United States Patent

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[54] **SHEET-FEEDING APPARATUS**
5 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **271/26,** 271/11
[51] **Int. Cl.** **B65h 3/08**
[50] **Field of Search** 271/11, 12, 13, 26, 30

[56] **References Cited**

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ABSTRACT: A sheet-feeding device is disclosed including a suction head adapted to hold a sheet of paper or the like presented thereto, and an adjacent sheet transfer means which periodically removes the sheet than being held by the said head and initiates transfer to a utilization point. Suction for the head is provided by the intake of an air pump. The outlet of the said pump is directed into a blower system which is arranged to move by airflow a portion of a stack of feed sheets to the suction head. The stacked sheets so moved are constrained so that they are moved to the head against gravity or other restoring forces. When the suction head contacts the closest of the moved sheets, that (single) sheet is held at the head for transfer. The held sheet, however, covers the head, thereby disrupting flow through the pump—and in particular stopping flow to the blower system connected to the pump outlet. Accordingly all sheets except the single sheet, are moved away from the head by the aforementioned restoring force, assuring that but a single sheet at a time is present for transfer.

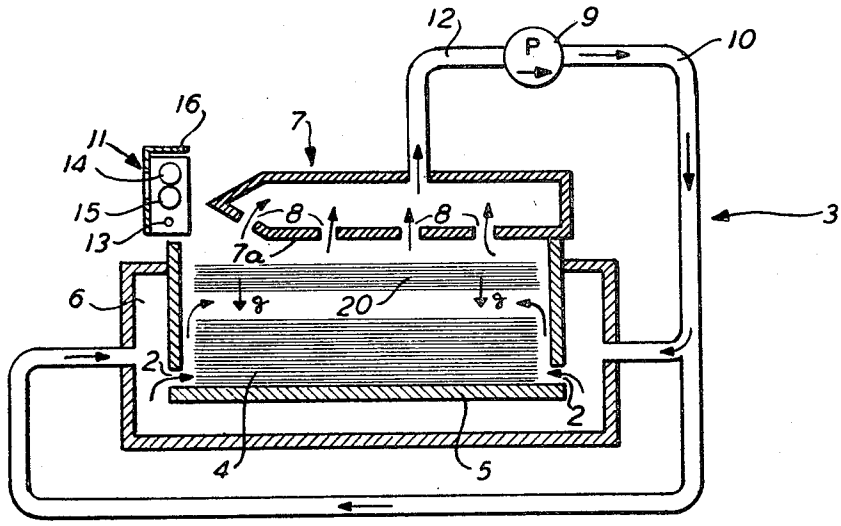


FIG. 1

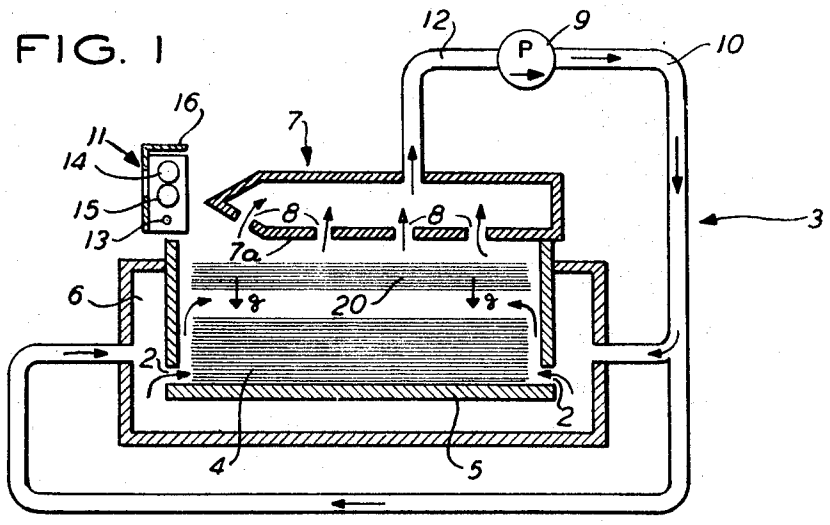
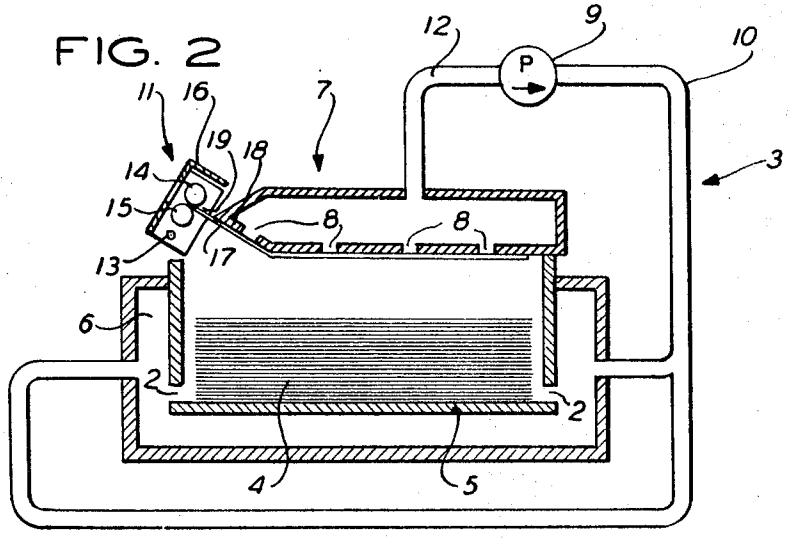


FIG. 2



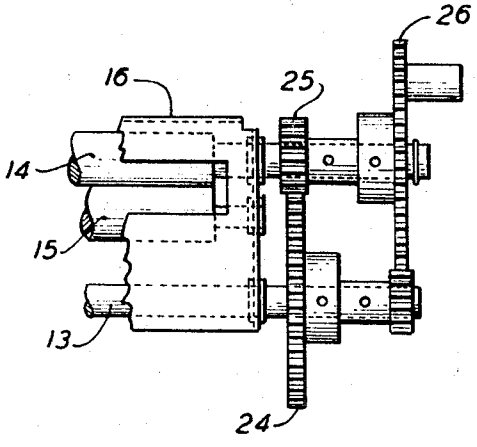


FIG. 5

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FIG. 3

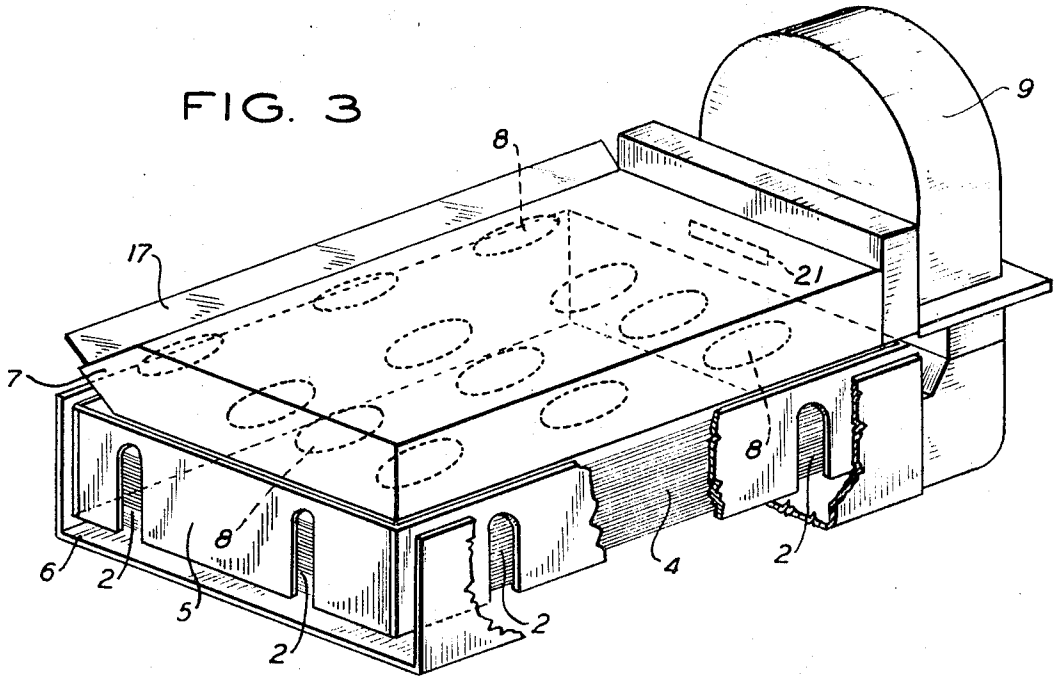


FIG. 6

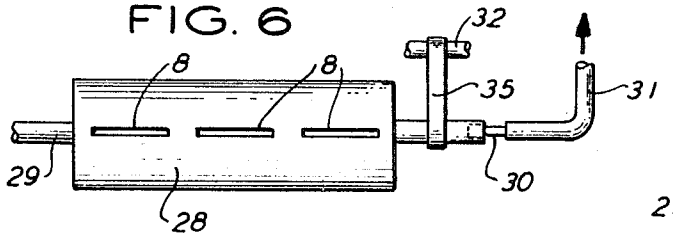


FIG. 7

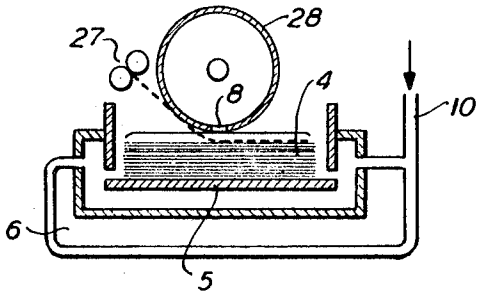
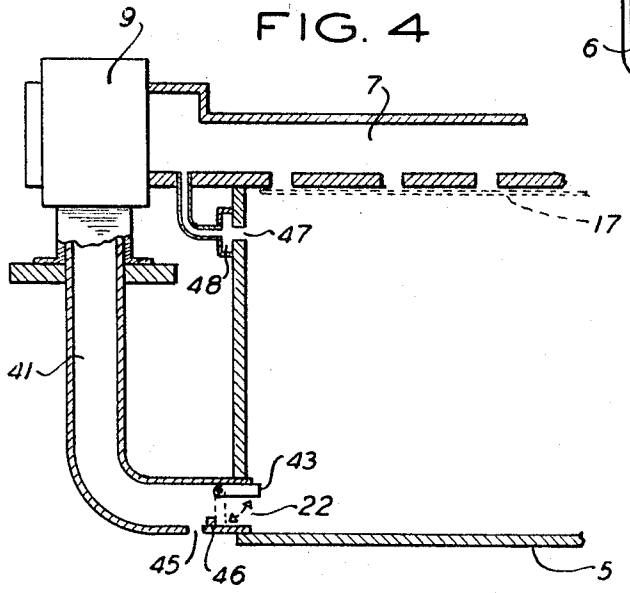


FIG. 4



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SHEET-FEEDING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to sheet-feeding apparatus, and more specifically relates to apparatus adapted to rapidly feed single sheets of paper or similar stock to duplicating machines, copiers, printing machines, or the like.

2. Description of the Prior Art

One of the more fundamental problems encountered in high-speed reprography, derives from the requirement to rapidly and effectively feed to the reprographic device, single sheet upon single sheet of copy paper from a voluminous stack of such paper maintained in appropriate reservoir. In high-speed photocopying, for example, it may be desirable to feed such sheets at rates as high as 6,000 sheets per hour; in yet other duplicating environments the feed mechanism any be called upon to accurately deliver single sheets at rates of up to 10,000 sheets per hour.

Particularly in the case of photocopying machines, it has in the past been most common to utilize roller feeding to achieve the objects indicated. Pursuant to this approach a rotatable rubber-surfaced roller rests upon the stack of copy paper. Periodic (or continuous) rotation of the said roller moves sheet after sheet of the stack toward pinch rollers or the like, the latter then serving to transfer the sheets toward a utilization point in the copying machine.

While roller feeding devices of the type mentioned are reasonably effective for feed rates up to 6,000 or so sheets per hour, several significant and persistent problems are presented by their use. Firstly the pressure of the roller on the copy sheets often introduces undesirable marking on the sheet surfaces. This is partially a result of high-speed skidding of the rubber-surfaced roller against the paper, but the effect is particularly compounded where—as frequently is the case—the sheets being fed are of the zinc oxide-coated variety. The latter, as is well known, are extremely sensitive to scratches or the like, abrasions of the coated surface often showing up as distinct darkened areas on the delivered sheet.

Uneven pressure along the length of the roller can, furthermore, result in skew feeding of the sheets, with resulting wasted paper, missing copies, jamming of the machine etc.

In addition, a most frequent difficulty encountered where roller feeding is utilized is the delivery by the feeder of double or multiple sheets. This is to say that the rubber roller will often move two or more adjoining sheets to the transfer device, instead of the desired single sheet. While a tendency of this type may be somewhat alleviated by use of an air separator or the like at the side of the stack, the incorporation of the additional pneumatic system adds complexity, cost, and bulk to the feed mechanism, and in any event does not improve the skewing or marking problems previously cited.

A more sophisticated approach, and one that has been utilized for higher speed feeding—10,000 sheets or so per hour—involves simultaneous use of a set of air jets and a vacuum pickup head. The vacuum pickup head—which by suction causes adherence of a sheet presented to it—even when utilized along eliminates the marking and skewing problems cited in connection with use of roller feeding. However it is found in high speed feeding applications that the pickup head will frequently draw to it several or more sheets at a time, unless the aforementioned air jets or the like are present to force positive sheet separation. The separation problem is in fact so severe that special sensors are often incorporated into apparatus of this type to assure that but single sheets are being fed.

OBJECTS OF THE INVENTION

In accordance with the foregoing it may be regarded as an object of the present invention to provide sheet-feeding apparatus adapted for high-speed feeding of single sheets to reprographic devices or the like.

It is a further object of the invention to provide sheet-feeding apparatus wherein sheets are pneumatically fed from a feed stack, thereby largely eliminating paper marking and skewing problems, the pneumatic feed scheme including, however, an adaptation which simply and dependably eliminates feeding of multiple sheets.

It is another object of the invention to provide sheet-feeding apparatus wherein the mechanism utilized for picking up sheets inherently prevent the feeding of multiple sheets, the indicated result being, furthermore, achieved without the use of auxiliary pneumatic means or sensors.

It is a yet further object of the present invention to provide apparatus capable of high-speed sheet-at-a-time feeding of stacked material, which is of such simplicity of design that virtually no moving parts are present in the sheet separation and pickup portion of the apparatus.

SUMMARY OF THE INVENTION

Now in accordance with the present invention, the foregoing objects, and others as will become apparent in the course of the ensuing specification, are achieved by a device, including a suction head adapted to hold a sheet of paper or the like presented thereto, and an adjacent sheet transfer means adapted to periodically remove the sheet held by the head and initiate transfer to a utilization point. Feeding of multiple sheets is prevented by a unique and simplistic scheme. In particular suction for the pickup head is provided by a simple air pump, the outlet of which is directed into a blower system adapted to move pneumatically a portion of stacked feed sheets to the said suction head. The stacked sheets are constrained so that movement thereof to the head is necessarily against gravity or other restoring forces. When suction head contacts the closet of the moved sheets, that (single) sheet is held at the head for transfer. The held sheet, however, covers the head, thereby disrupting flow through the pump—and in particular disrupting flow to the blower system connected to the pump outlet. Accordingly all sheets except the single adhering sheet are moved away from the head by the aforementioned restoring force, assuring that but a single sheet at a time is present for transfer.

BRIEF DESCRIPTION OF DRAWINGS

The invention is diagrammatically illustrated, by way of example, in the appended drawings, in which:

FIG. 1 is a highly schematic depiction of apparatus in accordance with the invention, and illustrates the pneumatic flow pattern in such apparatus prior to pickup of a sheet by the suction head;

FIG. 2 in a schematic fashion that of FIG. 1, depicts the pneumatic flow pattern in the FIG. 1 apparatus after a sheet is secured to the suction head, and illustrates the inherent mechanism which prevents feeding of multiple sheets;

FIG. 3 is an isometric, partially cutaway view of a lifter and separator portion of a sheet feeder designed in accordance with the invention;

FIG. 4 is a schematic, partially sectioned view of a portion of apparatus in accordance with the invention, and illustrates modifications in the FIGS. 1, 2, and 3 apparatus which reduce air leakage and increase operating speed of the apparatus;

FIG. 5 depicts in cross section the arrangement of gears and rollers utilized in the transfer means to achieve constant speed for sheet feed;

FIG. 6 is an elevational view of an embodiment of the invention employing an oscillating cylindrical member for the suction head; and

FIG. 7 is an end cross-sectional view of the FIG. 6 apparatus, and schematically illustrates the manner in which sheet pick up is achieved.

DESCRIPTION OF PREFERRED EMBODIMENTS

The schematic depictions of FIG. 1 and 2 illustrate generalized apparatus in accordance with the invention and in par-

ticular illustrate the pneumatic technique employed to assure that but single sheets-at-a-time of sheet stock are fed by the apparatus.

In FIG. 1 sheet feeding apparatus generally designated by reference numeral 3 is shown, which apparatus includes stock container 5, suction head 7, air pump 9, and sheet transfer means generally designated at 11. The container 5, which may be of any convenient material—such as metal, plastic, or the like—, is surrounded by a plenum chamber 6, which is fed the output of pump 9 by line 10. Plenum chamber 6 is interconnected to container 5 by a series of airflow ports, two of which appear at reference numeral 2.

The container 5 holds therein a stack 4 of sheet material—such as copy paper or the like. As is seen in the Figure the dimensions of container 5 are such that very little space is present between stack 4 and the adjacent depicted container walls. A similar paucity of space is present between stack 4 and adjacent container walls in the vertical plane not shown in the drawing, the net result being that the stack 4—and individual member sheets thereof—are constrained against any substantial movement except in the direction of suction head 7.

Suction head 7 is a hollow member, including a generally planar face 13 which is provided with a plurality of ports 8. Suction for head 7 is provided by the same pump 9 which furnishes positive pressure to plenum chamber 6, the said suction being provided via line 12 interconnecting head 7 with the pump inlet.

The FIG. 1 depiction illustrates the flow pattern present in apparatus 3 prior to pickup of a sheet at head 7. This configuration would, for example, be present immediately after the apparatus is turned on, or after removal of a sheet held at head 7 by transfer means 11. The latter, consisting of a frame 16 rotatable about axis 13, and a pair of driven pinch rollers 14 and 15, is in this configuration oriented with frame 16 in a vertical position. As ports 8 are not at this point in time covered by a paper sheet, airflow through the pump 9 is completely unimpeded and accordingly airblown by the pump flows freely through line 10 and into chamber 6, thereupon passing through ports 2 and against the stack 4 of sheets held within container 5. As the air sweeps about the stacked sheets, the uppermost sheets are fluttered up toward suction head 7. It is, of course, virtually impossible to flutter up by this simple airflow pattern but a single sheet; rather in practice a group 20 comprising several or many sheets is driven up toward the suction head 7, such group being carried upward against the restoring force of gravity—which in the Figure is designated as g.

As the group 20 reaches head 7, the topmost sheet contacts face 7*a* whereat it is securely held by the suction through ports 8. Such action immediately serves, however, to "close" ports 8, much in the manner of a flap valve, and while the pump 9 continues to draw against head 7, thereby holding the top sheet at face 7*a*, flow out of the pump through line 10 is disrupted. In consequence airflow to chamber 6 and through ports 2 is stopped. Except now for the single topmost sheet—being held at head 7—the remainder of group 20 fall back under the influence of restoring force *g*.

Aiding the falling away process described above is the fact that the portion of head 7 adjacent transfer means 11 is formed with an upwardly bent face 18. The upward bending at face 18 of the secured sheet 17 increases separation forces between sheet 17 and group 16. This increase in separation forces is particularly appropriate where high electrostatic attraction is present between adjacent sheets. Similar increases in separation forces can be achieved by the presence of other "deformations"in the face 7*a*—e.g. the face can be constructed with an undulating surface.

The topmost sheet referred to above is now securely held at face 7*a* and is designated in FIG. 2 by reference numeral 17. In FIG. 2, the configuration of apparatus 3 is shown as the single sheet 17 is picked up. As therein seen, all sheets except sheet 17 have returned to the stack 4, no airflow now being present through ports 2. It may be seen furthermore that the portion of head 7 defined by upwardly bent face 18—which includes ports 8 therein—has an extreme left edge which is somewhat to the right of the left edge of stack 4. This causes sheet 17 as it attaches to head 7 to come to rest with an edge 19 extending beyond the face 18. In order now to pick up the sheet 17 a cam arrangement or the like is provided which periodically pivots frame 16 clockwise about axis 13, whereby edge 19 is fed into rollers 14 and 15 and sheet 17 is withdrawn from head 17. The frame 16, as it draws the sheet, returns to its vertical position, and upon full removal of sheet 17 from the suction head the configuration of FIG. 1 is regained and the lifting, retention, and feed cycle is reinitiated.

FIG. 3 is an isometric, partially cutaway view of a lifter and separator portion of a sheet feeder designed in accordance with the invention. The device shown is very similar to the more schematic apparatus of FIGS. 1 and 2, and similar portions of the apparatus are designated by corresponding reference numerals. Suction head 7 interconnects to pump 9 through the port 21. It may be noted in this construction that plenum chamber 6 surrounds container 5 on all four walls and ports 2 extend from the base of container 5 almost to the top thereof. In a typical construction the dimensions of chamber 6 were approximately 10inch by 12 inch by 4 inch; interestingly, excellent results were yielded with a simple 50-watt blower acting as pump 9. Loading of the FIG. 3 device is simply accomplished by manually inserting paper through the space between container 5 and the edge of head 7; in more sophisticated versions of this lifter and separator an openable loading door is provided.

FIG. 4 is a schematic, partially sectioned view of a portion of apparatus in accordance with the invention, and illustrates two useful modifications which may be introduced into the FIGS. 1, 2, and 3 apparatus.

In the simplified FIG. 4 depiction, air pump 9, suction head 7, and container 5 are shown, all of these elements corresponding to similarly designated elements in FIG. 1 and 2. The output from pump 9, instead of feeding a plenum chamber, is shown as being fed to a duct 41 which is connected to container 5 by port 42, which is an elongated rectangular slot extending the entire length of the container 5 wall in which it is present. Duct 41 is coextensive with port 42 and includes, close to the junction with port 42, a hinged valve 43, comprising a lightweight plastic or metal material, secured to the duct top wall by a hinge 44. Duct 41 also contains an elongated but narrow, bypass slit 45, and an elongated lip 46 formed in the inner wall surface. Elements identical to those described are present at the opposite—unshow—wall of the apparatus.

The elements just described function during the period sheet 17 is secured to head 7 to prevent air leakage into container 5, thereby assuring rapid fall away of unsecured sheets and preventing possible upward movement of further sheets. In particular, valve 43, during the period of airflow through pump 9, remains—under pressure from the airflow— in an open position. As the airflow is interrupted by adhering sheet 17, however, valve 43 falls under its own weight to the vertical position indicated by the shadow lines, coming to rest against lip 46 and effecting a seal against leakage flow. Such leakage as may occur is then relieved by bypass slit 45—which is adequate to relieve limited leakage flow, but has little effect on volume of airflow during open pumping conditions.

High-speed feeding operations are also aided by the presence in the FIG. 4 apparatus of secondary suction ports 47. The latter, which may comprise several or a plurality of slits formed in the walls of container 5 at a position slightly below head 7, are connected to a chamber 48 encircling container 5. The latter, in turn is connected back to suction head 7, whereby a continuous flow of air enters port 47 from container 5 regardless of whether or not the flow to pump 9 is cut off by a sheet 17. Upon adherence of a sheet 17 to head 7, port 47 functions to immediately initiate reduction of pressure on the backside of the sheets immediately below the adhering

sheet. This assists the gravitational restoring forces, and thereby aids high-speed feeding operations.

FIG. 5, which should be considered in conjunction with FIGS. 1 and 2, depicts an illustrative construction for sheet transfer mean 11. FIGS. 1 and 2 show the two end positions of the nip rollers 14 and 15. When the frame 16 moves back about axis from the pickup position of FIG. 2 to the feed position of FIG. 1, a sheet 17 (FIG. 2) will be held in the nip. During this movement the speed of the sheet is held constant by the gear drive shown in FIG. 5. In particular gear 24 drives gear 25 which is locked to the shaft of upper nip roller 14. When the nip roller pair swings about the center of gear 24, gear 25 rolls over the periphery of gear 24 and thereby compensates for the arc movement of the hips around the center of gear 24 on the sheet speed. Gear 26 runs loose on its shaft and carries a cam follower 27 that contacts a stationary cam and then generates the swinging motion around gear 24, working against the action of a return spring.

FIGS. 6 and 7 illustrate an embodiment of the invention incorporating as the suction head a rotatable cylinder. A construction of this type is in some applications advantageous in that the sheet transfer means—such as the pair of rollers 27 in FIG. 7—need not be pivoted in their frame toward the picked-up sheet; instead the sheet is brought to the transfer means by rotation of the cylinder.

Construction details of cylinder 28 are shown in the elevational view of FIG. 6. As seen therein cylinder 28—a hollow member—carries a fixed axial shaft 29. The cylinder carries a series of port—which are again designated by reference numeral 8 in correspondence to the functionally identical ports of the earlier Figures. Shaft 29 at the right end of the Figure is hollow and in direct connection with the interior of cylinder 28. At its opposite end it connects with line 31 via connector 30. Shaft 29 is journaled about connector 30 whereby it, and cylinder 28, may freely rotate with respect to the connector. Line 31, in turn, is connected directly to an air pump inlet—so that cylinder 28 is the functional equivalent of the suction heads previously described.

In the FIGS. 6 and 7 apparatus, movement of a retained sheet to the transfer means is accomplished by rotating the cylindrical suction head some 30° toward the rollers 27. This action is best seen in the end view of FIG. 7, where the sheet 17 is shown in feed position (by solid lines), and in pickup position (by the shadow lines). The net movement of cylinder 28 is, of course, oscillatory, and for purposes of achieving such motion a belt 35 interconnects shaft 29 with an oscillating power shaft 32. It will, however, be evident to those skilled in the art that by choosing proper ratios between the rotational speeds of rollers 27 and the rotational speed of cylinder 28, a configuration like that of FIGS. 6 and 7 can be operated with cylinder 28 rotating at a constant speed in a single direction (in the sense of FIG. 10, clockwise).

The FIGS. 6 and 7 also serve to emphasize that the suction head utilized with the invention can, after securing of the feed sheet, itself provide the motion which leads the affixed sheet to the transfer means. It should thus be appreciated e.g., that in apparatus of the type depicted in FIGS. 1 through 5, one may provide a suction head capable of securing a sheet and moving with the sheet toward the transfer means, rather then provide a fixed suction head and a movable transfer device.

The restoring force tending to return unsecured sheets from suction head to the sheet stack—thereby avoiding multiple feeding—need not necessarily in the present invention be gravitational in nature. For example such restoring force may in certain constructions be provided by internal forces developed within the stack itself. Along these lines, for example, one may rigidly restrain an edge-stored feed stack for two thirds of its length, leaving the top third of the stack free to be driven by the blower head toward an adjacent suction head. In this case it is a lateral bending or deformation of the top third of the stack which is involved—rather then a lifting against gravity. Upon adherence of the first contacting sheet to the suction head, the restoring force tending to bring unsecured sheets back to an unbent position, is the internal tension within the bent stack.

While the present invention has been particularly described in terms of specific embodiments thereof, it will be evident in view of the instant disclosure, that numerous variations and modifications of the invention are enabled, which variations and modifications will yet lie within the scope of the present teaching. Accordingly the invention set forth is to be broadly construed, and limited only by the scope and spirit of the claim appended hereto.

We claim:

1. Sheet-feeding apparatus for serially individually feeding sheets from a stack of sheets to a utilization point comprising:

a walled, open top container for holding said stack of sheets, the spacing of said walls being only slightly larger than the dimensions of said stack for constraining the sheets of said stack against sideways movement;

air inlet ports proximate the bottom of said walls of said container for directing a stream of air supplied thereto upwardly along the edges of said stack for causing the topmost sheets of said stack to flutter upwardly;

a vacuum head mounted above said container, said head including a bottom face having air intake ports therein;

air-pumping having an inlet connected to said vacuum head and an outlet connected to said air inlet ports for causing the top sheet of said stack, fluttered towards said vacuum head by the air supplied to said inlet ports by the outlet of said pumping apparatus, to be drawn to and held against the bottom face of said vacuum head, the holding of said top sheet against said vacuum head acting to close off said intake ports in said bottom face and to stop the flow of air to said inlet ports in said walls of said container, thereby causing the sheets of said stack other than said top sheet to fall back to said stack under the influence of gravity; and

sheet transfer means for transporting the sheet held against the bottom face of said vacuum head toward said utilization point, the removal of said sheet from said head serving to restore the flow of air to said inlet ports in said walls of said container.

2. The sheet feeding apparatus of claim 1 wherein said bottom face of said vacuum head includes a first planer segment parallel with the sheets of said stack in said container and an edge segment oriented at an angle with respect to said sheets for upwardly bending the corresponding edge portion of said top sheet for assisting in separating said top sheet from the other sheets of said stack.

3. The apparatus of claim 2 wherein said sheet transfer means includes a pair of nip rollers pivotally mounted adjacent said upwardly angled edge of said lower face of said vacuum head for pivoting said nip rollers towards said angled segment of said lower face for receiving the edge of said sheet held there against.

4. The apparatus of claim 1 further including a secondary suction port in the upper portion of said wall of said container at a point between the top of said stack and said vacuum head and means connecting said secondary vacuum port to said intake of said pumping apparatus for assisting in the return of said sheets, other than said top sheet, to said stack under the influence of gravity when the ports of said vacuum head are covered by said top sheet.

5. Apparatus of claim 1 further including a normally closed flap valve connected between the outlet of said pumping apparatus and said inlet ports in the walls of said container, the flow of air from said outlet when the intake ports in said vacuum head are open being sufficient to overcome said bias and open said valve, said valve being closed when the flow of air through said pumping apparatus is disrupted by said top sheet of said stack for preventing a leakage to said inlet ports and a bypass to atmosphere upstream from said valve to relieve said leakage flow when said valve is closed.