United States Patent

[11] **3,572,686**

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[33] **Great Britain**
[31] **37,756/67**

[54] **SHEET ASSOCIATING DEVICE HAVING ROTARY PNEUMATIC SEPARATORS**
8 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **270/58,** 271/27
[51] **Int. Cl.** **B65h 39/02,** B65h 3/10
[50] **Field of Search** 270/58, 54; 271/27, 28, 29

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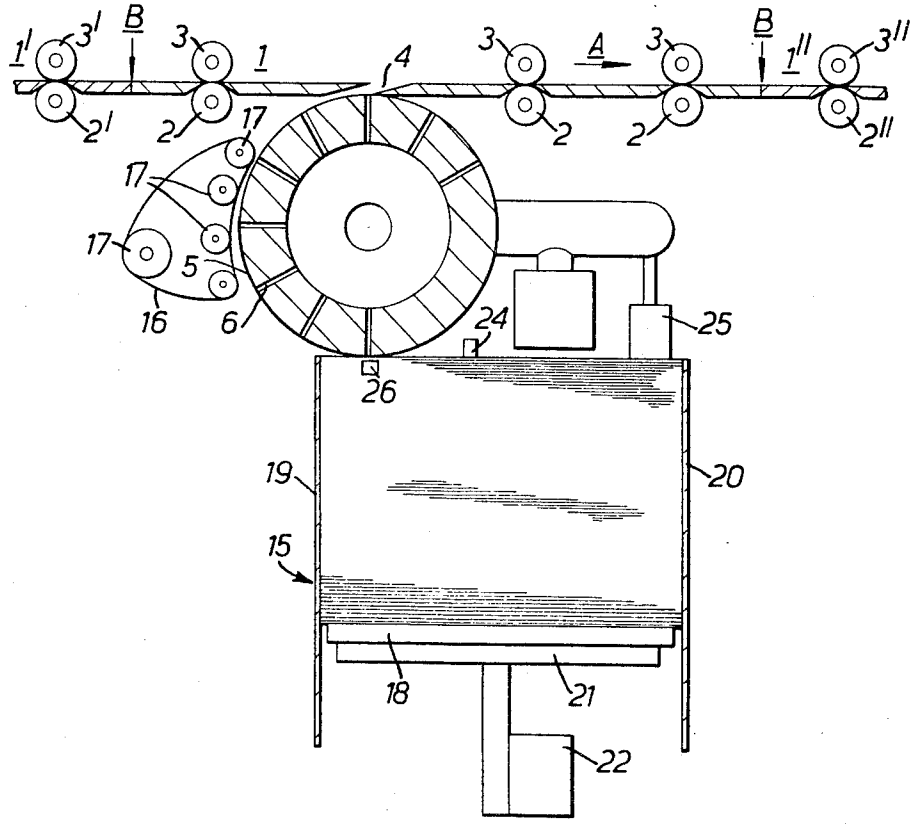
ABSTRACT: To feed assorted documents in a predetermined order to an in-line conveyor track, individual modular sections of a stationary track having drive rollers for the paper are each provided with a feed throat to which documents from the top of a stack contained in a magazine are fed by a continuously rotating suction drum in which a valve restricts suction to the upwardly moving side while a solenoid valve applies suction only at the time when the supply of a document from the hopper in question is required.



3 Sheets-Sheet 1

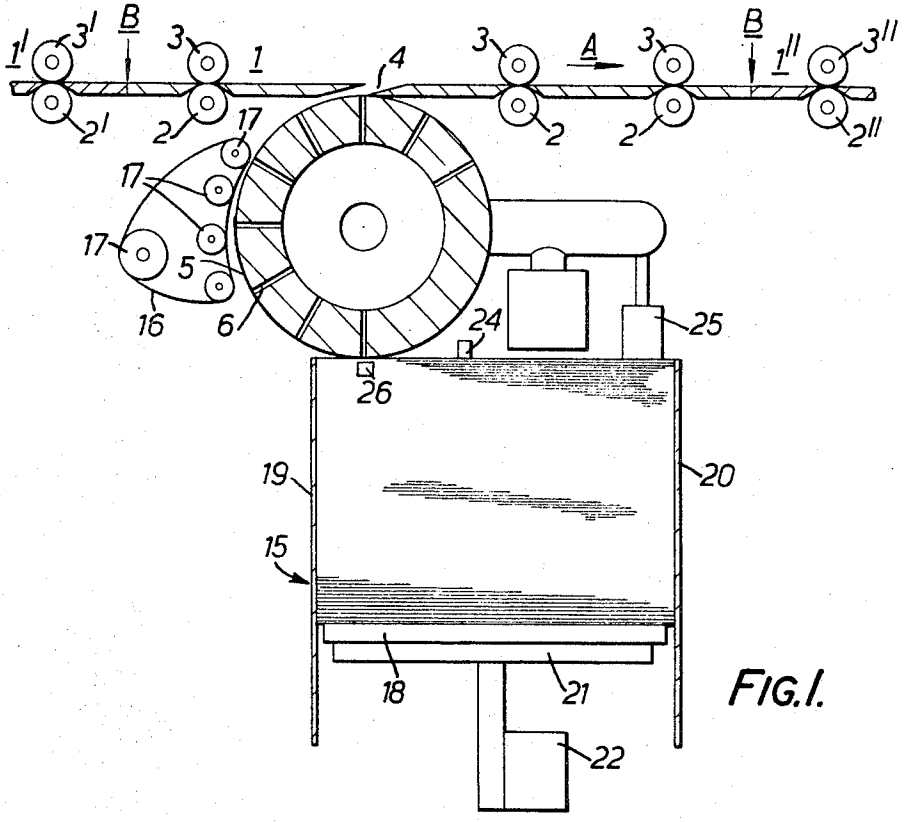


FIG. 1.

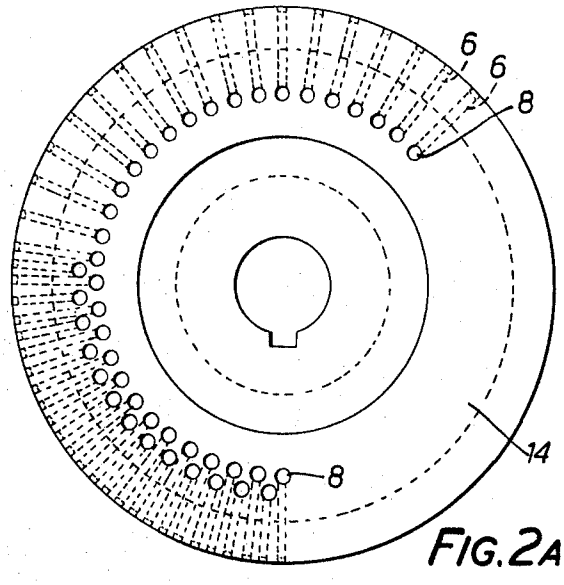


FIG. 2A.

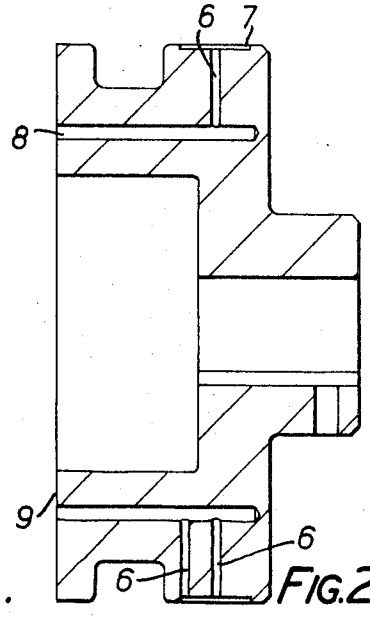


FIG. 2B.

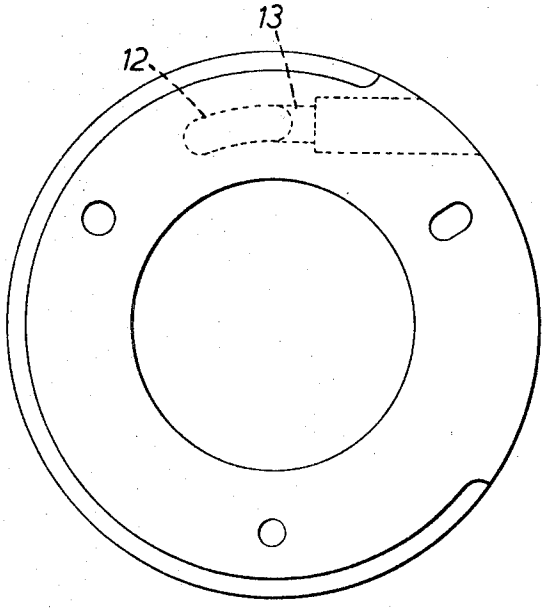


FIG. 3A.

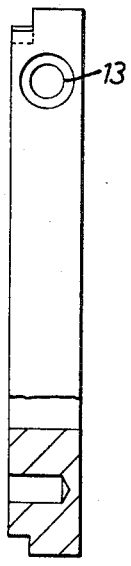


FIG. 3B.

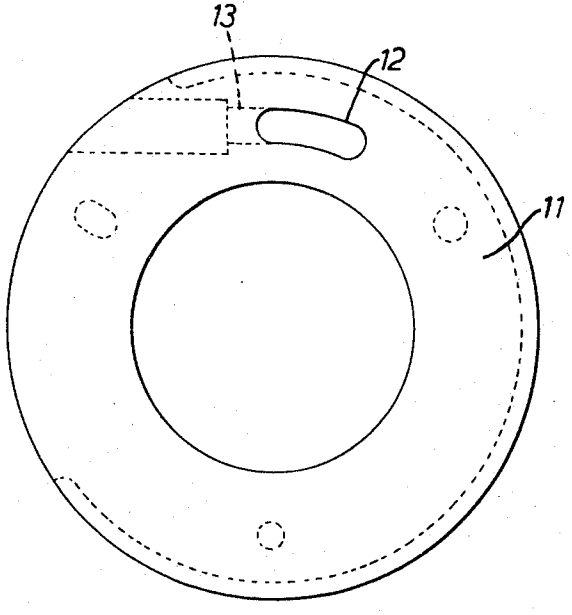


FIG. 3C.

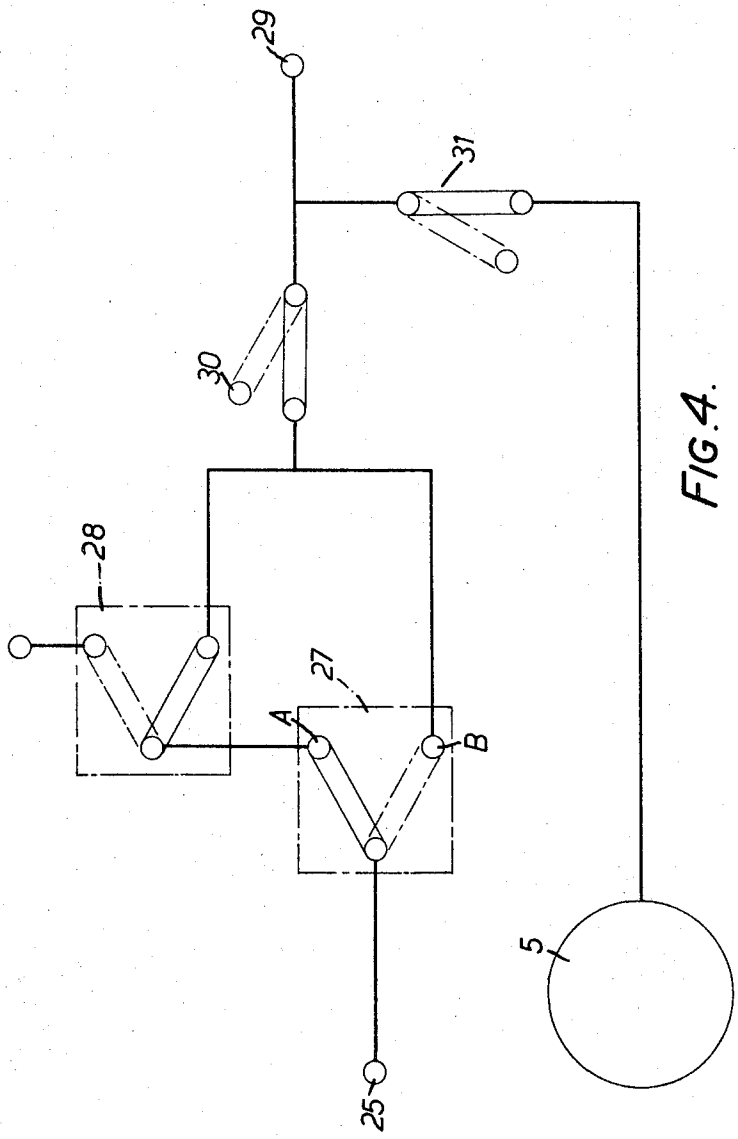


FIG. 4.

SHEET ASSOCIATING DEVICE HAVING ROTARY PNEUMATIC SEPARATORS

This invention relates to sheet conveyor devices, more particularly for the feeding of sheets of paper and has for an object to provide improved means for supplying a conveyor track with sheets from a number of separate magazines or equivalent sources.

According to a broad aspect of the present invention a number of hopper units are spaced along a conveyor track each hopper unit being equipped with apparatus for feeding individual sheets from the unit on to the track through a delivery throat in a direction and at a speed substantially similar to that of the movement maintained on the track, the apparatus with which the hopper unit is equipped being controlled by timing means programmed in a manner such as to ensure the desired order of the individual sheets on the track.

The apparatus may comprise a rotatable feed drum having suction ports in a part of its circumference for drawing in use one end of the top sheet away from a pile of sheets loaded in the hopper unit, suction foot means against which in use the top sheet is normally held by suction sufficient to resist a tendency for the sheet to be removed by the drum from the pile, and means for at least reducing at the suction foot means, the suction at a predetermined instant to enable the top sheet to be withdrawn from the pile as the drum rotates and thereafter delivered through the throat to the conveyor track. The means for at least reducing the suction at the foot may comprise a valve arrangement operable for effecting, in accordance with the angular position of the feed drum, pneumatic coupling between either a suction supply port or a control port which may be coupled through valve means either to reduced air pressure or suction source (i.e. a vacuum) or to atmosphere in accordance with signals provided by the timing means. The valve arrangement may take the form of a rotor disc valve which is driven mechanically at the same angular velocity as the feed drum so that during part of a revolution of the feed drum the suction foot is coupled to the suction supply port and during the rest of the revolution it is coupled to the control port. The control port is normally coupled through the valve means to a vacuum or partial vacuum until a signal initiated by the timing means causes the valve means to operate to couple the control port to atmosphere, atmospheric pressure thereafter being applied to the suction foot by the rotor disc valve thus removing from the top sheet the restraining force afforded by the reduced air pressure at the vacuum foot and allowing the sheet, through further rotation of the feed drum, to be carried away from the pile for subsequent ejection through the throat on to the conveyor track.

The valve means may comprise a two-way valve which is solenoid operated in accordance with signals produced by the timing means. When it is required to feed a sheet from a selected hopper unit on to the conveyor track a signal from the timing means causes a two-way solenoid valve to operate thereby to switch the control port from vacuum to atmosphere. This operation is preferably completed whilst a portion of the feed drum circumference having no vacuum ports is adjacent the sheet. As the feed drum rotates further the vacuum ports in its circumference draw one end of the sheet away from the pile and suction is still applied by the suction foot at the other end of the sheet causing the sheet to remain on the pile. The drum thus slips aver the end of the sheet which is drawn away from the pile. As the drum rotates further the rotor disc valve switches ports in the suction foot from "vacuum" to the control port which is now at atmosphere thus relieving from the sheet the restraining force previously applied by the suction foot and enabling the sheet to be carried round initially by the drum alone and then by the drum assisted by a belt drive, the to the throat through which it is ejected on to the conveyor track.

Sheets from each magazine are fed to separate entry points spaced preferably at equal intervals along the conveyor track. The rotor disc valves, one of which is associated with each magazine, are preferably operated in synchronism, their switching action only being effective for sheet feed purposes if

the two-way valve associated with the selected magazine is first operated. In this way the time spacing between successive sheet-feeding operations may be maintained constant independently of solenoid-operating times and vacuum decay times of the two-way valves, since the two-way valve only sets the state of the control port (either to vacuum or to atmosphere) which is actually sampled by the rotor disc valves as they operate contemporaneously and rotate synchronously with the feed drum.

Preferably the hopper unit includes a magazine which may be readily inserted into and withdrawn from a hopper structure and exchanged for another magazine when the stock in one magazine is exhausted or when it is desired to change over to different sheet forms. The conveyor track is preferably arranged above the magazine with the drum arranged over that end of the sheets in the magazine which faces the rearward end of the track, so that after passing over one-half of the circumference of the drum this end of each sheet will be ejected first on to the track through a suitably inclined throat to become the leading edge of the sheet during its travel.

Until the magazine in each of the hopper units are suitably positioned for sheet feeding the vacuum is automatically cut off. The hopper structure is arranged to raise a platform at the lower end of the stack of sheets in an inserted magazine until when the uppermost sheet reaches a predetermined level just below the feed drum, which is arranged to switch on the vacuum and to restart the feed movement when the level has fallen by a predetermined amount. This will ensure that the top sheet in the magazine will be reliably picked up by the suction of the drum when required and will avoid the risk of jamming due to pressure between the surface of the drum, the sheets and the magazine. In order to effect separation between the top sheet of the stack which has been picked up at one end by the suction foot and the next sheet, an air jet is directed across the top of the stack to effect this separation and obviate the risk of two sheets being picked up by the drum. The continuation of the movement of each sheet after its delivery to the track may conveniently be effected in a conventional way by driven rollers in the track bed, against which the sheets are resiliently urged by slightly loaded nondriven contact rollers.

Some exemplary embodiments of the invention will now be described with reference to the accompanying drawings in which:

FIG. 1 is a generally diagrammatic side elevation partly in section of sheet conveyor apparatus;

FIG. 2A and FIG. 2B are respectively an elevation and sectional view of a feed drum utilized in the apparatus of FIG. 1;

FIG. 3A, FIG. 3B and FIG. 3C are respectively, an end elevation, a side elevation partly in section, and the other end elevation of a face-sealing element for use with the feed drum shown in FIG. 2; and

FIG. 4 is a schematic diagram showing the valve arrangement of the apparatus of FIG. 1.

Referring now to FIG. 1 a conveyor track for feeding sheets of paper in the direction indicated by the arrow A is subdivided into modular lengths abutting at points B, each length being equipped with a number of continuously driven rollers 2 which project through the upper surface of the track 1 and face spring-loaded pressure rollers 3, which are freely rotatable about their axis and serve to maintain any sheet of paper moving along the track in adequate frictional contact with the driven rollers 2. Parts of the preceding and following modules corresponding to parts, 1, 2 and 3 have been indicated by the same reference numerals supplemented with a ' and '' respectively. Each module 1 of the track is further formed with an inclined throat 4 through which sheets of paper can be fed on to the track and throat 4 of each module 1 cooperated with a suction feed drum 5 part of whose circumference is formed with numerous suction ports 6. As shown in FIG. 2A and FIG. 2B the suction ports 6 extend radially from a shallow channel 7 in part of the circumferential surface of the drum 5, to join with suction feed bores 8 which extend axially from a sealing face 9 of the drum. The face 9 of the drum cooperates with a

stationary generally annular face seal valve **10** shown in FIG. 3A, FIG. 3B and FIG. 3C. The sealing face **9** of the drum **5** is urged, by means not shown, against face **11** of the valve **10**. An elongated aperture **12** in the face **11** cooperates with a vacuum feed bore **13** which extends from a position on the circumferential face of the annular face seal valve **10**. The respective radial positions of the suction feed bores **8** and the elongated apertures **12** are coincidentally arranged so that as the drum **5** rotates with respect to the valve **10**, suction is applied successively to the bores **8** so that suction is applied to the drum **5**, for about three-quarters of each revolution. For the other quarter of the revolution, the elongated apertures cooperate with a blank portion **14** in the face **9** of the drum **5** having no suction feed bores and consequently no suction is applied to the suction ports **6** of the drum **5**.

Arranged underneath the drum **5** is a hopper device which includes a readily exchangeable magazine **15**. This magazine is located in the hopper unit by bushes (not shown) which fit over pins (not shown) of the hopper unit. On one side of the drum is a belt **16** supported by a pulley arrangement **17** which in combination with the drum (which provides the driving force) drives the paper sheets to a position for ejection through the throat **4**. The hopper unit includes a baseplate **18** which is slidably movable between two end walls **19** and **20** and the hopper structure includes a jack plate **21** intended as a support for the baseplate **18** of the magazine. Lifting mechanism shown schematically at **22**, comprises an air cylinder controlled by a solenoid valve driving a shaft through a one-way clutch, with another one-way clutch acting as a backstop, although other forms of actuation could be used, and serves to progressively raise the support plate **21** and with it the magazine baseplate **18** and a stack of paper resting on the latter, until the uppermost sheet of paper in the magazine reaches a predetermined level, just short of contact with the drum **5**. At this predetermined level the top sheet of paper operates a feeler device **24** to deenergize the lifting mechanism **22** until a drop in the level of the uppermost sheet of paper occurs, due to withdrawal of individual sheets of paper by the drum has caused the level to fall by predetermined small amounts sufficient to reverse operation of the feeler device **24**. One or more continuously operated blast nozzles schematically indicated at **26** are provided to keep the uppermost sheet in the magazine in a more or less floating state, thereby counteracting any tendency for the second sheet to participate in the feed movement of the topmost sheet when this is withdrawn by the feed movement of the topmost sheet when this withdrawn by the feed drum **5**. Suction-type holding foot **25** is provided to retain the uppermost sheet of the stack in its position in the hopper up to the moment of its withdrawal by the drum **5** at which time the suction is arranged to be disconnected from the device **25**.

As shown schematically in FIG. **4** the suction-type holding foot is supplied from a rotor disc valve **27** which is driven mechanically from the feed drum **5**, to switch from position A to position B for each revolution of the drum. In this example during each revolution of the drum **5** the holding foot **25** is coupled to position A for about a quarter of a revolution and to position B for the rest of the revolution of the drum. At position A the holding foot **25** is connected to the wiper of a two-way valve **28** which may be connected either to atmosphere or to a vacuum pump indicated at **29** via a shut-off valve **30**, whereas at position B of the rotor disc valve the holding foot **25** is coupled via this shutoff valve **30** to the vacuum pump **29**. The vacuum pump is also connected to the feed drum **5** via another shutoff valve **31**. Assuming the two shutoff valves to be open as shown in FIG. **4** the operation of the equipment for paper feeding is as follows. The front end of a paper sheet is picked up by the feed drum **5**, wraps around it and then slides over its surface as the frictional and suction-holding force available from the holding foot **25** is greater than that available from the drum **5**. The rotary disc valve **27** which is synchronized with the feed drum disconnects the foot from vacuum and vents it to atmosphere at a predetermined time via the two-way solenoid valve **28**. This allows the paper to move forward and out of the hopper. As soon as the tail of the longest document which it is required to feed has cleared the foot, vacuum is reapplied at the foot and the sheet below is picked up and gripped preventing it from being accidentally drawn forward and holding it in readiness for the next cycle. If it is required to inhibit feeding, the vent outlet A of the disc valve **27** is switched from atmosphere to vacuum by means of the two-way solenoid valve **28**. The solenoid valve **28** may be operated when the disc valve **27** is coupling the foot directly to vacuum and its timing is thus not critical. In the inhibit condition vacuum is therefore applied to the foot at all times and the paper cannot be pulled forward. The shutoff valve **30** is solenoid operated and may be actuated to cut off all vacuum supply to the foot when the hopper is not in a loaded condition. The other shutoff valve **31** may be operated in accordance with a predetermined program, for cutting off vacuum to the feed drum, to reduce the vacuum consumption of the machine.

The energization of the two-way valve may be controlled by a solenoid which itself is controlled by a master control device which does not form part of the present invention and which may itself be preferably controlled by programming means which may be so arranged as to obtain on the track at the end of the last module a prearranged sequence of sheets from various hopper positions spaced at regular and substantially uniform intervals from each other irrespective of the point of the origin of each individual sheet.

The device can be used for the programmed assembly of multisheet publications for example brochures containing a number of illustrated pages intended to be used in all of the number of editions and say one descriptive page which is available in different languages, a different one of these being incorporated in each of the various language editions. It may also be used for feeding documents to an in-line printer, which may be for example intended to add a common overprinting to a sequence of otherwise different sheets and for other more or less equivalent purposes. Various modifications may be effected without departing from the basic principle of the invention thus instead of supplying documents withdrawn from the top of the magazine hopper to track arranged above the hopper, the arrangement may be reversed subject to minor modifications which will be readily appreciated by those skilled in the art, to withdraw documents from the bottom of the hopper and feed them from above to a track arranged beneath the hopper.

We claim:

1. Sheet-feeding equipment comprising a conveyor movable along a path, a number of hopper units spaced along the conveyor path, each hopper unit being equipped with a feed drum rotatable about an axis substantially perpendicular to the conveyor path and having suction ports in a part of its circumference for drawing in use, one end of a top sheet away from a pile of sheets loaded in the hopper unit, suction foot means against which in use the top sheet is normally held by suction sufficient to resist a tendency for the sheet to be removed by the drum from the pile, a rotor disc valve which is driven at the same angular velocity as the feed drum, so that during part of a revolution of the feed drum the suction foot is coupled to a suction supply port and during the rest of the revolution it is coupled to a control port, the air pressure at which is determined in accordance with the setting of valve means, operable for facilitating the provision at a predetermined instant of reduced suction at the suction foot, to enable the top sheet to be withdrawn from the pile as the drum rotates and thereafter to be delivered through a delivery throat in a direction and at a speed substantially similar to the movement maintained on the said track.

2. Sheet-feeding equipment as claimed in claim **1** wherein the control port is normally coupled through the valve means to a vacuum or partial vacuum until the valve means is operated to couple the control port to atmosphere, atmospheric pressure thereafter being applied to the suction

foot via the rotor disc valve thus removing from the top sheet the restraining force afforded by the reduced air pressure at the vacuum foot and allowing the sheet, through further rotation of the feed drum, to be carried away from the pile for subsequent ejection through the throat on to the conveyor track.

3. Sheet-feeding equipment as claimed in claim 2 wherein the valve means comprises a two-way valve including solenoid-operating means.

4. Sheet-feeding equipment as claimed in claim 3 wherein the hopper unit includes a magazine which may be readily inserted into or withdrawn from the hopper unit.

5. Sheet-feeding equipment as claimed in claim 4, wherein the conveyor track is arranged above the magazine with the said drum arranged over that end of the sheets in the magazine which faces the rearward end of the said track so that after passing over one-half of the circumference of the said drum this end of each sheet will be ejected first onto the said track through the said throat to become the leading edge of the sheet during its travel.

6. Sheet-feeding equipment as claimed in claim 5, wherein each magazine includes a baseplate at the lower end of the stack of sheets in a magazine and means for raising the baseplate until the uppermost sheet reaches a predetermined level just below the feed drum whereupon the upward movement is terminated under the control of a detector device which is arranged to switch on a vacuum and to restart the feed movement when the level has fallen by a predetermined amount.

7. Sheet-feeding equipment as claimed in claim 6, wherein the top sheet of the stack which is being picked up at one end by the suction foot and the next sheet are separated by an air jet which is directed across the top of the stack to effect separation and to obviate the risk of two sheets being picked up by the drum.

8. Sheet-feeding equipment as claimed in claim 7 wherein the continuation of movement of each sheet after its delivery onto the track is effected by means of driven rollers carried in the track bed against which the sheets are resiliently urged by slightly loaded nondriven contact rollers.