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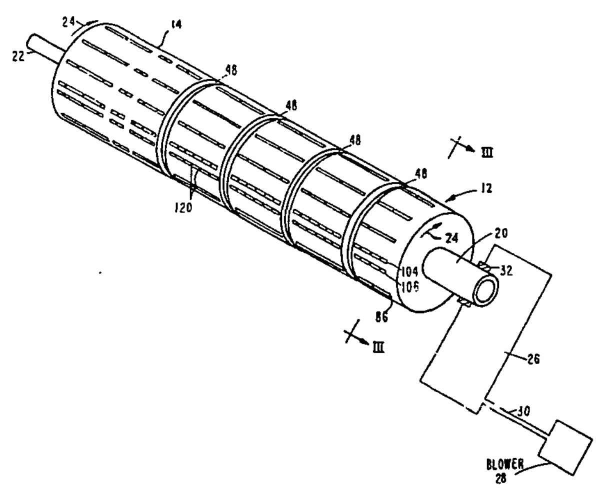
(54) **Sheet transport apparatus.**

(57) A low inertia rotary drum (12) supports flexible sheets of different sizes for transport and processing. A plurality of sets of grooves is disposed on the surface of the drum. The grooves are configured in spaced rows and columns along the longitudinal and circumferential dimension of the drum. A plurality of holes (120) form unvavlved communicating ports in the slots. The holes interconnect the interior or the drum with the surface. The number of holes varies circumferentially and longitudinally. A vacuum having a low vacuum, high flow blower (28) is coupled to the interior of the drum. Sheets are loaded onto the drum so that a minimum number of holes are vented to the atmosphere, and unloaded by movable fingers which enter circumferential grooves (48).



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SHEET TRANSPORT APPARATUS

The present invention relates to sheet transport apparatus and, more particularly to such apparatus comprising a rotatable, hollow drum and vacuum means for applying vacuum through holes in the cylindrical shell of the drum to attract and hold a sheet onto the drum.

The use of a rotary drum for transporting sheet-like material is well known. Rotary drums are often used in printing systems. In addition to the transport function, these drums support the sheet-like material during the printing process. Prior art printing systems are further fitted with paper handling mechanisms which load and unload a sheet of paper onto the drum.

A necessary component of the prior art print system is the means used to attach the sheet onto the drum. The prior art often used mechanical fingers for clamping sheets onto the drum. By way of example, US 2,451,079 discloses a rotary drum for supporting a sheet in a facsimile printing system. The drum is fitted with two linear rows of pins. The rows of pins are spaced circumferentially and extend outwardly from the surface of the drum. One row of pins releasably secures the leading edge of the sheet while the other row releasably secures the trailing edge of the sheet. A loading plate and a stripper bar are positioned relative to the drum. The loading plate loads a sheet onto the drum while the stripper bar strips a sheet from the drum.

Although the above-described mechanical clamping system works satisfactorily for its intended purpose, the system tends to be relatively slow and complex. The slowness stems from the fact that the response time in which the mechanical system clamps and releases a sheet is relatively long. As such, print drums using mechanical fingers for gripping the sheet are used with relatively low performance printing systems.

For high performance printing systems, the prior art generally uses pneumatics and/or electrostatic means for taking the sheet onto the drum. Prior art printing systems generally use coronas as the source for generating the electrostatic force. An example of a prior art printing system using a combination of pneumatics and corona for attaching a sheet onto a print drum is disclosed in DE-2,803,698, FR-2,379,458 and GB-157,990, in which is disclosed a low inertia rotary drum for transport of flexible sheets such as paper. The drum has two longitudinal slots disposed on its surface, with each slot being connected to internal segments by spaced ports extending therethrough. These slots enable a vacuum to be applied to the leading and/or trailing edge of the sheet separately. A valving system is used to control the vacuum to these slots independently through the internal segments. The spacing of the slots about the circumference of the drum is dependent on the size of the sheet to be processed. A charge corona is disposed relative to the drum and attaches the sheet to the drum by means of electrostatic attraction. The drum handles a single size sheet and requires the use of a corona for attaching the sheet to the drum.

As for pheumatic systems, the general scheme is to use a segmented drum to transport the sheet. Vacuum for attaching and/or dislodging the sheet is selectively applied to various zones or segments on the drum. The drum is referred to as being segmented because at times during the operation of the system, segments of the drum may or may not have vacuum present.

US-3,545,746 discloses a document transport consisting of a hollow cylindrical segmented transport drum and document loading and unloading means disposed relative thereto. The cylindrical surface of the drum is fitted with longitudinal and circumferential slots. The inside of the drum is vented to atmosphere by communicating holes. A static partition divides the interior of the drum into two pheumatically independent compartments. By rotating the drum and applying a vacuum to one of the compartments, a document can be carried around with it, to a limited extent, determined by the size of the evacuated compartment.

US-4,145,040 discloses another example of a prior art segmented type vacuum drum. The drum is adapted for transporting flexible sheets. The drum is fabricated with an active suction zone or sector for gripping the sheets. The drum consists of an inner stationary cylindrical member and an outer rotary cylindrical member. The stationary member is fitted with a suction source and a pressure source. Both sources are displaced relative to each other about the circumference of the stationary cylindrical member. The suction source is vented through a groove to the outside surface of the inner stationary member to the outside surface. A common duct interconnects a row of apertures to the groove or the recess. Each duct is fitted with a piston. The piston controls the pressure (negative or positive) to the apertures. Vacuum (negative pressure) and/or puffs of air (positive pressure) is applied to the sector of the drum as the outer member is rotated relative to the inner.

In US-4,202,542, DE-2,850,747, FR-2,410,619 and GB-1,581,419, there is disclosed a sheet transport device including a low inertia rotary drum for handling various size materials. The drum has a plurality of sets of longitudinally spaced ports formed on its surface. The ports are spaced arcuately from each other about the surface of the drum, with one set enabling a vacuum to be applied to the leading edge of a sheet, while only one of the other sets of ports applies a vacuum to the trailing edge of the sheet in accordance with the dimension of the sheet in the circumferential direction around the drum. The sheet transport device further controls how many of the ports of the two sets of ports apply a vacuum in accordance with the dimension of the paper along the length of the drum. A rotary valve is used to control the vacuum flow in accordance with the size of the sheet. The drum requires a rotary valve for controlling vacuum flow.

It is also well known in the prior art to use valves as a means to control vacuum flow to the active segment of the drum. By way of example, US-3,663,012, and US-3,466,029 disclose sectored vacuum transport drums wherein valves are used to control vacuum to the active sector of the drum.

Although the use of pneumatics or a combination of pneumatics and electrostatics is a significant improvement over the use of mechanical gadgets for tacking sheets onto a drum, the prior art pneumatic document transport systems still have several disadvantages. In the first instance, the segmented drum design tends to be complex. The complexity increases as the number of sheet sizes, which the transport system handles, increases.

A complex valving system is generally needed in the prior art pneumatic systems. The valving system is needed to select which port receives flow at any particular time. The valving system increases as the sheet size, which the system handles, increases. Another requirement for a valving system is that the system must know the paper size to enable the supply of vacuum to the proper ports. This requires the intervention of an operator to make a sheet size selection or the use of logic to detect the sheet size. Moreover, with a valving system, extra care is needed in selecting the valve and in positioning its relative to the drum. Both valve selection and valve positioning are important since the response time of the drum is directly dependent on both variables. Due to their complexity, the prior art pneumatic document transport system has relatively low reliability.

Another prior art problem area is in the type of vacuum system used. The vacuum system is needed to evacuate the drum and to create the force for tacking a sheet onto the drum. The problem in this area stems from the fact that in the prior art type of vacuum system, there is a wide swing in the vacuum between load and no-load conditions on the drum. By way of example, at no-load condition (that is with no paper on the drum), the vacuum is relatively low. At load condition (that is with paper on the drum), the vacuum is substantially higher.

The wide swing in vacuum has several undesirable repercussions. In the first instance, there is a large mismatch between the vacuum requirements to attach and retain a sheet onto the drum. Generally, a relatively high flow is required for attachment, but a relatively low vacuum force is required for retainment. There is a need to recognize that there is a close relationship between the design of the vacuum system which generates the vacuum and the requirements of the transport drum which uses the vacuum and to design the vacuum system to minimize the mismatch.

So far, the prior art has failed to recognize and address the interrelation between the vacuum requirements at the drum and the design of the vacuum system.

In addition, high vacuum tends to damage a sheet on the drum. More important, in some types of application, such as ink jet printing, the high vacuum is totally unacceptable. The reason is that the high vacuum sucks the ink through the paper. The prior art attempts to solve the problem by using a relief valve to reduce the pressure at the drum. The use of a relief valve tends to complicate the system and increase cost.

Accordingly, the invention is characterised in that the holes in the cylindrical shell of the drum constitute unvalved ports communicating directly with the interior of the drum and in that the vacuum means is constituted by a low vacuum, high flow blower connected to the interior of the drum.

Thus the use of valving or segments is avoided.

Further, a relatively uniform vacuum is provided between load and no-load conditions.

An embodiment of the present invention accomplishes the foregoing by generating variable flow zones on the surface of the drum during loading and variable vacuum force zones on the surface of the drum during the period of time when the sheet is retained on the drum. The vacuum force and flow zones are highest at predetermined zones; particularly, in the zones whereat the leading and trailing edge of the sheet attaches to the drum. The vacuum and flow are generated by grooves and communicating holes disposed on the surface of the drum. By varying the sizes of the grooves and the number and/or size of holes, the variable vacuum force and flow zones are created.

The present sheet handling apparatus includes a low inertia rotary drum which supports variable size sheets of paper. The drum is journaled at its opposite ends for rotation. A plurality of spaced elongated grooves is fabricated on the cylindrical surface of the drum. The grooves are placed along the longitudinal and circumferential dimensions of the drum. The grooves, along the longitudinal dimension of the drum, are configured to support three sizes of sheets. The grooves around the circumference of the drum are configured into a leading edge groove and a plurality of trailing edge grooves. The leading edge groove supports the leading edge of all sized sheets, while each trailing edge groove supports the trailing edge of a different sized sheet. The spacings between the leading edge grooves and the trailing edge grooves are dictated by the size of the sheets. A high flow, low vacuum blower is coupled to the drum. Communicating holes are fabricated in the grooves. The holes communicate the vacuum to the surface of the drum.

In one feature of the invention, one or more circumferential grooves are disposed in the circumferential dimension of the drum. One or more pick-off fingers coact with the grooves to strip a sheet from the drum.

In another feature of the invention, the population and/or size of the holes are greatest in the leading and trailing edge grooves.

In yet another feature of the invention, an elongated load guide is disposed relative to the surface of the drum. The guide forces a sheet to conform to the surface of the drum.

The scope of the invention is defined by the appended claims; and how it can be carried into effect is hereinafter particularly described, with reference to the accompanying drawings, in which :

FIGURE 1 is a schematic view of the sheet transport apparatus according to the present invention;

FIGURE 2 is a schematic of the print drum of Fig.1;

FIGURE 3 is a cross-sectional view of the print drum on the line III-III of Fig.2; FIGURE 4 is a side view of the apparatus;

FIGURE 5 is a schematic view of the vacuum drum shell unfolded to show the grooves; and

FIGURE 6 is a graph showing the relationship between the characteristics of a prior art vacuum system and the vacuum system used in the invention.

As used in this specification, the word "pump" means a type of air compressor characterized as a high pressure, low mass flow rate device usually of the positive displacement type.

As used in this specification, the word "blower" means a type of air compressor characterized as a high mass flow rate device usually of the nonpositive displacement (dynamic) type.

Although the present invention can be used in any environment wherein flexible sheet-like materials are transported, the invention is well suited for use in a printing environment, and as such, will be described accordingly.

Referring to the drawings, and particularly to Figs. 1 and 4, conventional elements such as support frame, mechanical coupling, bearings, etc. are omitted.

A document handling system 10 (Fig.1) includes a low inertia rotary drum 12 having a cylindrical shell 14 mounted on end members 16 and 18 at opposite ends. A tubular member 20 is secured to the end member 16 and communicates with the interior of drum 12. A shaft 22 is attached to the end member 18. The shaft 22 and member 20 are rotatably supported by bearings (not shown) in a machine frame (not shown). A drive motor (not shown) is coupled to drive the shaft 22 and rotate the drum in a direction shown by arrow 24. The tubular member 20 extends through a rotary seal 32 into a vacuum plenum 26 coupled to a low vacuum, high volume flow blower 28 by a tube 30. The interior of drum 12 is evacuated by the blower.

A loading station 32 and an unloading station 34 are peripherally spaced about the surface of the rotating drum. At the loading station 32 the drum is loaded with a single sheet of flexible sheet-like material such as paper. Paper sheets are fed seriatim from a stack 36 of sheets on support tray 38. The topmost sheet in the stack is fed along guide channel 40 and the leading edge 78 of the sheet 44 is first attached by vacuum to a predetermined zone on the cylindrical surface of the drum. Downstream from the loading station, in the direction of drum rotation, an arcuate elongated guide member 42 is mounted and spaced from the cylindrical surface of the drum. The function of the guide member 42 is to force a sheet to conform to the surface of drum 12. The guide member has a length substantially equivalent to the length of the drum and runs in a direction parallel to the axis of rotation of the drum. In the preferred embodiment of this invention, the space between the cylindrical surface of the drum and the inner surface of the guide member is approximately 0.05 centimetres. The paper sheet 44 is attached by vacuum to the cylindrical surface of the drum and is processed by a processing station (not shown) which is preferably positioned between the loading and unloading stations. The processing station may be an ink jet head which writes readable characters on the paper as paper sheet is transported through the processing station. Such processing may require several rotations of the drum. After processing, the sheet 44 is stripped from the drum by four stripping fingers 46 which are pivotally mounted so that their free ends may be spaced from the surface of the drum (Fig.4) or lowered to enter four circumferential grooves 48 (Fig.2) fabricated in the circumferential dimension of the drum shell. The detached sheet travels over the top surface of a guide member 51 onto an output tray 53. An operator can then remove the processed sheet from the output tray.

Although four circumferential grooves and fingers are used to detach the sheet from the drum, a single groove and finger are sufficient and any convenient number of grooves and fingers may be used to detach a processed sheet from the surface of the drum.

Projecting through the guide channel 40 upstream of the loading station in the direction of paper feed is a pivoted paper gate 62 (Fig.4) coupled by a mechanical linkage 64 to a solenoid 66. Upstream of the paper gate in the direction of paper feed, a feed roller 52 projects through the guide channel 40 and is spaced from a drive roller 50 rotatable by motor means (not shown). The roller 50 is connected by a mechanical linkage 54 to a solenoid 56 to be movable into driving contact with the roller 52. The space between the rollers 50 and 52 is relatively small, but sufficient to allow free passage of a sheet therebetween.

In operation, a sheet of paper is fed from the top of a paper stack on tray 38 by a feed mechanism (not shown), but which may be a shingler such as described in US-4,113,245, DE-2,815,567, FR-2,387,886 and GB-1,565,629 or US-4,175,741. The paper passes through the opening between rollers 50 and 52 and the leading edge is stopped by paper gate 62. Enabling signals are output by a controller 60 on conductors 58 and 68 to the solenoids 56 and 66, respectively. Activation of the solenoid 66 causes the gate 62 to pivot from the leading edge of the sheet, and activation of the solenoid 56 forces the drive roller 50 down to grip the sheet between the rollers. The roller 50 is then rotated clockwise at a surface speed equal to that of the drum 12, thus feeding the sheet onto the cylindrical surface of drum 12. The timing of the actuation of the solenoids and rotation of the drive roller is synchronised with the rotational position of the drum to bring the leading edge of the sheet into contact with the drum at a predetermined zone of the surface. Vacuum within the drum attaches the sheet to the drum for loading. The drum is rotated slowly during loading and is then speeded up for processing, after which it slows down again when a sheet is to be removed therefrom.

The stripping fingers 46 have free ends which are fabricated with an upper sloping surface and are substantially cone-shaped with the bottom surface of the cone having a concave surface corresponding to the convex surface of the drum. The fingers 46 are fixed to a shaft 70 coupled by a mechanical linkage 72 to a solenoid 74. When a sheet is processed and ready to be stripped the controller 60 puts out an enabling signal on conductor 76 to the solenoid 74 to pivot the fingers counterclockwise. The signal is timed to be synchronised with drum rotation so that the fingers 46 enter the grooves 48 between the trailing and leading edges of the sheet 44 on the drum. When the shaft 70 has pivoted the stripping fingers into the grooves 48, the sheet 44 which is on the drum rides along the upper inclined surfaces of the fingers 48 over guide member 51 and into tray 53.

Other types of loading and unloading devices may be used, for example, those described in US-4,252,307, DE-2,803,698, FR-2,379,458 and GB-1,579,900 and US-4,202,542, DE-2,850,747, FR2-410,619 and GB-1,581,419.

To apply the vacuum in the interior of the drum to attach a sheet to the drum, a plurality of grooves and holes are provided in the surface of the shell 14. These enable variable force vacuum zones to be present on the cylindrical surface of the drum. No valving or segmenting is needed to establish the variable force vacuum zones on the drum. On the surface of the drum shell 14 (Fig.5) are inscribed a longitudinal scribe line 74 and a circumferential scribe line 76. The scribe lines are the alignment lines on the drum. Generally, the leading edge 78 (Fig.1) of the sheet is aligned with or close to the scribe line 74. The lengthwise dimension of the sheet is usually aligned with the longitudinal scribe line 74. Similarly, the widthwise dimension of the sheet is usually around the drum with the top edge aligned with or close to the circumferential scribe line 76.

Elongated grooves are formed in the cylindrical surface of the drum to allow the vacuum to be effective over a wide area of paper. The grooves are arranged in linear rows parallel to the longitudinal axis of the drum and the scribe line 74 and spaced around the circumference of the drum. The grooves in each row are spaced apart in the longitudinal direction of the drum to allow for the grooves 48 and for different lengths of paper. The groove 86 is one of a row of leading edge grooves which generate the vacuum force which attaches the leading edge of the sheet to the drum. Grooves 88, 90, 92, 94, 96, 98, 100 and 102 are in intermediate rows and function to attach the main part of the sheet onto the drum. Grooves 104 and 106 are in closely spaced trailing edge rows and function to attach the trailing edge of a sheet onto the drum. The width of the grooves may vary. Thus the grooves of the leading edge and trailing edge rows are wider than the grooves by the intermediate rows. This enables a slightly higher vacuum force to be present at the leading and trailing edges of the sheet.

The lengths of the corresponding grooves in each row are the same, though this is not essential. The lengths are determined basically by the positioning of the grooves 48 in relation to the scribe line 76. However, beyond the groove 48 furthest from the scribe line 76, the grooves are divided into different length grooves to suit different length sheets. Considering columns of grooves around the circumference of the shell 14, the leading edge grooves 86 are located close to the scribe line 74, the intermediate grooves 88, 90, 92, 94, 96, 98, 100 and 102 are equally spaced and the trailing edge grooves 104 and 106 are closely spaced. The grooves are configured into groups adapted for different size sheets. A first group of slots within the rectangle identified by lines 108 and 118, extends in the longitudinal dimension of the drum between scribe line 76 and dotted line 110, and in the circumferential dimension between the scribe line 74 and the trailing edge grooves 106. The first group of grooves would be covered by a first size sheet, in this case 8.5" x 11" (215.9mm x 279.4mm).

A second group of grooves (some of them common with those of the first group) within the rectangle identified by lines 112 and 116 extend in the circumferential dimension of the drum between scribe line 74 and trailing edge grooves 104, and in the longitudinal dimension between dotted line 109 and scribe line 76. The second group of grooves would be covered by a second size of sheet, in this case the international paper A4. The size of the A4 paper is approximately 210 x 297mm (8.25" x 11.7").

A third group of grooves (including all those of the first and second groups) within the rectangle identified by the lines 114 and 118 would be covered by a third size of sheet, in this case 8.50" x 14" (215.9mm x 355.6mm).

The third group of grooves extend in the longitudinal dimension between dotted line 111 and scribe line 76 and in the circumferential dimension between scribe line 74 and trailing edge groove 106.

The grooves may be so configured as to provide more than or fewer than three sizes of rectangle to be covered by different sizes of sheet.

The discontinuities in the grooves furthest from the scribe line 76 are such that the sheets for which they are designed would cover complete grooves, rather than only part of some grooves. This ensures that the bottom edge of a sheet is firmly attached by vacuum to the drum.

Each of the grooves communicates with the interior of the drum through at least one communicating port 120, in the form of a radial role fabricated in the cylindrical surface of the shell 14. Thus air is drawn from the grooves by the blower 28 to generate flow zones on the surface of the drum. The number and/or size of the ports 120 communicating with the grooves may be different, so that different variable flow zones are generated on the cylindrical surface of the drum. A relatively high number of ports open into the leading edge grooves 86. Thus a relatively high flow zone is generated which attaches the leading edge of the sheet. Similarly, a relatively high number of ports open into the trailing edge grooves 104 and 106, so that a relatively high flow zone is generated for attaching the trailing edge of the sheet. Only a single port opens into each intermediate groove, so that a relatively low flow zone is generated between the leading and trailing edges. The size of the ports may be different to achieve or enhance this effect. In a preferred embodiment of the present invention (now shown) the population and/or size of the ports in the trailing edge grooves are greater than those in the leading edge grooves. This creates a higher flow zone at the trailing edge of the sheet than at the leading edge.

The leading and trailing edge zones on the drum are the most critical areas for attachment and retention of a sheet. For attachment of the leading and trailing edges of a sheet, high flow is required which is provided by a large port flow area (ie, number of holes and/or size). For retention of the leading and trailing edges, a certain vacuum force is required which is provided by wide grooves. Zones intermediate the leading and trailing edge zones have lower flow and vacuum force requirements for attachment and retention. These zones only need a low flow and a low vacuum force which are provided by smaller port flow areas and narrower grooves, respectively.

By the use of a high volume flow blower, the requirements for the different zones can be met in the no-load condition, where all the ported grooves are open, in the partial load condition, where some of the ported grooves are not covered by a sheet, and in the full load condition, where all of the ported grooves are covered by a sheet.

Although the particular combination of grooves and ports may be chosen for particular application, so that the number of grooves and the sizes of the ports can be different, the following tables 1 and 2 give an example of groove size and number of port size and number.

TABLE I

	WIDTH (mm)	DISPLACEMENT CIRCUMFERENCE SLOT CENTRELINE (°)	LONGITUDINAL (mm) SEG 1	SEG 2	SEG 3	SEG 4	SEG 5	SEG 6	SEG 7	LENGTH (mm) SEG 1	SEG 2	SEG 3	SEG 4	SEG 5	SEG 6	SEG 7
Row 86	2.25	3.5	2.3	38.8	108.8	178.8	248.8	279.0	295.3	27.9	61.4	61.4	61.4	28.7	14.8	58.2
Row 88	1.50	39.3	2.3	38.8	108.8	178.8	248.8	279.0	295.3	27.9	61.4	61.4	61.4	28.7	14.8	58.2
Row 90	1.50	75.2	2.3	38.8	108.8	178.8	248.8	279.0	295.3	27.9	61.4	61.4	61.4	28.7	14.8	58.2
Row 92	1.50	111.0	2.3	38.8	108.8	178.8	248.8	279.0	295.3	27.9	61.4	61.4	61.4	28.7	14.8	58.2
Row 94	1.50	146.9	2.3	38.8	108.8	178.8	248.8	279.0	295.3	27.9	61.4	61.4	61.4	28.7	14.8	58.2
Row 96	1.50	183.5	2.3	38.8	108.8	178.8	248.8	279.0	295.3	27.9	61.4	61.4	61.4	28.7	14.8	58.2
Row 98	1.50	219.3	2.3	38.8	108.8	178.8	248.8	279.0	295.3	27.9	61.4	61.4	61.4	28.7	14.8	58.2
Row 100	1.50	255.2	2.3	38.8	108.8	178.8	248.8	279.0	295.3	27.9	61.4	61.4	61.4	28.7	14.8	58.2
Row 102	1.50	291.0	2.3	38.8	108.8	178.8	248.8	279.0	295.3	27.9	61.4	61.4	61.4	28.7	14.8	58.2
Row 104	2.25	316.0	2.3	38.8	108.8	178.8	248.8	279.0	295.3	27.9	61.4	61.4	61.4	28.7	14.8	58.2
Row 106	2.25	326.9	2.3	38.8	108.8	178.8	248.8	279.0	295.3	27.9	61.4	61.4	61.4	28.7	14.8	58.2

TABLE 2

	DIAMETER (mm)	TOTAL POPULATION	POPULATION PER SEGMENT						
			SEG 1	SEG 2	SEG 3	SEG 4	SEG 5	SEG 6	SEG 7
Row 86	1.2	28	3	5	5	5	3	2	5
Row 88	1.0	7	1	1	1	1	1	1	1
Row 90	1.0	7	1	1	1	1	1	1	1
Row 92	1.0	7	1	1	1	1	1	1	1
Row 94	1.0	7	1	1	1	1	1	1	1
Row 96	1.0	7	1	1	1	1	1	1	1
Row 98	1.0	7	1	1	1	1	1	1	1
Row 100	1.0	7	1	1	1	1	1	1	1
Row 102	1.0	7	1	1	1	1	1	1	1
Row 104	1.2	28	3	5	5	5	3	2	5
Row 106	1.2	28	3	5	5	5	3	2	5

The columns in table 1 identify the particular row of grooves, the circumferential width of the grooves in that row, the angular displacement in degrees of the groove centreline from the scribe line 74, the longitudinal displacement of one end and the length of each groove in the row. The grooves in each row are identified by a SEG number SEG1 being the groove nearest the scribe line 76.

The columns in table 2 identify the particular row of grooves, the diameter of the communicating ports for that row, the total population of communicating ports for that row, and the number of communicating ports for the individual grooves in that row.

The graph (Fig.6) showing the relationship between the characteristics of a traditional vacuum pump, such as used in prior art vacuum systems, and a blower suitable for use in the present invention, is helpful in understanding the fluctuation in vacuum experienced on the surface of the rotary drum. It is also helpful in understanding the problem previously described relative to the prior art. Vacuum pressure in pound per square inches (PSI) is plotted along the ordinate of the graph and flow in cubic foot per minute (CFM) is plotted along the abscissa of the graph. Curve 120 represents the characteristic operating curve for a 0.9 horsepower (HP) blower. Similarly, curve 122 represents the operating characteristic curve for a 1.0 horsepower (HP) vacuum pump. The pump has a relatively low flow with a relatively high vacuum and its characteristic operating curve is almost parallel to the ordinate of the graph. The blower has a relatively high flow with relatively low vacuum, and its characteristic curve is much less steep and closer to the abscissa of the graph. Different flows were applied to a drum both with and without a sheet attached, and the vacuum measured and plotted on the graph. Curve 124 represents the result with no paper attached to the drum. Curve 126 represents the result with paper attached to the drum. The operating points of the system occur at the intersections where the vacuum pump characteristics curve 122 and the blower characteristics curve 120 intersect the no-load and load drum curves 124 and 126. As can be seen the no-load drum curve 124 intersects the blower curve 120 at point 3 whose height along the ordinate of the graph indicates the effective vacuum present in the grooves. The load drum curve 126 intersets the blower curve 120 at point 4, whose height along the ordinate of the graph shows the effective pressure in the grooves. As can be seen, there is little change in effective pressure between no-load and load conditions, the vacuum remaining substantially constant. This shows that for optimum operation a vacuum system including a blower having a relatively high flow with relatively low vacuum is very desirable.

The no-load drum curve 124 intersects the pump curve 122 at point 1, and the load drum curve 126 intersects the pump curve 122 at point 2.

It will be seen that there is a wide swing in the vacuum in the drum between no-load and load conditions. This is undesirable and the traditional vacuum pump is not suitable for use in the evacuating system of a paper transport system unless the drum is segmented and a vacuum relief mechanism is used.

The advantages associated with the document transported of the present invention, may be summarized as follows :

The system is simple and low cost, which provides high reliability and fast response.

The system requires no valving or internal segmentation for controlling the vacuum in the drum. The population and/or size of the holes control the flow and provide the source of vacuum to the slots when covered.

Another advantage of the present invention is that it enables different size sheets of flexible material to be handled by a nonsegmented vacuum drum.

CLAIMS

1 Sheet transport apparatus comprising a rotatable hollow drum (12) and vacuum means (28) for applying vacuum through holes (120) in the cylindrical shell (14) of the drum to attract and hold a sheet (44) onto the surface of the drum, characterised in that the holes constitute unvalved ports communicating directly with the interior of the drum, and that the vacuum means is constituted by a low vacuum, high flow blower connected to the interior of the drum.

2 Apparatus according to claim 1, in which the ports are configured so that zones on the surface of the drum have different rates of airflow therefrom.

3 Apparatus according to claim 2, in which there are first, second and third zones on the surface, the first and third zones for attaching leading and trailing edges of a sheet having a relatively higher rate of airflow than the second zone therebetween.

4 Apparatus according to claim 3, in which the third zone has a relatively higher rate of airflow than the first zone.

5 Apparatus according to any preceding claim, in which the unvalved ports include longitudinal grooves (86,88,90,92,94,96,98,100,102,104,106) in the surface of the drum and communicating with the interior thereof by holes (120).

6 Apparatus according to claim 5, as appendant to claim 2, 3 or 4, in which the population of holes to grooves varies according to the adjacent zone.

7 Apparatus according to claim 5 or 6, in which longitudinally aligned grooves are separated, whereby to enable different sized sheets to be transported.

8 Apparatus according to claim 7, in which in one row of longitudinally aligned grooves (86), each groove has a plurality of holes (120) to provide a relatively high rate of air flow for attaching a leading edge of a sheet.

9 Apparatus according to claim 7 or 8, in which in two adjacent rows of longitudinally aligned grooves (104,106), each groove has a plurality of holes (120) to provide a relatively high rate of airflow for attaching a trailing edge of a sheet.

10 Apparatus according to claim 7, 8 or 9, in which circumferential grooves (48) are formed in the surface of the drum between the longitudinal grooves.

11 Apparatus according to claim 10, including fingers (46) movable into the grooves (48) to strip a sheet from the drum.

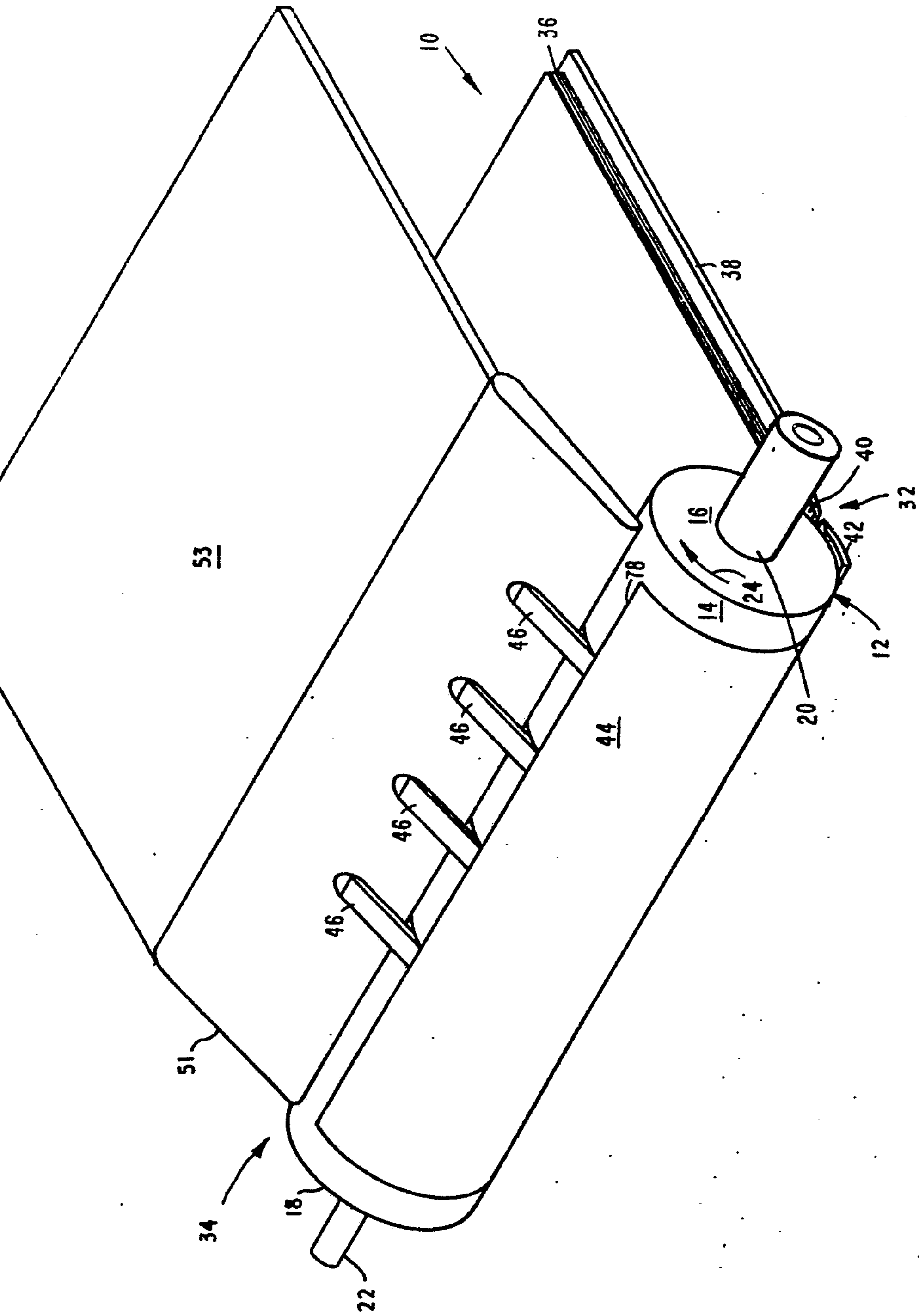


FIG. I

FIG. 2

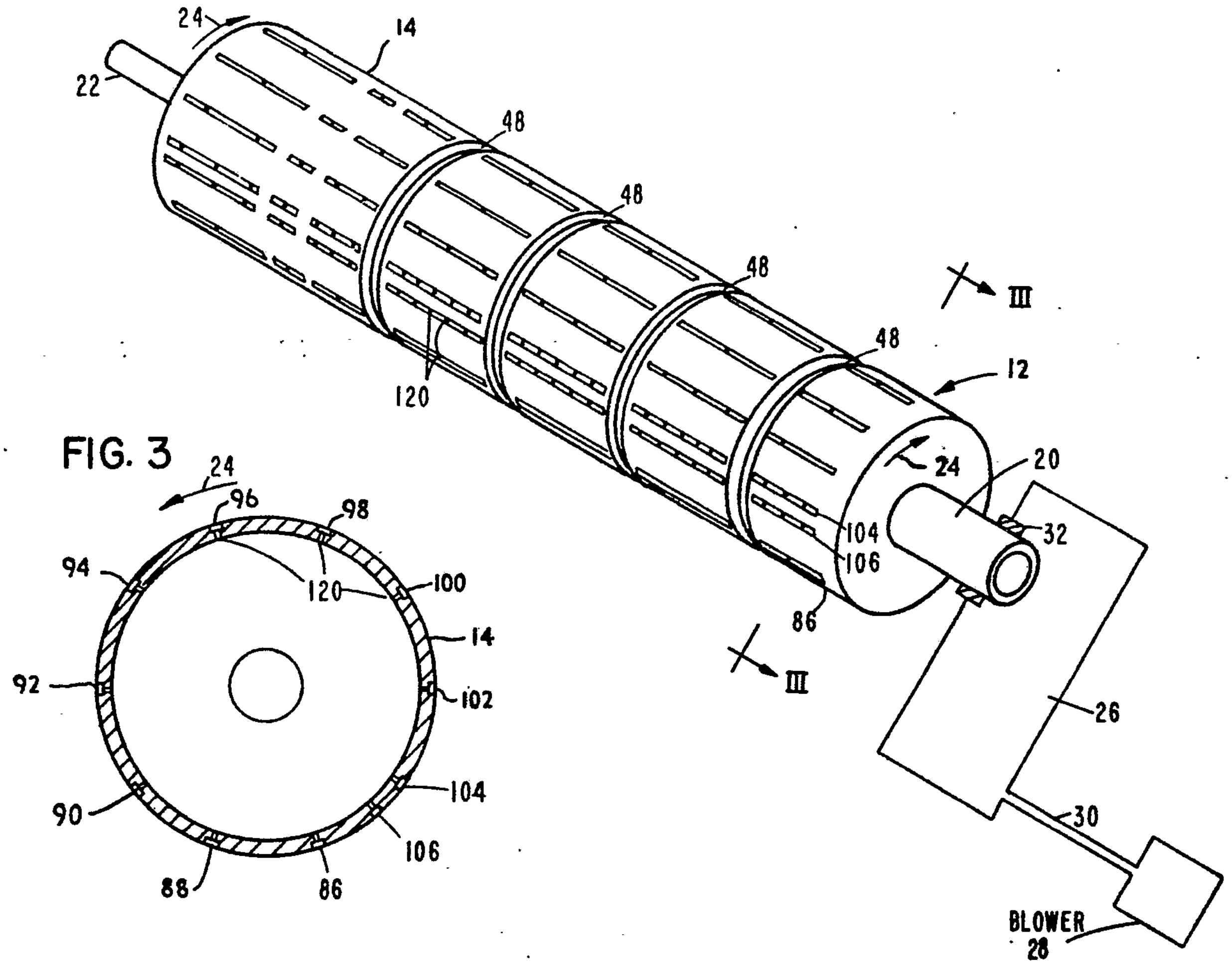
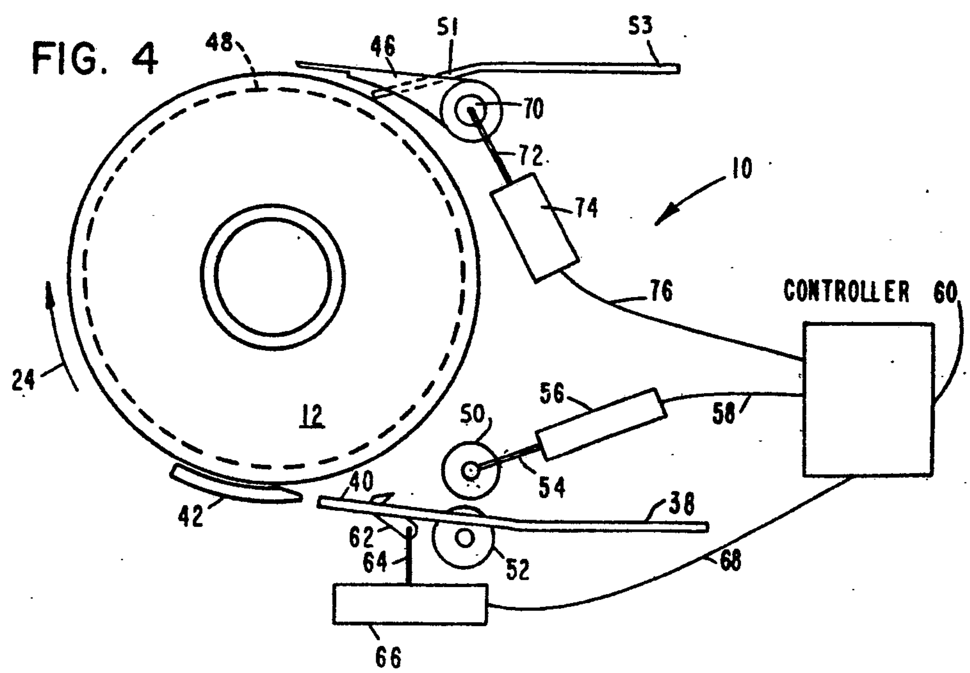


FIG. 3

FIG. 4



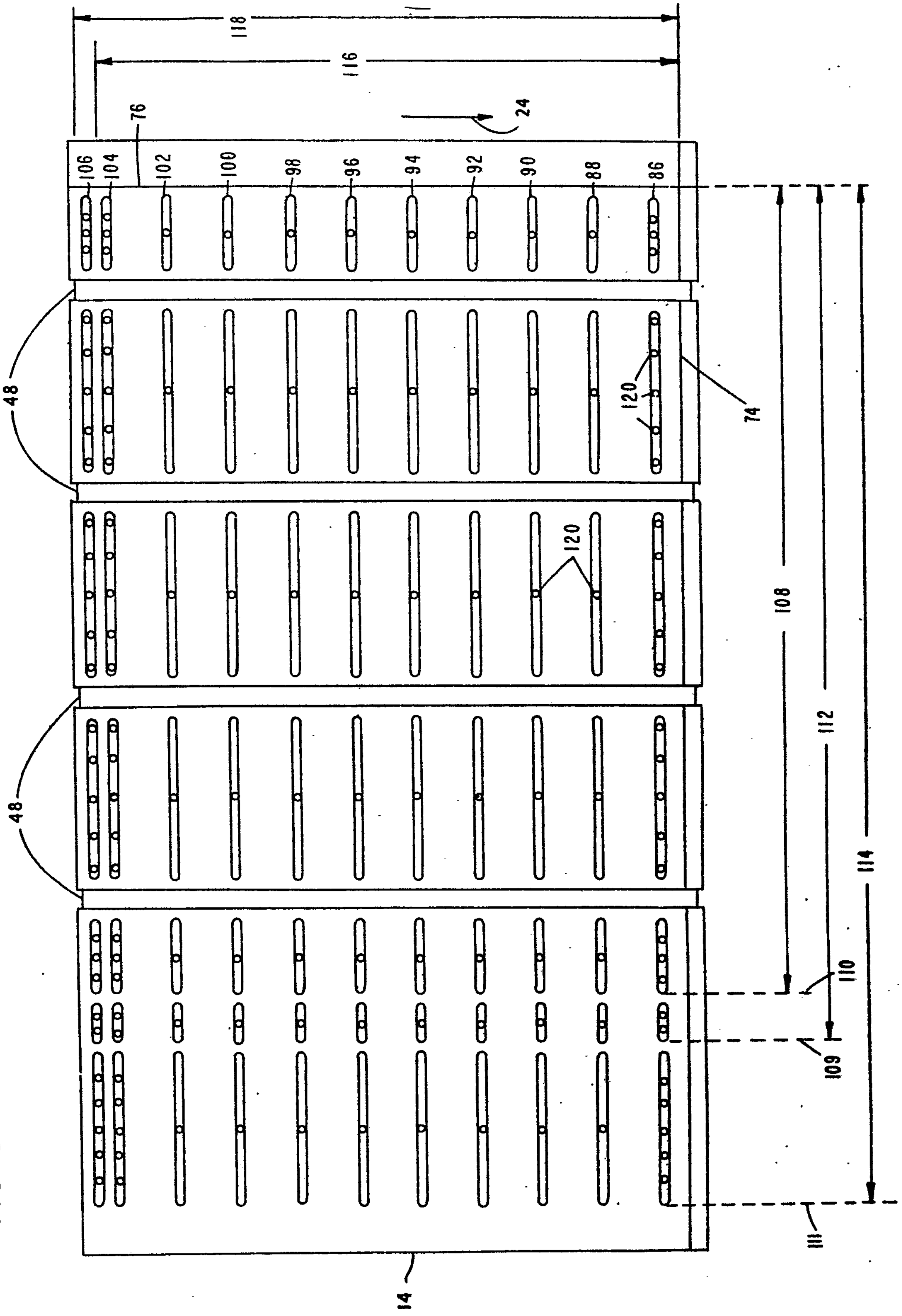

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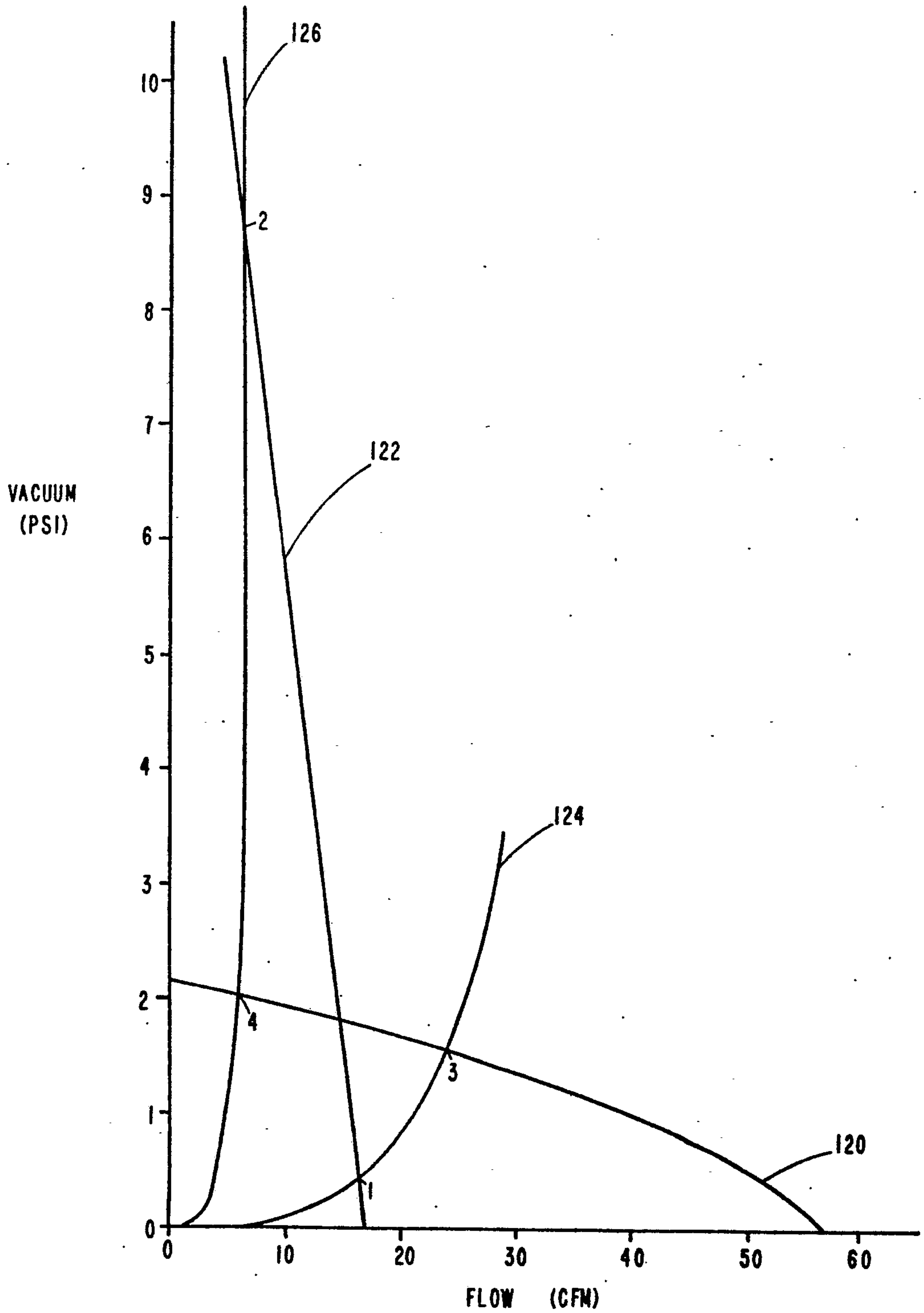
FIG. 5

FIG. 6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European Patent Office

EUROPEAN SEARCH REPORT

0048826

Application number
EP 81 10 6708

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim
X	GB - A - 2 006 168 (CROSFIELD) * Page 3, lines 17-78; figures 1,3 *	1,2, 10,11
	IBM TECHNICAL DISCLOSURE BULLETIN, vol. 19, no. 5, October 1976 GLOWA et al. "Vacuum transport drum", pages 1645-1646 * Whole document *	1,2,3, 5,7,8, 9,10
A	FR - A - 2 393 749 (FRANCOIS) * Page 4, lines 13-22 *	1
AD	US - A - 3 545 746 (LEDGER) * Whole document *	1,10, 11

CLASSIFICATION OF THE APPLICATION (Int. Cl.3)

B 65 H 5/22
17/30
29/24

TECHNICAL FIELDS SEARCHED (Int. Cl.3)

B 65 H
G 06 K

CATEGORY OF CITED DOCUMENTS

X: particularly relevant
A: technological background
O: non-written disclosure
P: intermediate document
T: theory or principle underlying the invention
E: conflicting application
D: document cited in the application
L: citation for other reasons

&: member of the same patent family, corresponding document

X The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	08-12-1981	LUTZ