequence of actions is repeated.

As shown in FIGURES 7 and 9 the drive for the blade **89** is obtained from a wheel **91** driven by an internally ridged belt **92**. A driving hub **93** is freely rotatable on an eccentric pin **94** projecting from the wheel **91**. A driving shaft **95** has one end connected to the hub **93** and passes through a cylindrical bore in a pedestal **96**. The shaft **93** is free to slide within the bore and moreover the member **97** within which the bore is formed is freely rotatable with respect to the base of the pedestal **96**. It will be seen as the wheel **91** rotates the tip of the blade **89** will trace out an elliptical path. After entering the space between the first and second sheets the blade will undergo lateral movement, tending to increase the separation, as the penetration increases and then will continue to move laterally in the same direction during the first part of its withdrawal.

Although in the example described the blade follows an approximately elliptical path, in apparatus operating at slightly lower speeds, a reciprocatory motion could be employed without setting up undesirable vibrations.

I claim:

1. Sheet feeding apparatus including a stackholder having an outlet opening and in which a stack of sheets is aranged to be positioned flat with the leading edges of the sheets adjacent said outlet opening, a first restraining means arranged in register with at least a portion of the leading edges of all the sheets to prevent their passage through the outlet opening, suction means including a suction wheel acting on said first sheet and means for continuously rotating said suction wheel, said suction wheel imparting to said first sheet a curvature in a direction such that said sheet is no longer subject to the effect of said first restraining means and a curvature in a direction perpendicular to the first direction, a second restraining means unaffected by the curvature of said first sheet and means for rendering said second restraining means temporarily inoperative at regular intervals, whereby said first sheet is given the curvatures in the two directions while restrained by said second restraining means and is moved through said outlet opening when next said second restraining means is rendered temporarily inoperative and said sheets are fed out of said stackholder at substantially regular intervals.

2. Apparatus according to claim 1, in which said second restraining means has an aperture arranged to be positioned adjacent the trailing edge of the first sheet and a rotating spindle having a recess, said apparatus further including a source of vacuum connected to said recess, said aperture being connected to the recess in said rotating spindle for a given portion of each revolution of said spindle.

3. Apparatus according to claim 2, in which the spindle is provided with a further recess which communicates with the atmosphere.

4. Apparatus according to claim 1, in which the suction means comprises two rotatable suction wheels each having peripheral apertures through which suction is applied, the directions of the shafts of the wheels being such that the spacing between them varies from point to point around their peripheries.

5. Apparatus according to claim 1, in which the suction means comprises two perforated endless belts passing over two suction pulleys rotating about axes which are inclined to one another.

6. Sheet feeding apparatus according to claim 1, in which said stackholder includes means supporting said first sheet in the vicinity of said suction wheel and forming a slot through which said suction wheel acts on said first sheet, whereby a curvature in said second direction is imparted to said first sheet.

7. Apparatus according to claim 1 in which the restraining means is a finger projecting from a side wall of the stack holder into the space through which the sheets are to be fed, the finger including an air passage communicating with an outlet at its tip, the apparatus further including a pipe communicating with the air passage for connection to a source of compressed air.

8. Apparatus according to claim 1 in which a number of independent conveyors, each provided with a push member or push members for urging a stack of sheets along a common path towards the suction means are provided in the base of the stackholder, and further comprising means for independently controlling the motion of the conveyors, whereby when a first stack of sheets is being urged towards the suction means by a first push member or push members a second stack can be placed

in the stackholder for control by a further push member or push members associated with a different conveyor.

9. An apparatus according to claim 1 including a plate adjacent said suction means for urging the sheets towards the suction means and against said plate and pressure-sensitive means to the pressure of the stack of sheets against said plate and adapted to maintain this pressure substantially at a predetermined value.

10. Apparatus according to claim 3 in which a starting valve is provided between the recess and a vent to the atmosphere.

11. Sheet feeding apparatus comprising: a stackholder having a base plate and a pair of mutually perpendicular side plates supported on said base plate, said side plates being spaced from each other to provide an outlet opening, said stackholder being adapted to receive a stack of sheets arranged so that the first sheet of the stack lies flat against one of said side plates with the leading edge thereof adjacent said outlet opening; means for moving the first sheet along said one side plate through said outlet opening; a first restrainig means on said other side plate for engaging at least a portion of the leading edges of all the sheets in the stack to prevent their passage through said outlet opening; a rotatable suction means for curving the first sheet out of alignment with said first restraining means; means for continuously rotating said suction means; means for imparting a second curvature to the sheet in a direction perpendicular to that imparted by said rotatable suction means; a second restraining means on said one side plate and spaced from said first restraining means and said suction means; and means for operating said second restraining means to hold the first sheet while it is being curved by said suction means and to release the first sheet for movement thereof through said outlet opening by said moving means.

12. Sheet feeding apparatus including a stackholder in which the stack of sheets is arranged to lie or stand flat with the leading edges of the sheets adjacent an outlet opening in the stackholder, means for moving the first sheet of the stack through the outlet opening, a first restraining means arranged in register with at least a portion of the leading edges of all the sheets to prevent their passage through the outlet opening, and suction means for imparting to the first sheet a curvature such that the said sheet is no longer subject to the effect of the first restraining means; a second restraining means operable to restrain the first sheet from moving out of the stackholder in spite of its curvature, the second restraining means being rendered temporarily in operative at intervals to enable the sheets to be fed at regular intervals; and a blade undergoing a repeated movement in the vicinity of the first restraining means, the path of the blade being such and the movement being so synchronised with the operation of the second restraining means that when the front sheet has its leading edge drawn by the suction means away from the remainder of the stack and is awaiting removal, the blade enters the space between the leading edges of the front sheet and the next sheet and increases the separation between them.

13. Apparatus according to claim 12, in which the first restraining means is a finger obstructing the path of the sheets in the stackholder and in which the finger is formed with a notch through which the blade penetrates to enter the space between the first and second sheets.

14. Apparatus according to claim 12, in which the blade is given a substantially elliptical motion.

15. Apparatus according to claim 14, in which the blade is mounted at the end of a rod the other end of which is eccentrically mounted on a rotating wheel, and in which the intermediate part of the rod passes through a fixed pedestal in a manner such as to permit sliding motion of the rod through the pedestal and pivotal motion of the rod about the axis of the pedestal.

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