United States Patent [19]

Wojtowicz et al.

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[45] **Dec. 23, 1975**

[54] **DEVICE FOR SINGULATING DOCUMENTS**

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[73] Assignee: **Burroughs Corporation**, Detroit, Mich.

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[52] **U.S. Cl.** **271/10**; 271/11; 271/18; 271/37; 271/94; 271/104; 271/111; 271/121; 271/150; 271/259

[51] **Int. Cl.²**... **B65H 1/02**; B65H 3/06; B65H 3/10; B65H 7/14

[58] **Field of Search** ..... 271/10, 11, 12, 18 R, 30 A, 271/34, 35, 37, 94, 96, 104, 110, 111, 112, 121, 123, 126, 149, 150, 265, 258, 259; 214/8.5 K, 8.5 SS, 8.5 H

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Primary Examiner—Evon C. Blunk
Assistant Examiner—Robert Saifer
Attorney, Agent, or Firm—Francis A. Varallo; Edward J. Feeney, Jr.; Kevin R. Peterson

[57] **ABSTRACT**

A document feeding device is described for generating a singulated flow of documents, such as mail pieces from a stack of documents. The documents may then be sorted to destination storage areas based upon the address information which each document bears. The present device is especially useful in processing mail flats. The double feeding of documents is substantially prevented by the device which effects the continued separation of the documents in a plurality of stages while they are all in a dynamic state. More specifically the device utilizes a buffer technique wherein simultaneous separation can take place in two series stages on different documents during the singulation process.

18 Claims, 28 Drawing Figures

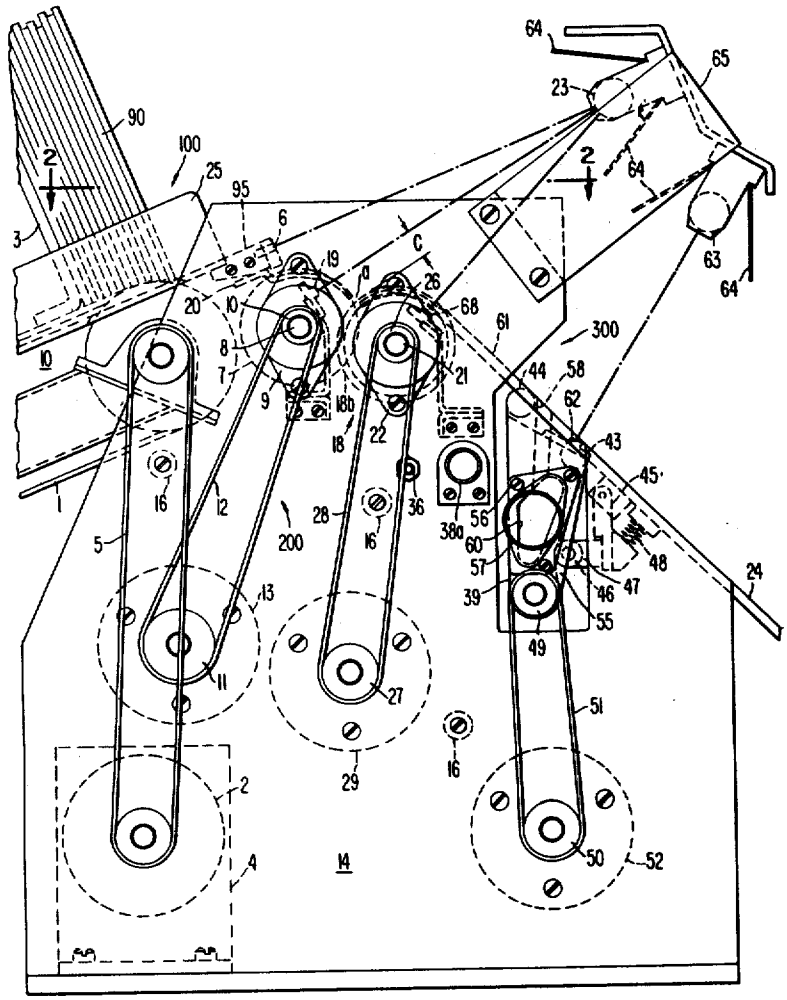


Fig. 1

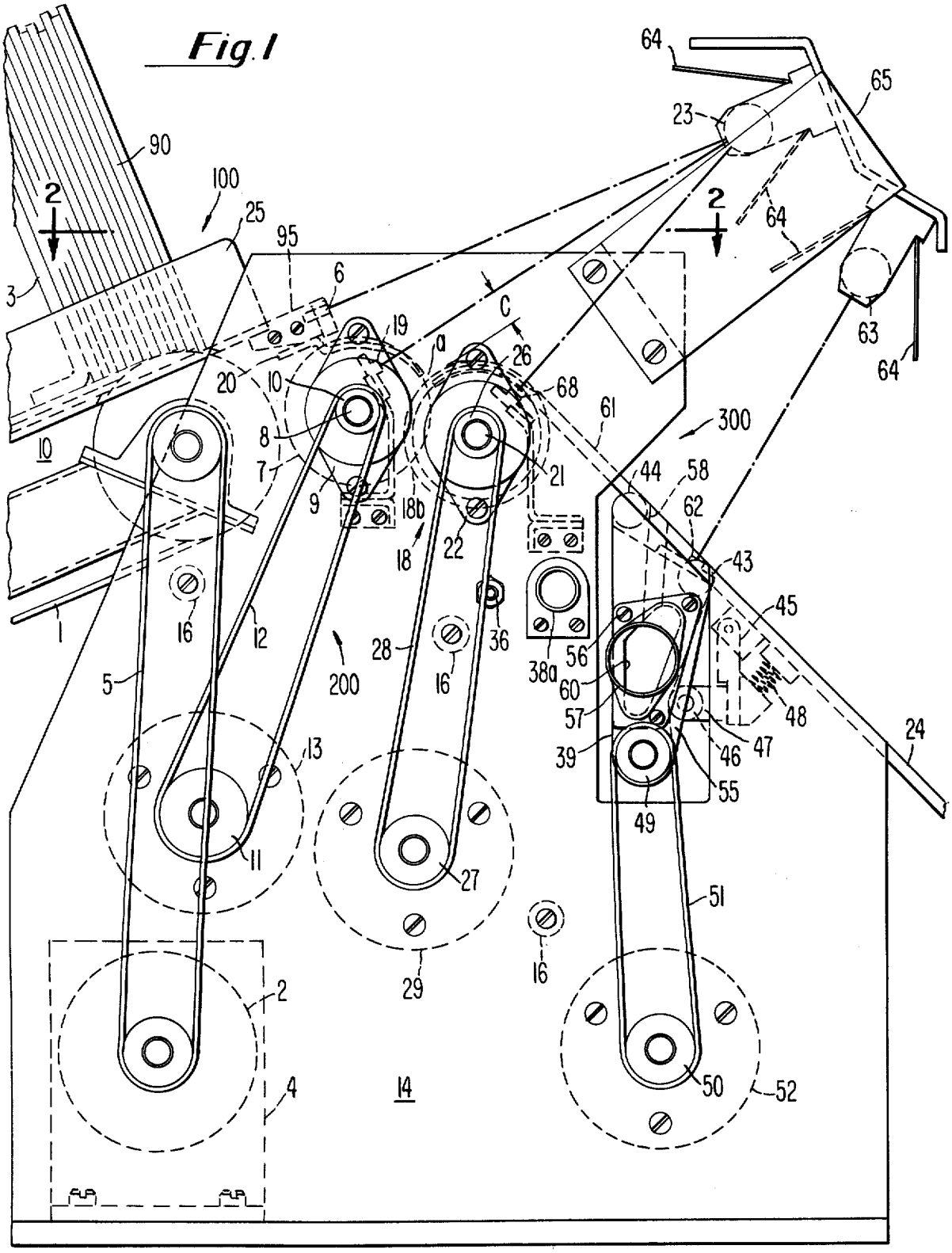

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100
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18b
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38a
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Fig. 2

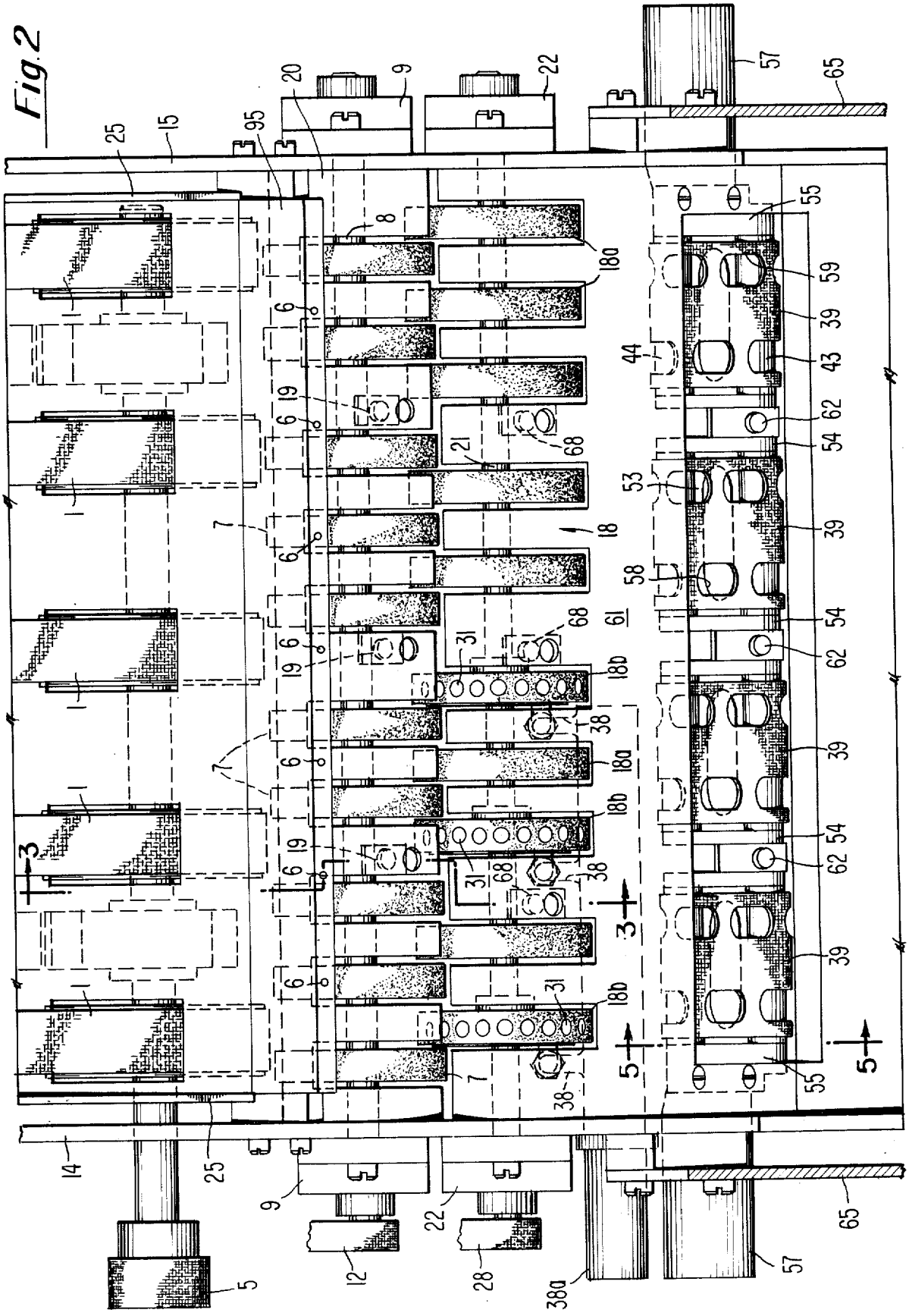

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Fig.3

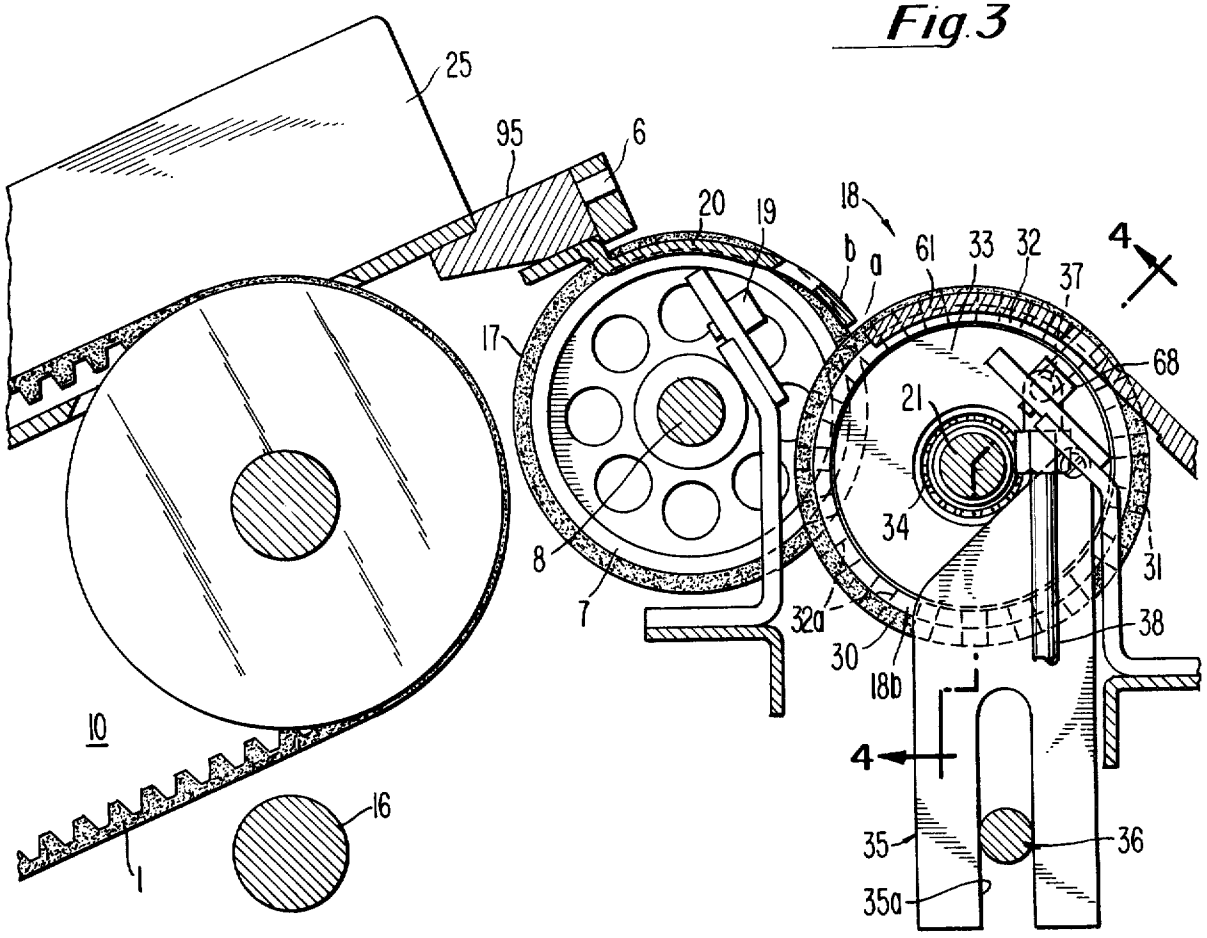
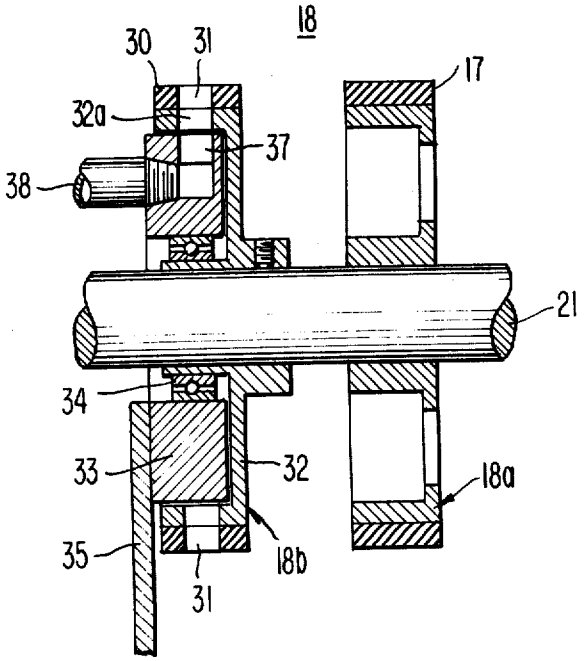

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18b
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1
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35a

Fig.4


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32a
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18a
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18b
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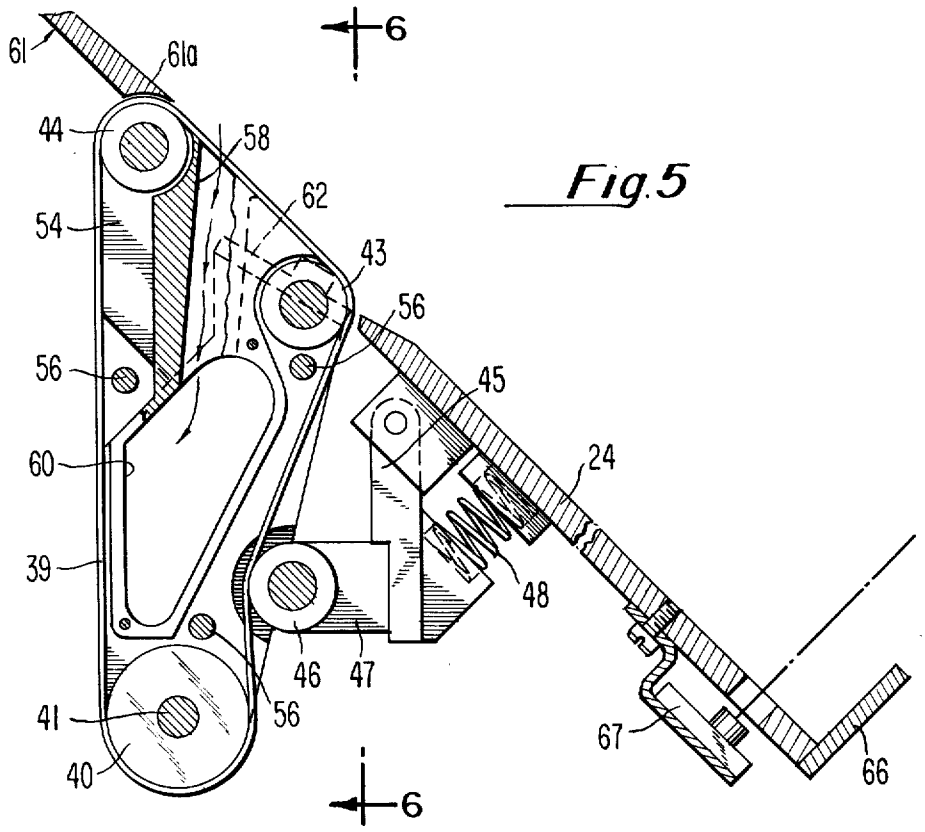

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Fig.5

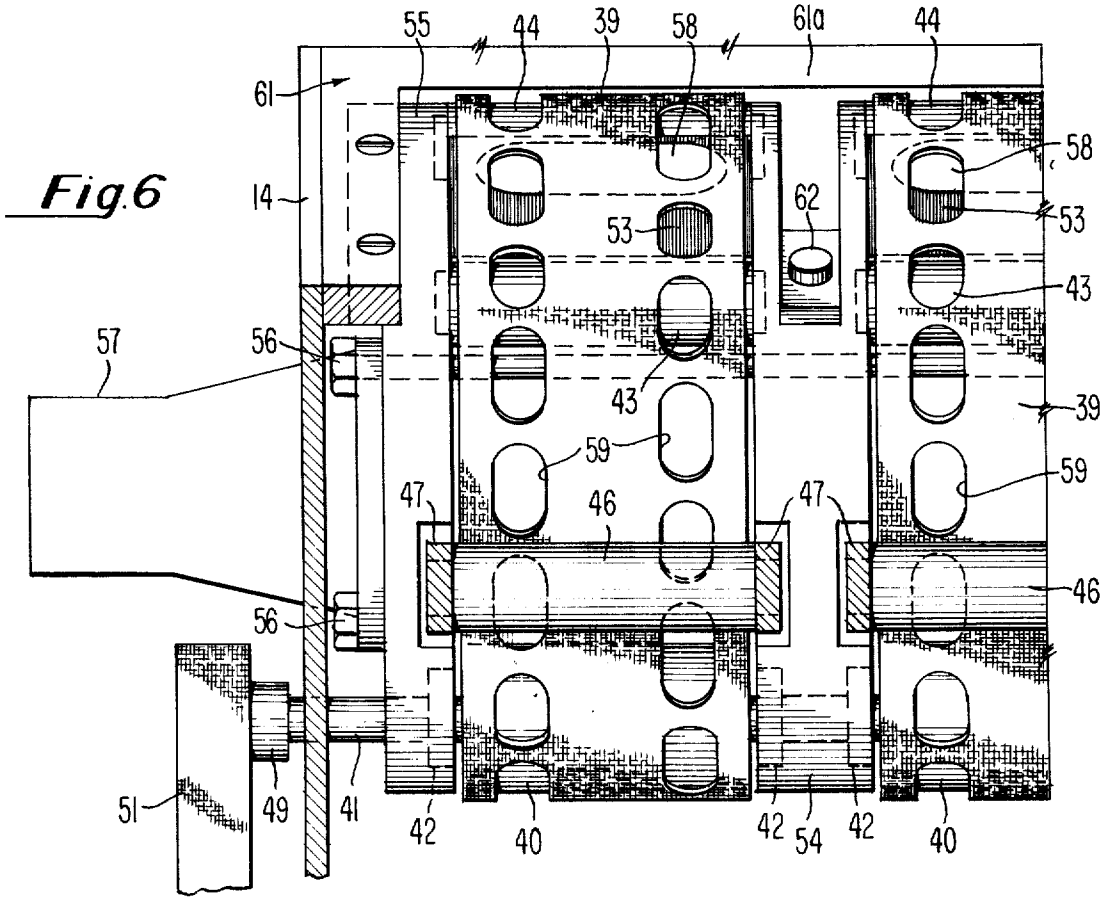

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Fig.6

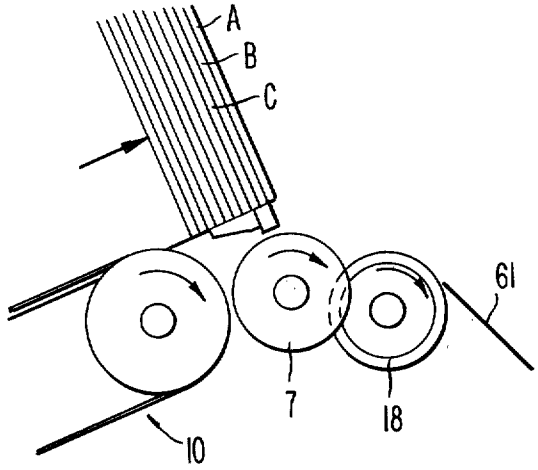


Fig. 7A

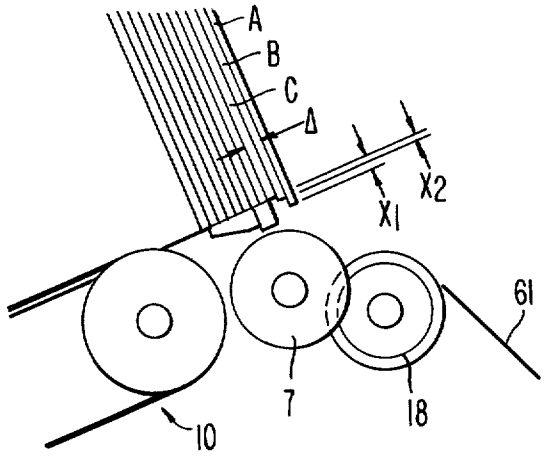


Fig. 7B

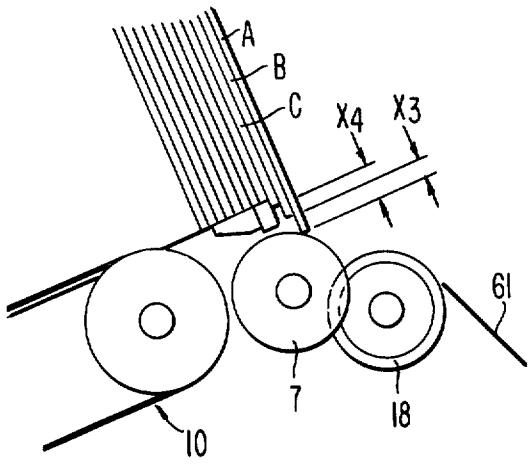


Fig. 7C

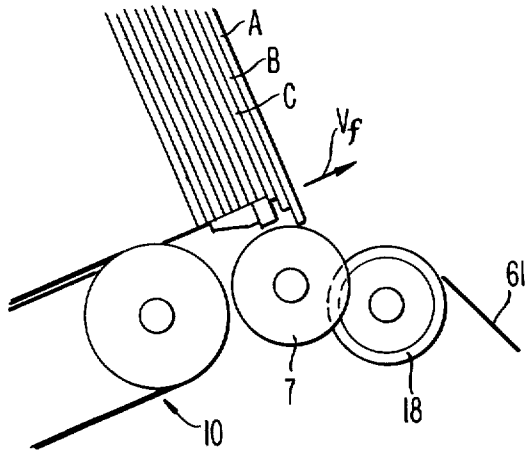


Fig. 8A

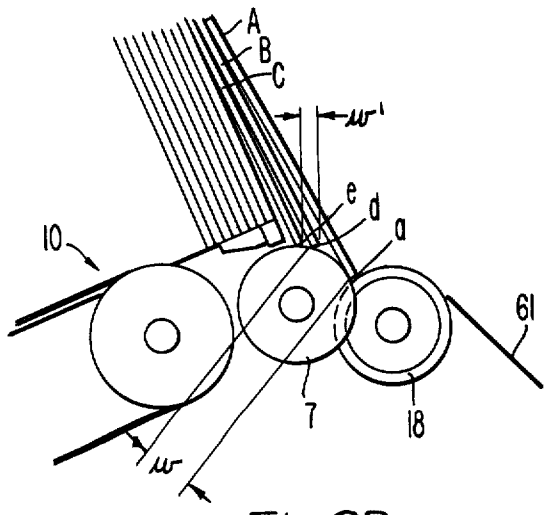


Fig. 8B

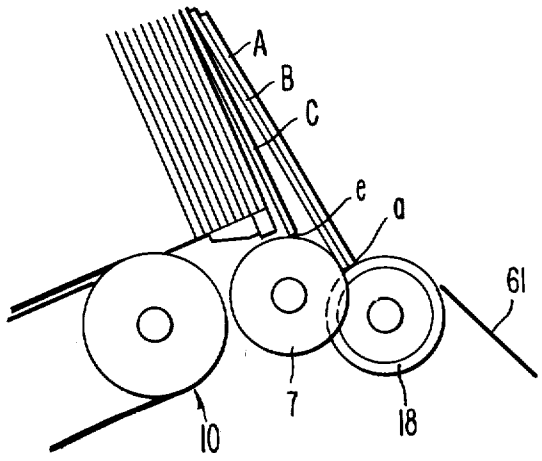


Fig. 8C

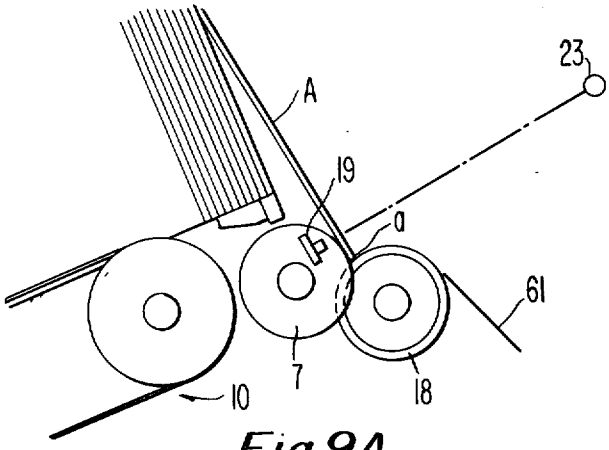


Fig.9A

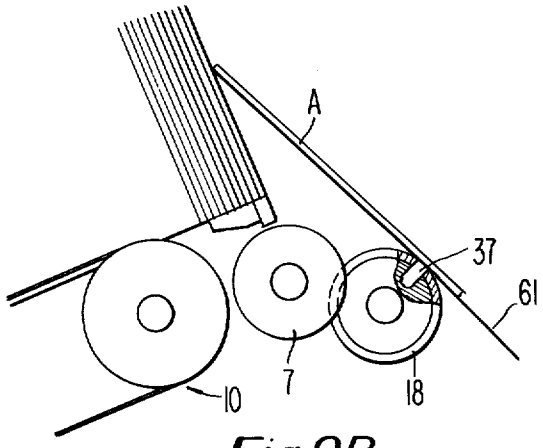


Fig.9B

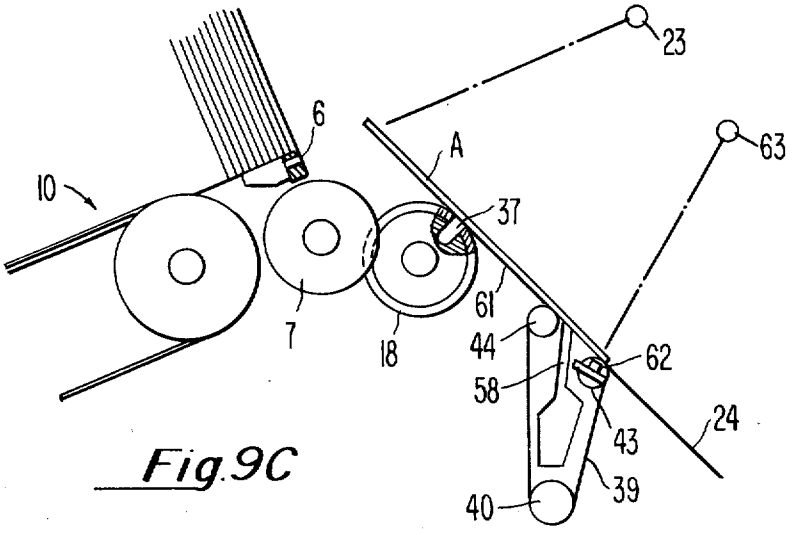


Fig.9C

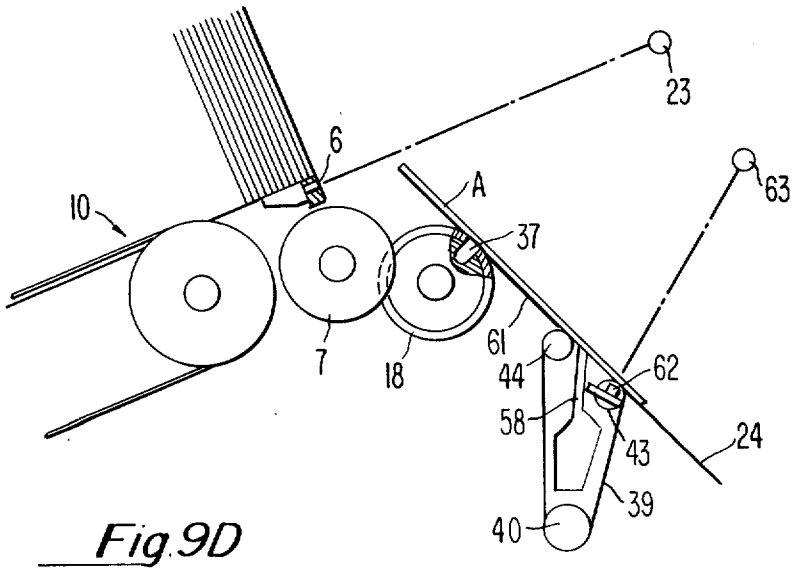


Fig.9D

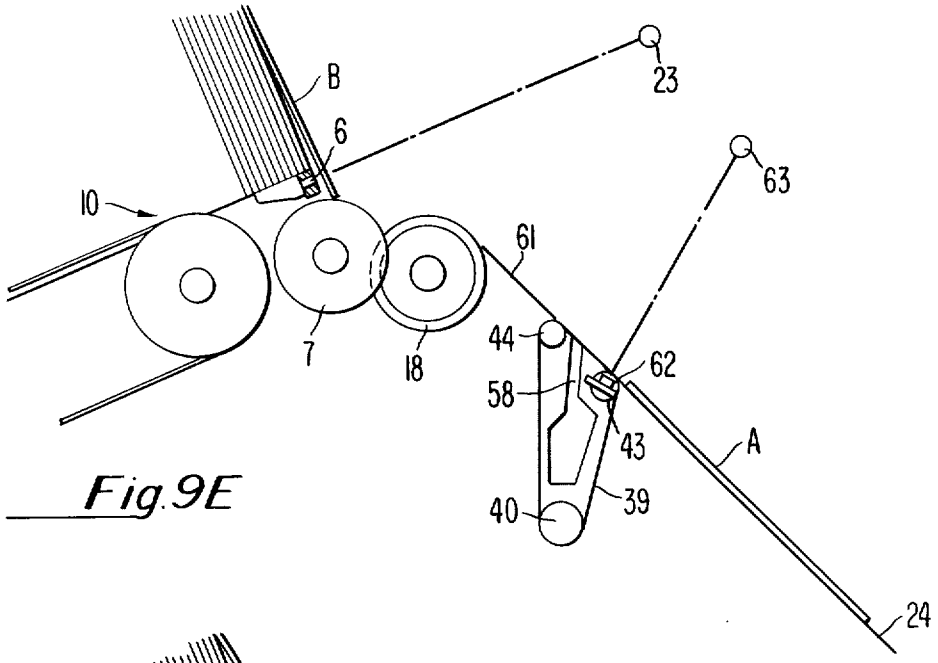


Fig. 9E

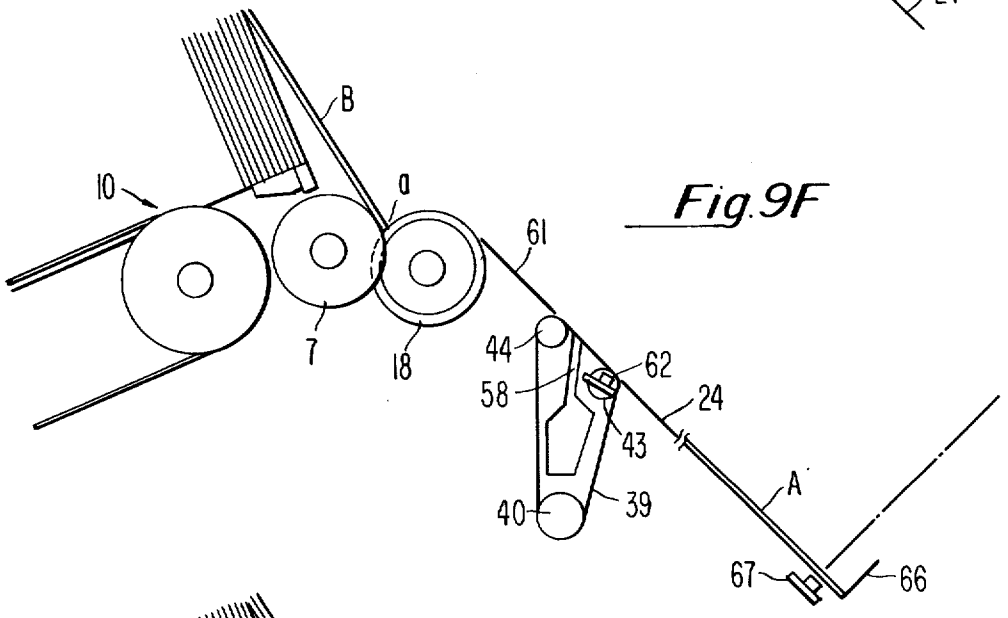


Fig. 9F

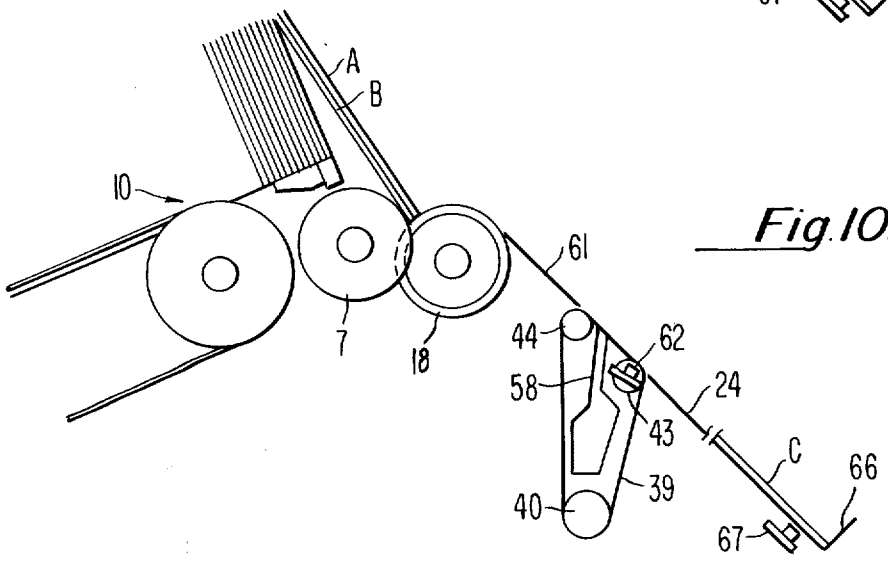


Fig. 10A

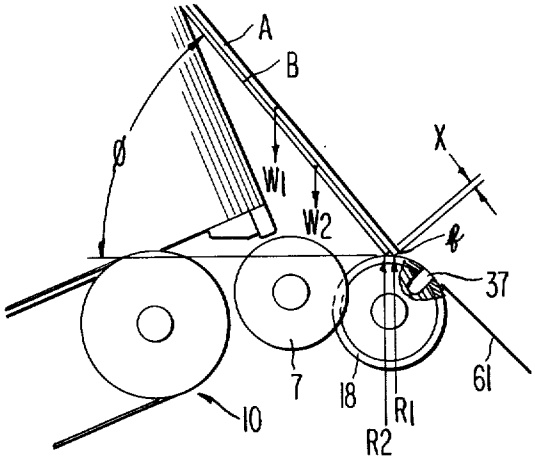


Fig.10B

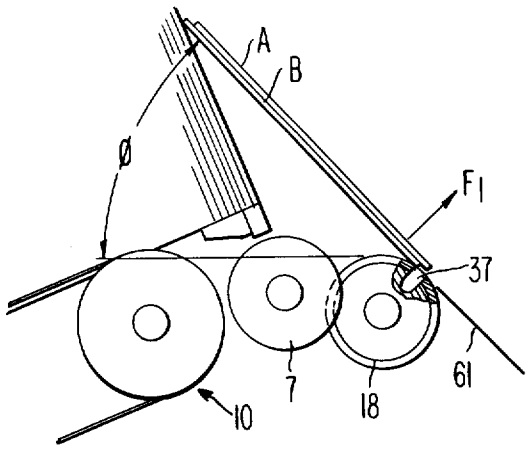


Fig.10C

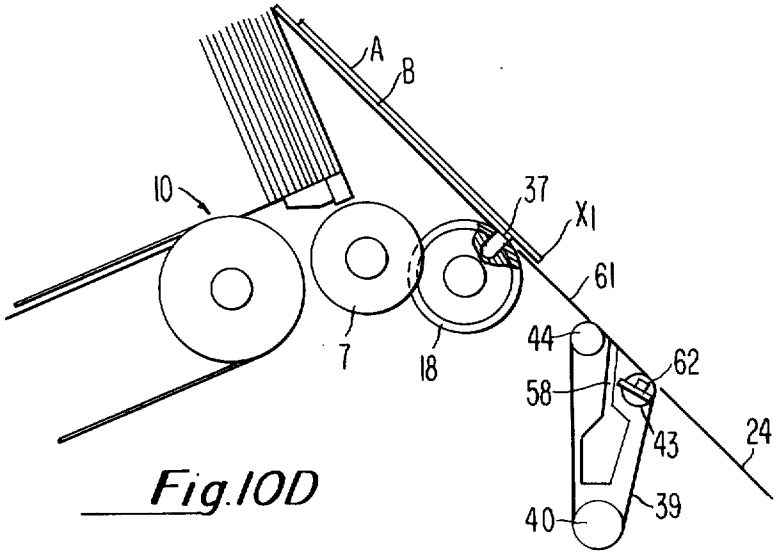


Fig.10D

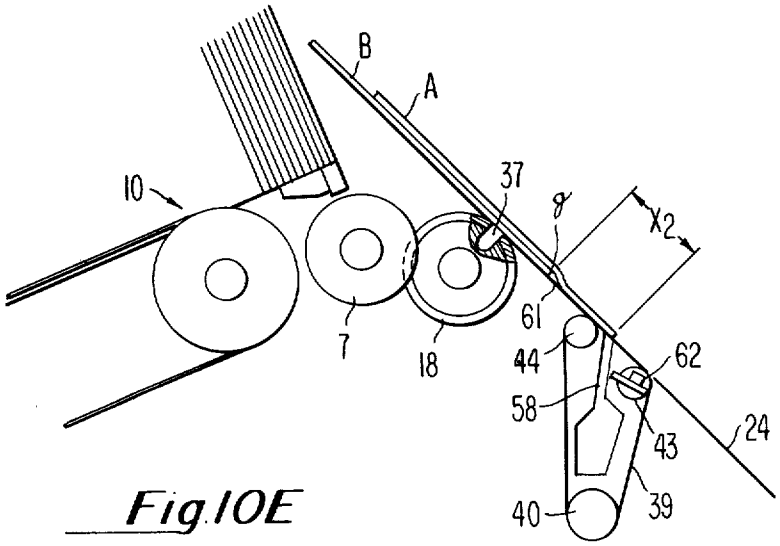


Fig.10E

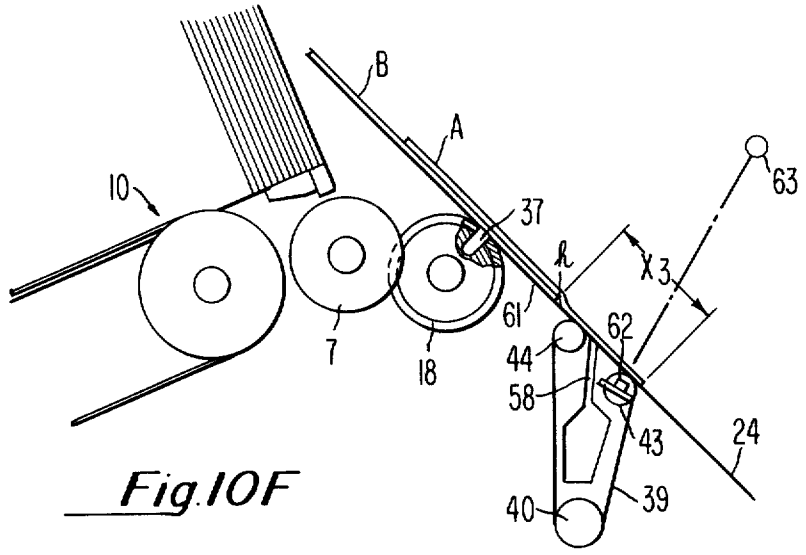


Fig.10F

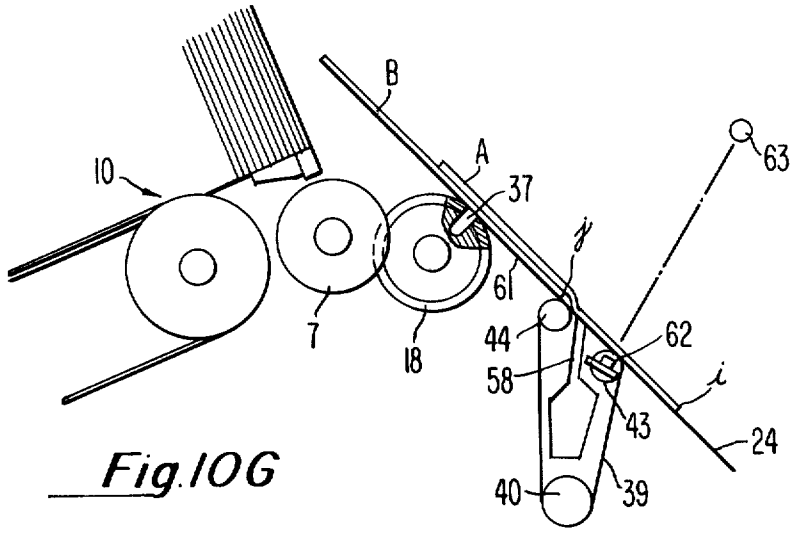


Fig.10G

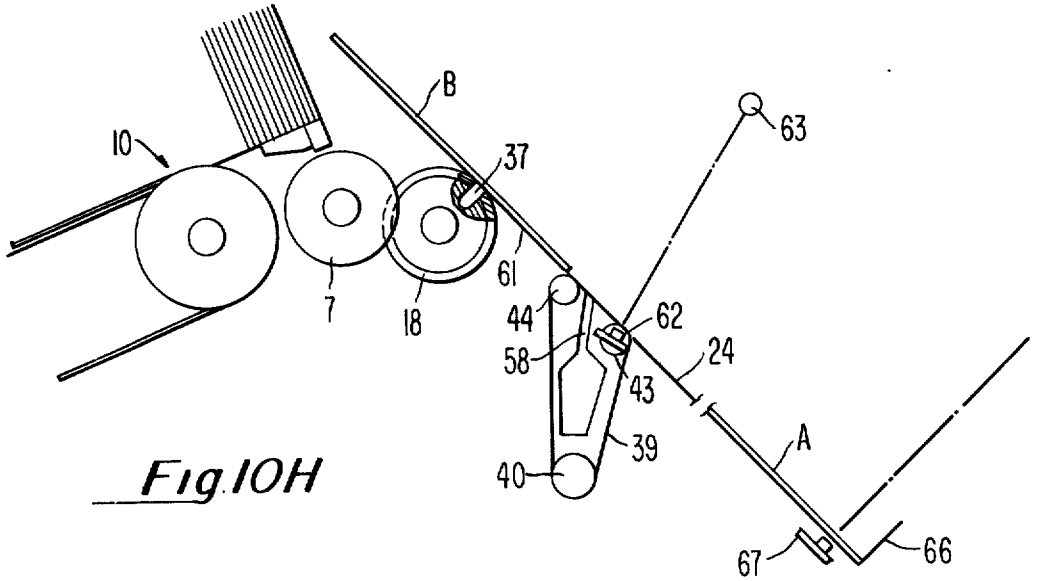


Fig.10H

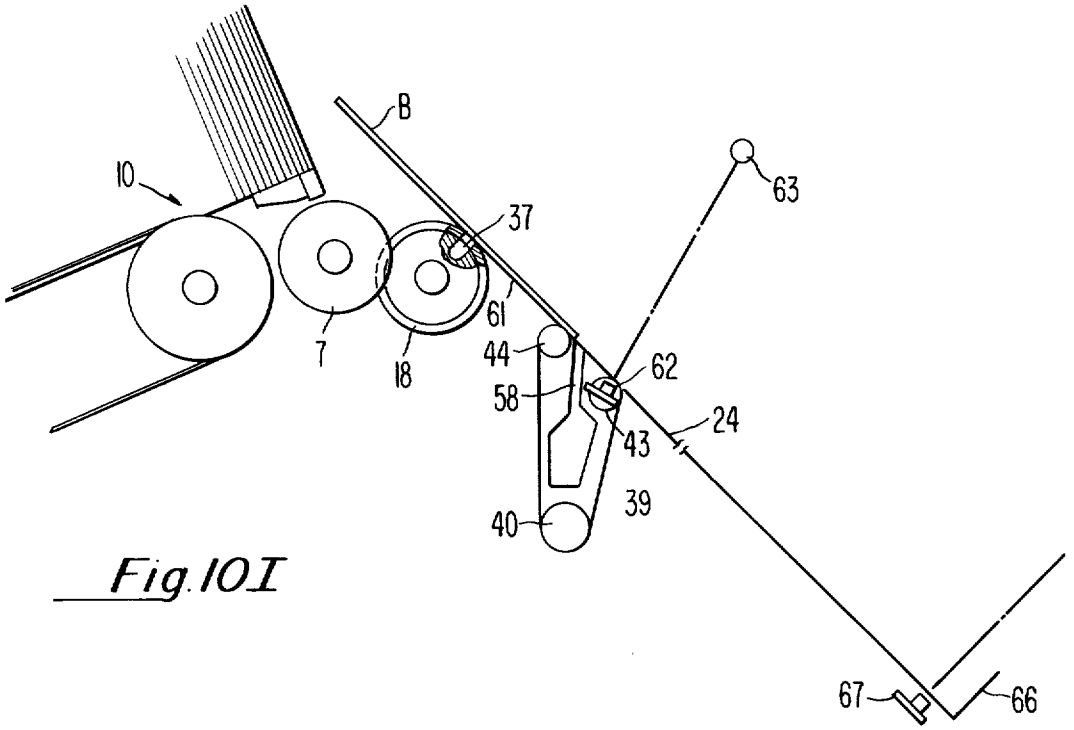


Fig. 10I

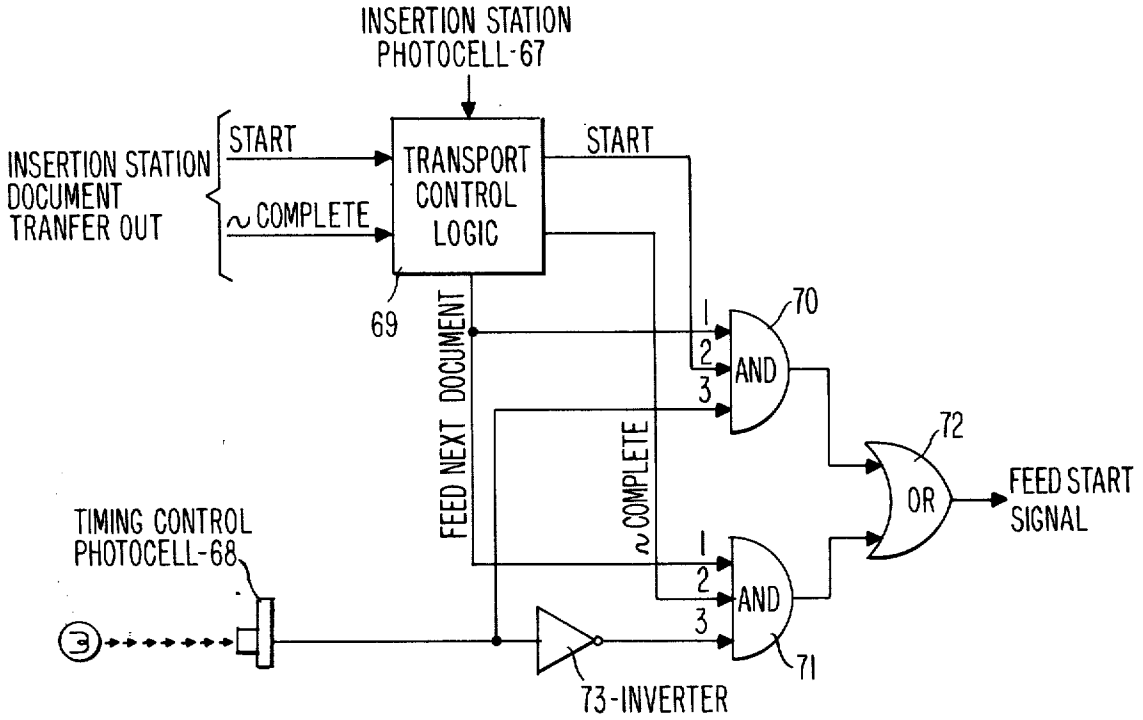


Fig. 11

DEVICE FOR SINGULATING DOCUMENTS

BACKGROUND OF THE INVENTION

The feeding or singulating of documents, such as mail pieces, one at a time from a stack is an essential step in the processing of such documents to their ultimate destinations. Special problems are involved in the handling of mail flats which are regarded as falling within the following size ranges, height 3 inches to 15 inches; length 4¼ inches to 15 inches; thickness 0.006 inches to ½ inch; weight up to one pound; and aspect ratio (height to length) of 1 to 1 up to 1 to 4. Such flats may include magazines, folded newspapers, stiff documents such as vehicle license plates, as well as large envelopes. Many document feeders are in use today which use vacuum forces for accomplishing singulation. The vacuum pickup heads in these feeders are virtually useless, however, in handling documents such as magazines and folded newspapers because the vacuum forces affect only one, or a few, of the multiplicity of sheets in these documents, causing them to pull away from the others.

Apart from the special difficulties in singulating flats, present day feeders generally operate on the principle that mechanization is provided only to separate the first document from a stack of documents, with no provision being made for further separation. Thus, if a double feed occurs, the documents enter the system and eventually must be removed therefrom before further processing can be performed.

In contrast to the foregoing feeder operation, the present device provides a mechanization that addresses itself to continued separation in a series of stages. Moreover, these stages separate documents while they are all in a dynamic state. The mechanism of separation involved in the device permits a series of stages to be arranged such that a document, or documents can be brought to rest or stored after partial dynamic separation, in order to await final separation and insertion into the system. A buffer concept is utilized in which simultaneous separation can take place in two series stages on different documents, during the singulation process. Each successive series stage in the feeder operates upon and separates documents which comprise the residual of the preceeding stage.

SUMMARY OF THE INVENTION

In accordance with the present invention, the problem of singulating documents, including flat mail pieces without incurring multiple feeds is solved by using multiple stages in a dynamic operating mode. These stages comprise a drop ledge, friction roller means and vacuum roller means.

The documents to be singulated are placed on an inclined conveyor, in stack form with proper address orientation. Perfect document edge registration on the initial loading of stacks is not a system requisite. The conveyor advance the entire stack until the lead document in the stack falls off the drop ledge. The lower edge of the falling lead document is sensed by suitable means such as a ledge photocell assembly, which through the action of control circuits terminates the conveyor advance. Because a finite time is needed for complete conveyor stoppage, more than one document may drop from the ledge in a given cycle. In any event, the documents drop in serial fashion onto the second stage friction roller. The advance of the lower edge of the lead document to the point where it contacts the edge of the third stage vacuum roller (the park point) is sensed by photocell means which terminates the rotation of the friction roller. The documents remain that is, are stored, in this position until it is desired to feed a document to the insertion station. Removal of a document from the station generally initiates the next phase of the processing cycle which involve starting the rotation of the vacuum roller. Frictional forces in this last roller move the lead document in contact therewith along the periphery of the roller to a point where vacuum forces grip the face of the document. Continued rotation of the vacuum roller advances the document down an inclined ramp which incorporates a vacuum takeaway belt system. At a predetermined point on the ramp, after the leading edge of the document is under control of the takeaway belt, the rotation of the vacuum roller is terminated. The vacuum force of the takeaway belt overcomes the vacuum resisting force of the stationary vacuum roller and accelerates the document down the ramp to the insertion station.

As will be described in detail hereinafter, even with a multiple drop from the ledge, two documents at the park point are separated by the vacuum roller stage. Eventually, the ledge photocell assembly initiates conveyor movement and the succeeding document or documents in the stack are pushed from the ledge.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a side elevation of the feeder device of the present invention.

FIG. 2 is a plan view of the device as seen along the lines 2—2 of FIG. 1 and illustrating particularly the relationship of the various belts and rollers which are utilized in the device.

FIG. 3 is a section view taken along lines 3—3 of FIG. 2 and depicting in detail portions of the drop ledge, friction roller and vacuum roller stages.

FIG. 4 is a section view taken along lines 4—4 of FIG. 3, and illustrating in particular a vacuum disc and friction type disc employed in the vacuum roller stage of the feeder.

FIG. 5 is a section view taken along lines 5—5 of FIG. 2 and illustrating the takeaway vacuum belt system of the device.

FIG. 6 is a partial front view of the takeaway belt system taken along lines 6—6 of FIG. 5.

FIGS. 7A, 7B and 7C are schematic representations of the sequence of events which take place during ledge separation.

FIGS. 8A, 8B and 8C indicate in schematic form, the sequence of events involved in separation by the friction roller stage.

FIGS. 9A–9F inclusive indicate in schematic fashion the sequence of events which occur in the vacuum roller stage in the case where a single document input to the stage is involved.

FIGS. 10A – 10I inclusive are sequential schematic representations of events in the vacuum roller stage involving the separation of two documents appearing together as inputs to the stage.

FIG. 11 is a simplified logic diagram dealing with the correlation of output from the insertion station of the feeder device and the control of the vacuum roller stage to bring succeeding documents into the station.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 depicts the major elements which make up the feeder device of the present invention. The elements are distributed among three singulation stages which include respectively the drop ledge stage **100**, the friction roller stage **200** and the vacuum roller stage **300**. Associated with the drop ledge stage **100** are the conveyor **10** and its drive means **2, 4** and **5** and the ledge photocells **6**. The friction roller stage **200** utilizes roller drive means **10–13** inclusive, and park point photocells **19**. A motor drive **26-29** inclusive, and vacuum system with port **37** are included within the vacuum roller stage **300**. Also associated with this last stage are the feed cycle control photocells **68** and the output elements - the takeaway photocells **62**, takeaway belt **39** with its drive means **49–52** inclusive, the vacuum system with port **58** and the insertion station **66** with photocell **67**, as seen in FIG. **5**.

Each of these stages will be considered in turn, and the cooperate relationship of their elements examined.

Drop Ledge Stage

Conveyor System

With general reference to FIG. **1** and more specific reference to FIGS. **2** and **3**, the purpose of the conveyor is to support and advance a stack of documents **90** which will be used to create a singulated flow of documents to the insertion station (FIG. **5**) for further processing.

The conveyor **10** is positioned at an angle with respect to the horizontal plane. It is comprised of a plurality of timing belts **1** which are driven by belts **5** and stepping motor **2** through a reduction gear box **4**. The stepping motor can drive the set of belts in either direction. For purposes of illustration the figures depict a support plate **3** clamped directly to the belts **1** and moved in synchronism with them when the stack of documents **90** is advanced. Utilizing this arrangement, when a stack is completely fed out, the support plate can be returned to its original position in order to permit the loading of a new stack. It should be noted that a recirculating support system for individual stacks being advanced by the conveyor, may also be used in the present system.

The purpose of the stepping motor drive is to permit stopping of the conveyor and stack in a very small distance. This in turn minimizes the conveyor overtravel, Δ, and therefore minimizes multiple document drops at the ledge **95**. The gear box **4** permits the stepping motor **2** to operate at its maximum power speed while driving the conveyor **10** at its required velocity.

The conveyor angularity permits the stack to be self-supporting and this eliminates the need for any front stack support plates. The documents at the front of the stack are free of any stack compression forces, such as the interdocument friction forces that would result if a front plate were used, and the lead document is free to drop off the ledge **95** unhindered.

In connection with a description of the conveyor system, the method of operating stepping motor **2** is important. Basically, the best method is one which permits the conveyor **10** to move at the slowest velocity possible consistent with the desired throughput of the system. This velocity minimizes the conveyor overtravel, Δ, and maximizes the serial delay time between documents at the drop ledge. Both of these considerations tend to minimize the overall system doubles rate. In order to accomplish these effects, electrical ramping of the stepping motor may be used to obtain the desired characteristic of conveyor velocity. Ramping is a well known technique in stepping motor operation. Briefly, instead of achieving a predetermined velocity in the time of no more than two steps of the motor — normally referred to as error free unramped operation, the speed of the conveyor is permitted to rise linearally as represented by the slope of a curve and to achieve said predetermined velocity after a considerably longer period of time. Thus, the amount of conveyor overtravel, Δ, can be significantly reduced if the conveyor is stopped during the ramp portion of the cycle, compared to the final velocity portion of the characteristic velocity curve. Throughput of the system need not be compromised by the ramping scheme if the final velocity is increased above the aforementioned predetermined velocity. This higher velocity compensates for throughput loss in the feeding of thick documents. In general, ramping significantly reduces the doubling threshold in the present system. This threshold involves a dimension related to document thickness, beyond which doubles will not occur. Also the serial delay time of the documents dropping off the ledge **95** is lengthened, thereby increasing the effectiveness of the succeeding friction roller stage **200**. It should be noted that ramping is not required on termination of conveyor motion, since fast stopping is desirable, and is aided by gravity braking provided by the mail stack.

Drop Ledge and Ledge Photocell System

The drop ledge stage **100** is depicted in FIGS. **1–3** inclusive. The conveyor is terminated at a point which represents the closest practical distance that the moving conveyor **10** can be positioned to the ledge **95**. Ideally, the distance should be zero since frictional effects tend to compress documents during movement along the ledge. Frictional effects and erratic expansion of the stack may be responsible for the generation of doubles.

Documents **90** are placed in the conveyor **10** approximately against the registration wall **25**, with correct address orientation. These documents advance up the incline until they drop off the conveyor belts **1** and continue to be pushed through the ledge zone by the remaining documents in the stack on the belts. The drop off creates a smooth transition between the moving belts and the static support surface of the ledge **95**.

The purpose of the drop ledge stage **100** is to provide a separation between documents in a direction parallel to the face of the document. This is accomplished by moving the stack toward the ledge, so that the lead document in the stack falls and is separated from the stack by the force of gravity. The remainder of the ledge acts as a restraint to prevent additional documents from dropping with the lead document. This is true in the ideal case, but as will be discussed in detail hereinafter several documents may drop serially from the ledge for each conveyor cycle.

As the lead document is free of the ledge, that is begins vertical separation, conveyor motion is terminated to prevent additional documents from dropping. This is done by sensing the actual vertical motion of the lead document. A series of photocells **6**, positioned near the top of the ledge, perform this function. The lead document interrupts the photocell beam and

through appropriate electrical control circuits stops the conveyor. The distance of the cells from the top of the ledge represents the closest practical placement. The photocells **6** are separated from one another by a distance which insures that minimum length flats can in the worst case, cover at least two photocell beams in the course of dropping. The reason for the actuation of two photocells, rather than one, is to prevent a failure to feed condition which takes place under certain circumstances. For example, it is possible for a document to start to drop, but not to complete its drop to the surface of the friction rollers **7**. In the absence of the requirement for the actuation of two photocells, in a partial drop, one corner of the document may interrupt one photocell beam and stop the conveyor motion while the remainder of the document remains stable on the ledge. Magazines and folded newspapers behave in this way and in general, this can be attributed to folds and magazine leaves reacting like separate documents. The requirement that two adjacent photocell beams be covered by the document requires that the document drop further in order to satisfy the second photocell actuation. Dropping further, significantly improves the chances of successfully completing the drop to the surface of the friction roller.

With respect to the most effective ledge design, in general, the most effective angularity for documents **90** on the ledge **95** is one where the documents are perpendicular to the ledge. This provides the best support condition for the documents and prevents forward cascading. However, it should be noted that absolute perpendicularity is not always possible with variable height documents, because the lead document is supported by the trailing documents. If the trailing documents are small, and the leading document is taller, then a tilt will develop. The ledge itself should terminate in a ninety degree angle and should have no radius of curvature whatever. The effect of such a radius would be to tend to prolong drop time, which is undesirable. Drop time is defined as the time it takes for a document to move through the approximately vertical distance from the top of the ledge to the interruption of the light beams impinging on the ledge photocells **6**. The question of drop time is important because it relates directly to the amount of conveyor over-travel Δ, generated and therefore to the amount of doubles created. In effect, it is a measure of the singulation ability of the ledge. The dynamics of drop time generation may be considered by visualizing a document approaching the ledge drop point and being pushed by the stack which in turn is moved by conveyor motion. The document has a velocity component, V_c, in the vertical direction, at an angle which corresponds to that of the orientation of the conveyor with respect to the horizontal. As the document clears the ledge, it is still moving at velocity, V_c, and it experiences a component of gravity acceleration. The weight force of the document can be broken into two components representing the accelerating force and the force normal to the stack. The summation of the gravity force and the opposing friction force, the latter being caused by the normal force component and the friction coefficient between documents, causes a downward acceleration to occur. The document therefore is under the influence of two velocity components simultaneously, namely, the conveyor velocity, V_c, and the constantly increasing velocity of the acceleration component. The locus of the curve approximates a parabola up to the point of photocell interruption.

Operation of the Drop Ledge Singulation Stage

Before proceeding with a discussion of the singulation which occurs in the drop ledge stage **100**, it should be noted that the feeder of the present invention has two basic operating modes, namely a single document feed mode, and a multiple document feed mode. Mode selection is automatic and is based entirely on document thickness. In the system described herein, the single document feed mode will result if the document thickness of mail in the conveyor stack, following the document being fed, is greater than approximately 0.020 inches. The multiple document feed mode will result if the document thickness is less than approximately 0.020 inches. Although the former mode will occur a much greater percentage of the time, since a greater number of documents are more than 0.020 inches thick, the following discussion of the operation of the feeding device will consider the singulation of multiple document feeds, since the elements of the feeder are especially adapated to overcome this more complex problem.

As noted hereinbefore the present feeder has three singulation stages. In general, the drop ledge stage **100** in the multiple document mode can be deposit as many as three minimum thickness documents onto the surface of the friction roller. The friction roller stage **200** has the ability of retaining the last one of these documents and in turn to deposit the leading two documents onto the vacuum roller. The vacuum roller stage **300** in turn has the ability of retaining the trailing document, and inserting the leading document. Therefore, with this action, single document flow is the output of the device, even through initial singulation from the stack was three documents.

With continued reference to FIGS. **1–3** inclusive, ledge singulation is effected as follows. As noted hereinbefore when the first document in the stack is pushed off the ledge **95** and drops to the surface of the friction roller **7**, the lower edge of this document interrupts light beams to photocells **6** in the ledge. The approximate theoretical time of drop to the point of interruption is forty milliseconds. Interruption of the photocell beams stops conveyor motion. The ideal stop point for the conveyor occurs when the backside of the initial document is coincident with the edge of the ledge. This condition would truly supply only one document on command and no further stages would be required. The ideal requirement is approached by sensing the first indication of vertical motion. Due to the fact that a certain period of time is required to sense vertical motion, the conveyor continues to advance past the ideal stop point and therefore has an opportunity to deposit more than one document onto the surface of the friction roller. If the symbol Δ is assigned to conveyor over-travel or motion in excess of the first document thickness, then the excess can be expressed by a relation, namely, the product of V_c and T_s. V_c is the conveyor velocity in inches per second and T_s is equal to the drop time in seconds to the point of photocell beam interruption. This relationship is a measure of the error generated in the ledge singulation stage. Obviously the quantity Δ should be minimized consistent with the required throughput rate.

FIGS. **7A, 7B and 7C** indicate in schematic form the sequence of events which takes place in depositing

three minimum thickness documents A, B and C from the ledge **95** onto the surface of the friction roller **7**. With reference to FIG. **7A**, conveyor motion has advanced the lead document A to a point where it loses ledge support. The backside of the document is aligned with the substantially vertical portion of the ledge. This is also an indication of the ideal stop point condition, from the standpoint of zero doubles generation.

In FIG. **7B**, the conveyor **10** has continued its advance for a distance Δ until the lead document A interrupts the photocell beam, at a distance X_1 from the top of the ledge. The second document B begins its vertical drop and is positioned at a distance X_2. Similarly, the third document C is no longer supported by the ledge and is at the threshold of dropping.

FIG. **7C** illustrates a third event which involves a serial dropping of the documents. Thus, the lead document A is shown at the point of contact with the surface of the friction roller **7**. The second document B is shown at a distance positioned X_3 from the surface of the friction roller and the third document C is shown positioned at a distance X_4 from the surface of the friction roller.

Friction Roller Stage

The purpose of the friction roller stage **200** is to provide for continuing singulation after initial singulation has taken place in the ledge stage **100** described hereinbefore. With continued reference to FIGS. **1–3** inclusive, in an operative embodiment of the device, the roller is comprised of ten discs **7** separated in such a way as to permit intersection with comparable discs **18** in the succeeding vacuum roller stage **300**. The discs **7** are mounted on a shaft **8** supported by ball bearings **9**. The roller is driven with a **2:1** step up ratio from a stepping motor **13** through a timing belt set **10, 11** and **12**. Both bearings and the stepping motor are supported from two side plates **14** and **15**. These side plates in turn are held together by three tie bars **16**.

The periphery of the discs on the friction roller is occupied by a high friction rubber tire **17** (FIG. **3**) which snaps into a groove (not shown) on the disc. The rotation of the roller is clockwise, as shown, away from the ledge. The envelopes of the friction rollers **7** as seen in side elevation intersect the envelopes of the vacuum rollers **18**, in order to create an abrupt stop for documents traveling on the periphery of the friction roller. This stop is at the apex of the two rollers at point "*a*", the park point.

The documents being dropped onto the surface of the friction roller **7** are accelerated to a high peripheral velocity through the action of the stepping motor drive and the high friction material of the discs. The leading edge of the lead document interrupts the photocell beam of the park point photocells **19** just before the park point, which through the action of control circuitry stops the friction roller **7** rotation. A light beam is created by a fluorescent tube **23** which continuously illuminates all three park point photocells **19** (FIG. **2**). Interruption of only one cell is sufficient to stop the rotation of the friction roller **7**. The spacing between photocells **19**, as well as their positioning with respect to the document registration wall, is such that a document of minimum length, for example four inches, must interrupt at least one photocell when driven to the park point "*a*". The positioning of the photocells **19** at a predetermined height above the apex, permits an early stop of the friction roller **7**, without comprising the necessary arrival of the document at the periphery of the vacuum roller. This occurs because the photocell is located within the friction roller unstable zone. However, the established separations between documents are preserved since trailing documents are permitted to be in a more stable zone on the roller **7**. The leading document after interruption of the photocell beam skids into the park point "*a*" and therefore into contact with the surface of the vacuum roller **18**. The main reason for stepping motor control of the friction roller **7** is to provide a rapid start and stop condition. A rapid start condition to achieve the design peripheral velocity is required to take full advantage of the document separation philosophy developed for this stage, which philosophy will be discussed in detail hereinafter. Likewise, a rapid stop condition permits maintaining developed separations between documents.

As depicted in FIG. **7C**, three documents A, B and C may drop from the ledge in a serial fashion. The concept of singulation on the friction roller **7** is based on the serial delay time between documents as they contact the surface of the friction roller in succession. Assuming a constant drop time for each of the three documents, the serial delay time can be expressed as

$$T = \left(\frac{t}{V_c}\right)$$

where T is the delay time between document drops to the surface of the friction roller, t is equal to the document thickness, and V_c is the conveyor velocity.

Important to a discussion on singulation is an expression of the amount of separation that can be expected. If the separation of the leading edges of two documents on a moving friction roller **7** is designated by the dimension "*y*" then this quantity can be expressed in terms of the above equation as:

$$y = V_f T$$

where y is the expected maximum separation between the documents without slip, V_f is equal to the peripheral velocity of the friction roller and T is the serial delay time between documents.

If the former equation is substituted into the latter equation, we obtain:

$$y = \left(\frac{V_f}{V_c}\right) t$$

It is seen that the ratio of velocities of the friction roller to the conveyor velocity is the most important aspect of maximizing singulation in the friction roller stage. For purposes of example, if a friction roller peripheral velocity of 40 inches per second is used, with a conveyor velocity of approximately 0.5 inches per second, a separation of 80 times the document thickness being processed is possible. If a practical minimum thickness of approximately 0.01 inches can be considered a reasonable dimension, then the minimum separation will be 0.80 inches.

Continuing a consideration of the mechanization of the friction roller stage, the spaces between discs on the roller are occupied by metallic comb **20**. The surface of the comb is located below the surface of the roller **7**. The purpose of this stationary sheet metal is to correct excessive skew of the documents, as they drop from the ledge **95**. Thus, in the absence of the metallic comb, the

leading corner of a severely skewed document can drop a considerable distance between adjacent discs. The document has no opportunity to correct the skew with a clockwise rotation, since the friction roller is continuously rotating during the drop. With the addition of the stationary comb **20**, the leading corner of a severely skewed document can only drop a short distance between adjacent discs before contacting the comb. The overall effect of the comb is to give the document an opportunity to correct its skew before moving out on the periphery of the friction roller. It should be noted that the comb **20** projects outside of the roller envelope at a point "*b*" to permit the parked document to obtain as much normal force on the vacuum roller **18** as possible. With thin light weight documents, a low normal force creates a bouncing action and a loss of time in outputting. Loss of friction roller surface and driving in this zone is not detrimental since separation cannot be maintained and also the sheet metal surface creates a low friction surface in dropping documents to the park point.

Park Point Photocell System

The purpose of the park point photocell system utilized in connection with the friction roller is to stop the rotation of the latter, when the lead documents leading edge interrupts the photocell beam. As seen in FIG. **2**, there are three photocells **19** in this system, and these are spaced evenly between the discs **7** of the friction rollers. As noted hereinbefore, the system of three cells provides for interruption of at least one beam regardless of the size or position of the document as it is being transported by the friction roller toward the park point.

Both the ledge photocells **6** and the park point photocells **19** are serviced by a fluorescent lamp **23** which is positioned at the apex of the line of action from each set of photocells.

The park point photocells are positioned at a distance "*c*" from the apex of the friction rollers **7** and vacuum rollers **18**. The criterion on positioning the park point photocells is that they should be placed as far away from the apex as possible without jeopardizing the ability of the document being transported from reaching the surface of the vacuum rollers **18**. The reason for this is that it prevents trailing documents from entering an unstable zone on the roller periphery where separation of the documents cannot be maintained.

Operation of the Friction Roller Stage

FIGS. **8A**, **8B** and **8C** indicate in schematic form the sequence of events which take place in the singulation produced by the friction roller stage. Two case situations are illustrated one involving the ideal situation the other the minimum functional requirement case. FIGS. **8A** and **8B** are directed respectively to the initial and final sequence of the ideal case, and FIG. **8C** depicts the final sequence of the minimum functional requirement situation. In the latter case, the initial sequence is assumed to be identical to that of the ideal case depicted in FIG. **8A**. Before proceeding with a description of these Figures, it should be recalled that the main purpose of the friction roller stage is to separate the leading edges of documents dropped onto its surface, in such a way that only one document is supplied to the vacuum roller stage for insertion. In the device described herein, no more than two documents are to be supplied to the surface of the vacuum roller, in order to assure single document flow from this latter stage.

With reference to the ideal case and the initial sequence depicted in FIG. **8A**, it is assumed that the conveyor motion has caused three documents A, B and C to be dropped from the ledge. Document A has contacted the surface of the friction roller; document B is a distance from the top of the ledge; and document C is on the verge of vertical motion, after being pushed off the ledge. Similarly, the friction roller is on the verge of imparting a velocity V_f to document A.

In the final sequence depicted in FIG. **8B**, the friction roller **7** drives the leading edge of document A to a point of contact with the surface of the vacuum roller **18**, at the park point "*a*". The motion of the friction roller **7** has been stopped by the actuation of the park point photocell system **19** by the leading edge of document A. Document B contacts the surface of the friction roller at some time later and is advanced to a position "*d*" which is at a peripheral distance "*w*" from the leading edge of document A, at the time of stopping of the friction roller. The third document C contacts the surface of the friction roller at some time after document B has contacted it. The leading edge of the last document stops at a position "*e*" which is at a peripheral distance "*w*" from the leading edge of document B, at the time of stopping of the friction roller **7**.

With respect to the minimum functional requirement, the initial sequence of this case situation is exactly the same as that depicted in FIG. **8A** for the ideal case. The final sequence depicted in FIG. **8C** differs from that of the ideal case and is generally the situation which occurs with very thin documents. Thus, document A reaches the park point and is in contact with the vacuum roller **18**. The friction roller **7** motion has been stopped by the leading edge of document A. Document B contacts the surface of friction roller **7** at some time later than document A, and attempts to stop in a stable position on the friction roller, such as the distance "*w*" depicted in the ideal case. However, since it has been assumed that document B is thin and light weight, it will slip forward when the friction roller **7** has stopped. Its eventual position generally displaces document A from the surface of the friction roller, and it too contacts the surface of the vacuum roller. The last document C, maintains its position on the friction roller, at point "*e*", which is a stable position and is the same as that depicted in the ideal case of FIG. **8B**.

It should be noted that in the operation of the present device, no more than two documents should occupy the park point position as shown in FIG. **8C**, if single document flow is expected from the vacuum roller stage, to the insertion station therebeyond.

Vacuum Roller Stage

Vacuum Rollers, Stepping Motor Drive, and Vacuum Supply System

The purpose of the vacuum roller stage **300** is to provide a final stage of document separation prior to the transporting of the documents to the insertion station **66** (FIG. **5**).

As depicted in FIGS. **1–3** inclusive, the vacuum roller is comprised of ten discs **18** mounted on shaft **21** which in turn is supported by bearings **22**. Seven of these discs designated **18***a* are identical to those of the friction roller stage, and the remaining three discs, **18***b*, are vacuum rollers. The location of the vacuum rollers is

depicted in FIG. 2. The vacuum roller system is driven by a timing pulley and belt set 26, 27 and 28 from a stepping motor 29. The pulleys form a 2:1 speed increase from the motor to the vacuum roller shaft 21.

The three vacuum rollers 28*b* are required in order to arrest the trailing document in the singulation process in this stage. The three vacuum rollers are positioned such that they are biased toward the registration wall 25. This was done to centralize the arresting force on the bottom document only. If the rollers were evenly positioned, a situation could result with overlapped documents, where the separation process would not take place. For example, if the top document were longer than the bottom document the situation could exist where both documents would be attracted to the roller and the singulation process would be nullified.

With particular reference to FIGS. 3 and 4, the vacuum roller may be described as follows. The roller is comprised of an outer rubber tire 30 which has holes 31 in its periphery. The holes are approximately ¼ inch in diameter and are evenly spaced on approximately ½ inch centers throughout the periphery. The tire is fastened to an aluminum wheel 32 which is in turn fastened to the drive shaft 21. The ¼ inch holes 31 in the tire are permanently aligned with similar ¼ inch diameter holes 32*a* in the aluminum wheel. The tire and wheel rotate about a stationary disc 33. The outer periphery of the stationary disc is positioned closely to the inner periphery of the aluminum wheel 21. A small clearance exists between the disc 33 and wheel 21, permitting a seal to be maintained while at the same time avoiding contact with the stationary disc. A ball bearing 34 is used to obtain the required radial and axial relationship between the rotating wheel and the stationary disc. A torque arm 35 prevents the stationary disc from rotating. The torque arm has a "U" shaped slot 35*a* which envelops a round bar 36, which in turn is rigidly connected to the frame. The slot permits a coupling action to take place between the disc and the frame.

As rotation of wheel 32 takes place, the holes 31 and 32*a* in the tire and wheel respectively, align with a drilled hole 37 positioned in the stationary disc 33 such that it is perpendicular to the ramp 24. The drilled hole is joined with a fitting and hose 38, one from each of the three vacuum wheel assemblies being connected in common to a manifold 38*a*, which in turn is connected to a vacuum pump (not shown).

Air flow through holes 31 during rotation causes documents to be attached to the vacuum roller 18 as they contact the holes. A continuous moving grip is generated between the face of the document and the roller.

The high friction rubber tire 30 enhances the grip between the roller and the document and considerably improves arresting efficiency by limiting relative motion during stopping.

As seen particularly in FIG. 2, a series of three photocells 68 lie along the same line as the vacuum ports 37 and in approximately the same positions relative to the vacuum rollers 18 as photocells 19 are to rollers 7. The purpose of photocells 68 will be explained in detail hereinafter. For the present, it will suffice to indicate that they are used in conjunction with the control logic of the feeder device, to control the timing of a feed start signal which initiates vacuum roller motion.

Takeaway Belt, Motor Drive and Vacuum System

With specific reference to FIGS. 5 and 6, the purpose of the takeaway system of the third stage of the present device, is to transport documents via an inclined ramp 24 to the insertion station 66. The belt system with its vacuum supply grips the face of the document as it is being transported by the vacuum roller 18, in the case of a single document, and maintains motion of the document even though the vacuum roller stops and creates a braking effect. The takeaway vacuum force is greater than the vacuum roller force and therefore, the document is stripped off the vacuum roller. The takeaway belt system is continuously moving, in contrast to the intermittent operation of the other members of the stages. The takeaway belt system is comprised of four perforated vacuum belts, various pulleys, a vacuum chamber, and a motor and drive belt system.

The purpose of the four perforated belts 39 (seen as a set in FIG. 2) is to grip and drive a document into the insertion station 66. With reference to the detailed illustration in FIGS. 5 and 6, the belts are driven by a series of crowned rollers 40 mounted on a common shaft 41 and supported by ball bearings 42. Ball bearing rollers 43 and 44 permit the belt to conform to a roughly triangular configuration. Driving tension and slack take-up is provided by a ball bearing idler system 45. This latter system is comprised of a roller 46 mounted in a pivoting yoke 47, which in turn is forced against the belt 39 by a spring member 48.

As seen in FIGS. 1 and 6, the drive shaft 41 is in turn driven by a timing pulley and belt system 49, 50 and 51, from a drive motor 52.

The vacuum chamber is composed of four vacuum chamber segments 53, joined by intermediate sections 54 and end pieces 55. These various sections and pieces are sandwiched together by three tie bars 56 which also are used to mount two air exit transition pieces 57.

The purpose of segments 53 is to permit air to enter through port 58, after having passed through holes 59 in the belt 39. The air then enters a triangular passageway 60 and exits through the transition pieces 57 and goes to a vacuum blower. The system has two blowers, each servicing two of the takeaway belts 39.

The purpose of intermediate sections 54 is to support the ball bearings required for all the takeaway belt rollers, and to permit a means for disassembling the system. Sections 54 are also used to support the takeaway photocell system.

The path of the air flow entering the system is depicted by the arrows in FIG. 5.

A metallic comb 61 (FIG. 5) performs a similar function to the comb 20 in the friction roller stage. The lower portion of the comb 61*a* is a transition piece from the vacuum roller to the takeaway belt. It is contoured to cover the idle portion of the takeaway belts 39. This feature supplies an important function in that it prevents arrested documents from contacting the belt at this point. It has been noted that arrested documents contacting the idle portion of the belts frequently go out as doubles, even though they do not contact the vacuum portion of the belt. This is so because the top document creates a pinch force on the arrested document and pulls it out along with the top document. By extending over the belts 39, the curved sheet metal 61*a* which comprises the lower portion, prevents this from happening in the idle portion of the belt. The slight

elevation of the documents above the belts at this point does not materially affect the driving force exerted thereon.

Takeaway Photocell System

As shown in FIGS. **2, 5** and **6** there are three takeaway photocells **62** mounted on the intermediate pieces **54.** These photocells are serviced by a fluorescent lamp **63.** The purpose of these photocells is to stop the rotation of the vacuum roller system **18,** when the leading edge of the lead document interrupts the photocell light beams. Both fluorescent lamps **23** and **63** are fitted with reflectors **64** which are used to gather and project the light from the fluorescent lamps and direct it toward the photocells. These fluoroescent lamps are mounted on a bracket **65** which is in turn mounted on side plates **14** and **15.**

Insertion Station Photocell System

The insertion station **66** is located down stream from the takeaway belts at a distance which is determined by the maximum height of the documents being handled. A photocell **67** is mounted in proximity to the station to signal to the control logic of the feeder device, the arrival of a document at the station. In the system incorporating the feeder device of the present invention, the initial document is transported out of the station such as by vacuum belt means, and this document is replaced by a new document which has been advanced into the insertion station as a result of the initiation of rotation of the vacuum rollers **18.**

Operation of the Vacuum Roller Stage

FIGS. **9A–9F** inclusive and **10A–10I** inclusive illustrate in schematic fashion the sequence of events which take place in this, the final stage of singulation in the present device. Two case situations are depicted. One involves the handling of a single document which has arrived at the park point and is in contact with the surface of the vacuum roller **18.** The other case deals with the situation where the ledge and friction roller stages have failed to separate two adjacent documents, the leading edges of which are both in contact with the surface of the vacuum roller **18.**

In the former case, it is inconsequential for this description whether only this single document had dropped from the ledge, or whether three documents had dropped therefrom with the last two remaining in a stable position on the stationary periphery of the friction roller. It is only the single lead document in contact with the vacuum rollers **18** that will be considered at this time. FIGS. **9A–9F,** inclusive illustrate the sequence of events in the last mentioned situation where a single document feed mode is involved.

FIG. **9A** depicts a document A having had its leading edge advanced to the park point "*a*", and being in contact with the surface of vacuum roller **18,** through the action of the friction roller **7.** The leading edge of this document has interrupted the light beam, to photocell **19** (FIG. **3**) and stopped the rotation of the friction roller **7.** It is assumed that the system condition is such that the vacuum roller **18** is also stopped.

With reference to FIG. **9B,** upon a system feed start signal to feed a document, the vacuum roller **18** commences rotation. A vacuum port **37** associated with this last mentioned roller, at the point of tangency with the ramp **24,** grips the document A. The rotation of the vacuum roller **18** continues with the document being driven down the ramp at the peripheral speed of the roller. The continuous vacuum grip during rotation, is created by a series of holes **31** (see FIG. **2**) in the periphery of the roller as explained hereinbefore. As one hole **31** leaves its aligned position with vacuum port **37,** another hole **31** assumes this alignment, resulting in a continuous grip on the document.

FIG. **9C** illustrates the continued rotation of the vacuum roller **18** as it advances the document to the point of interruption of the light beam actuating photocell **62** in the takeaway photocell system. Interruption of the beam stops the vacuum roller, but the vacuum grip on document A is maintained. At the point of interruption of photocell **62,** the leading edge of document A completely covers vacuum port **58** in the takeaway belt system. The friction drive created by the moving belt **39** and the vacuum pressure accelerates the document down the ramp by overcoming the vacuum resisting force of the now stationary vacuum roller **18.**

FIG. **9D** illustrates the continuing cycle of operation wherein the vacuum belt takeaway system drives document A to a position where its trailing edge uncovers the light beams to photocells **6** of the ledge photocell system. Uncovering the latter beam initiates the advance of the conveyor **10,** in order to supply the friction roller stage **200** with additional documents.

In FIG. **9E** the document A has advanced to a point where it is released from the takeaway belt **39** and drops by gravity toward the insertion station **66.** At the same time a succeeding document B has dropped onto the surface of the friction roller **7** and is advancing to the park point "*a*".

Finally, in FIG. **9F,** the document A has advanced by gravity to the fully inserted point at station **66** and awaits transfer to other parts of the system for further processing. Interruption of the light beam to photocell **67** indicates that the document is in a fully inserted condition. Document B has reached the park point "*a*", in position for the next feed cycle.

The sequence of events corresponding to the situation where two documents repose at the park point "*a*", in contact with the surface of vacuum roller **18,** is illustrated in FIGS. **10A–10I,** inclusive.

The initial position of the documents A and B is shown in FIG. **10A.** The friction roller **7** and the vacuum roller **18** are stationary. Takeaway belts **39** are continuously moving. Air continuously enters the tangential vacuum ports **37** in the vacuum roller **18** as well as the ports **58** in the takeaway belt system. A document C occupies the insertion station **66.**

In FIG. **10B** it is assumed that document C has been transported out for further processing and that the rotation of the vacuum rollers **18** has been initiated to effect the delivery of the next document "A" to the insertion station. As the vacuum rollers move, the initial separation X takes place while both document leading edges are in contact with the surface of the vacuum roller. Document A is in direct face contact with document B, and derives some support therefrom. Depending on the length of the documents involved, a tangent condition develops with the leading document A and the vacuum roller **18.** This tangency occurs at point "*f*", and takes place at various angularities ϕ. Document B is in firm contact with the vacuum rollers **18** since it has the weight force components, W_1 and W_2 from documents A and B respectively pressing it against the surface of the rollers. The reaction force R_2 therefore is greater than the reaction force R_1. The

friction driving force on document B, therefore is greater than that on document A.

As seen in FIG. **10C**, when document B moves toward the tangency point of the vacuum rollers, it lifts document A from contact with the rollers. The force F_1 is transmitted to document A from document B resulting in an instantaneous separation from the surface of the vacuum rollers. This separation occurs at the approximate tangency point. Document A no longer sees the high coefficient of friction of the vacuum rollers, but rather is exposed to the much smaller interdocument frictional coefficient. The force of gravity on document A accelerates it in respect to document B, while both documents move at a peripheral velocity of the rollers.

Document B continues to move at the peripheral velocity of the vacuum rollers, because it gets captured by the tangent vacuum ports of the rollers, thus guaranteeing that document A will continue to accelerate with respect to document B. The force of gravity acts on document B also, but it cannot overcome the vacuum force of roller **18**. Therefore, only acceleration of document A takes place. The amount of separation between documents is related to the coefficient of friction between documents, the developed angularity ϕ (which in turn is related to document length), and the time that the process of separation is permitted to continue. With respect to the developed angularity, the longer the document, the greater the angularity and so the greater the component of gravity acceleration. The equation for separation is

$$S = \tfrac{1}{2}at^2$$

where S is eqqal to the separation, a equals the developed acceleration rate, and t equals the time that the process is permitted to continue. This time in turn is determined by the position of the takeaway photocells **62**.

With reference to FIG. **10D**, continued vacuum roller movement brings document B in contact with the vacuum ports **37** on the vacuum roller. The lead document A cannot get captured by the vacuum ports. The vacuum force grips document B and assures that the velocity of the document will not exceed the velocity of the vacuum roller, even through the weight force component of document B attempts to accelerate it down the incline. The first document A further accelerates away from the second document B to a position (X_1).

In FIG. **10E**, further rotation of the vacuum roller, brings the second document B to position "*g*". At the same time document A accelerates still further to a separation of distance X_2, in respect to document B. The leading edge of document A is now coincident with the vacuum port **58** of the takeaway belt system. A high rate of air flow creates a partial vacuum between document A and the takeaway belt vacuum ports. This partial vacuum pulls document A into contact with the takeaway belt **39**, flexing it to permit it to bend around the lower document B. Document A experiences a much higher acceleration rate at this point due to the high vacuum forces available.

In FIG. **10F** document A has advanced to the point of interruption of the light beam for the takeaway system photocell **62**. This interruption is effective in stopping the rotation of the vacuum roller. Document B at this instance is at point "*h*". A separation of X_3 exists between the leading edges of documents A and B.

In the next FIG. **10G** the first document A is at position "*i*" past the beam for photocell **62**. The second document B stops at point "*j*" just short of the moving belt **39** in the takeaway system. Movement of document B between the events depicted in this FIG. and FIG. **10F**, is due to arresting the inertia of the vacuum roller, as well as a slip condition between document B and the surface of the vacuum roller. It should be emphasized that the maximum expected thickness of document B in the event illustrated in FIG. **10G** is approximately 0.020 inches under ideal conditions. This is the case since the ledge and friction roller have separated all documents thicker than 0.020 inches, before they reach the park point. Therefore, the maximum mass of document B is predictable. Knowing the maximum mass of vacuum resisting forces of the vacuum roller, as well as its peripheral velocity, permits determining position "*j*", such that document B never contacts the takeaway belt **39** when fully arrested.

In FIG. **10H**, document A is shown at the bottom of the insertion station **66**, at which point it intersects the light beam for the insertion station photocell **67**. Document B remains positioned on the vacuum roller **18**. Both the friction roller **7** and the vacuum roller **18** are stationary at this time.

With reference to FIG. **10I**, document A is transferred out of the insertion station **66** for further processing. Upon a system start feed signal, the vacuum roller **18** moves document B to the point of contact with the vacuum takeaway belts **39**, which start to strip the document away from the vacuum roller.

At this point, the sequence of events to complete the cycle is the same as that illustrated in FIGS. **9C–9F** inclusive, and reference thereto, along with the accompanying description, should be made.

Feeder Throughput Considerations

Feed Start Control Photocells

As mentioned hereinbefore, the photocells **68**, associated with the vacuum rollers **18** are employed to control the feed cycles initiated by the movement of these rollers.

Documents can be fed into the insertion station **66** from two distinct positions, storage on the friction roller **7** at the park point (as seen in FIG. **9A**) and from an arrested position on the vacuum roller **18** (FIG. **10H**) as a result of having had two documents at the park point (FIG. **10A**) on the previous cycle. The actual position of the leading edge of the arrested document with respect to the takeaway belts **39** is a function of the document weight, type, frictional coefficient, etc.

The present feeder design is such that the trailing edge of a fully inserted document of maximum height, that is, 15 inches, just clears the takeaway belts **39**. A distance - time relationship exists for a stored document (either at the park point or arrested on the vacuum roller) to arrive at the same point occupied by the trailing edge of the inserted document. A cycle overlap time exists wherein a document in storage can start insertion into the station before the previous document in the station has been fully transferred out. This permits the friction roller buffer to fill earlier, significantly improving throughput of the feeder.

In the case of a document stored at the park point, the initiation of insertion of this document by commencement of rotation of the vacuum roller **18** could be arranged to occur simultaneously with the initiation of transfer of the document out of the insertion station without danger of collision, even with a maximum

height document. On the other hand, with the insertion of an arrested document, the transfer of the document out of the insertion station must be already underway (and in fact approaching completion) before the signal to start rotation of the vacuum roller to accomplish insertion of the arrested document is given.

The photocells **68** perform the function of determining whether or not a document is in an arrested condition on the surface of the vacuum roller **18** and of relaying this information to the system control logic circuits.

FIG. **11** illustrates in simplified form, a logic diagram to demonstrate the action of the photocells **68.** A Transport Control Logic block **69** is depicted along with two "AND" gates **70** and **71,** or "OR" gate **72,** an inverter **73** and the photocell **68.**

In operation, it is assumed that the insertion station photocell **67** has supplied a signal to the Transport Control Logic **69** indicating that a document is present at the insertion station **66.** The transfer of the document out of the insertion station is initiated. Simultaneously, the Logic **69** will call for the next document to be inserted by enabling input **1** of "AND" gates **70** and **71.** The enable signal to the gates is considered a logic "**1**". If a document is not arrested on the vaccum roller **18,** photocell **68** will be unblocked, resulting in a logic "**1**" on input **3** of gate **70** and because of inverter **73,** a logic "**0**" on input **3** of gate **71.** Means associated with the removal of the document from the insertion station sense the initiation of its transfer therefrom, and signal the Logic **69** to supply a transport advance cycle START signal (a logic "**1**") to input **2** of gate **70.** This causes a "feed start signal" to be generated via "OR" gate **72** and to be applied to stepping motor **29** to initiate the rotation of the vacuum roller **18.** This begins the insertion of the next document into the station.

On the other hand, if a document had been in the arrested position on the vacuum roller **18,** a photocell **68** would have been blocked. This results in a logic "**1**" signal on input **3** of gate **71** and a logic "**0**" on input **3** of gate **70.** The transport advance cycle START signal would have been ineffective in generating a "feed start signal". As the document proceeds to fully exit the insertion station, sensing means associated with the transfer, signal the Logic **69,** that the transfer out is nearly complete. In response to this latter signal, the Logic **69** puts out a transport advance cycle COMPLETE signal, enabling input **2** of gate **71.** This action causes a "feed start signal" to be generated via "OR" gate **72,** to initiate the rotation of vacuum roller **18.** The arrested document may now be delivered to the insertion station without danger of collision with the exiting document.

Summary and Conclusion

Summarizing the cooperative relationship of the multiple stages, documents are transported to a ledge by a conveyor, where face separation takes place. The documents drop from the ledge onto a friction roller which transports them to a vacuum roller while effecting edge separation and providing multiple storage of separated documents. The vacuum roller transports the documents to the takeaway system, provides face separation and single arrested document storage. Finally, the takeaway belt system transports the documents, at high speed to an insertion station. Each of the stages has the capability of being independently controlled by an operator, that is, to effect movement in any of the stages by "push-button" control, to correct jam conditions which are not unusual in the handling of flats, such as magazines and newspapers.

The inventive concepts and implementations described herein have proved highly satisfactory in an actual operative system. It should be understood that changes and modifications of the feeder may be needed to suit particular requirements. Such changes and modifications insofar as they are not departures from the true scope of the invention, are intended to be covered by the claims appended hereto.

What is claimed is:

1. A document feeding device comprising:

drop ledge means for performing an initial separation on a stack of documents being pushed from said ledge means by moving transports means,

moving friction roller means positioned in proximity to said drop ledge means for receiving and transporting on its surface the documents which drop thereon,

vacuum roller means positioned in a proximate intersecting manner with said friction roller means and being adapted to perform a final separation on said documents, means for terminating the movement of said friction roller means at a predetermined point in the travel of a given document on its surface, said termination of movement permitting the leading edge of said last mentioned document to contact the periphery of said vacuum roller means at the roller means intersection point, said vacuum roller means being adapted to transport said document on its surface and being operatively connected to a vacuum source for exerting a vacuum force upon said document as it traverses a predetermined point on the circumference of said roller means,

a ramp including takeaway belt means positioned in proximity to said vacuum roller means and in tangential relationship with said predetermined point on the circumference of said vacuum roller means, said ramp being adapted to receive documents exiting from the surface of said vacuum roller means, said takeaway belt means including means for exerting a vacuum force upon said document,

means for terminating the movement of said vacuum roller means in response to the attainment of control of said document by said last mentioned vacuum force, said document being acted upon simultaneously by the respective vacuum forces of said vacuum roller means and said takeaway belt means, the vacuum force exerted by the latter means being of greater magnitude than that of the former means and being effective in stripping said document from the surface of the stationary vacuum roller means, said takeaway belt means accelerating said document along said ramp.

2. A document feeding device as defined in claim **1** wherein said transport means comprises a conveyor having a plurality of timing belts driven by a stepping motor through a reduction gear box, said conveyor being positioned at an actute angle with respect to the horizontal.

3. A document feeding device as defined in claim **2** wherein the face of said drop ledge means is perpendicular to the surface thereof which supports said document.

4. A document feeding device as defined in claim **3** further including light sensitive means positioned in the

face of said drop ledge for sensing the leading edge of a document as it drops from the ledge, said light sensitive means being operatively connected to halt the motion of said conveyor in response to the sensing of said document.

5. A document feeding device as defined in claim 4 wherein said friction roller means and said vacuum roller means are each comprised of a plurality of discs spaced apart in such a manner that the disc envelopes of the friction roller means intersect those of the vacuum roller means.

6. A document feeding device as defined in claim 5 wherein said means for terminating the movement of said friction roller means comprises a park point photocell system which includes a source of light beams, and additionally includes light sensitive devices, the plural elements of which are spaced between the discs of the friction roller means, the interruption of the light beams striking at least one of said elements being effective in stopping the movement of said friction roller means.

7. A document feeding device as defined in claim 6 further including a stationary comb-like member positioned between the discs of said friction roller system, a substantial portion of the surface of said comb-like member being located below the surface of the discs, said member being effective in correcting excessive skew of the documents as they drop from the ledge.

8. A document feeding device as defined in claim 7 wherein said vacuum roller means includes a plurality of wheel-like discs, several of which are of the vacuum type, each of the vacuum type discs having a plurality of spaced apart apertures in the wheel periphery, a stationary disc positioned in close proximity to an inner peripheral surface of said vacuum discs and having a port therein, said port being adapted to be connected to a vacuum source, said holes in the wheel periphery of each of said vacuum discs extending to said inner surface and coming consecutively into alignment with said port in said stationary disc during rotation of said vacuum discs.

9. A document feeding device as defined in claim 8 further including at least one registration wall situated alongside said conveyor and perpendicular to the surface of the belts transporting said documents, said vacuum type discs in said vacuum roller means being spaced-apart but offset from the center of the vacuum roller means toward said registration wall, this biased condition assuring that in the case of overlapped documents regardless of size, the arresting vacuum force will affect only one of the documents.

10. A document feeding device as defined in claim 9 further characterized in that a high friction rubber tire is mounted on each of said vacuum roller discs, the tire on each of said vacuum discs having a plurality of apertures in alignment with homologous apertures in the wheel periphery of said last mentioned discs.

11. A document feeding device as defined in claim 10 wherein said takeaway belt system is comprised of a plurality of perforated belts and a vacuum chamber, said belts being operatively arranged to contiguously traverse the face portion of said vacuum chamber.

12. A document feeding device as defined in claim 11 wherein said means for terminating the movement of said vacuum roller means in response to the attainment of control of said document by the takeaway vacuum forces comprises a takeaway photocell system, the plural elements of which are spaced between the belts of said takeaway belt means.

13. A document feeding device as defined in claim 12 further including a stationary comb-like member positioned between the discs of the vacuum roller means to provide a transition piece from the latter to the takeaway belt systsem, a portion of said member being configured to cover the idle portion of said belts in said system so as to prevent arrested documents from contacting the belts at this point.

14. A document feeding device as defined in claim 13 wherein said ramp terminates in an insertion station, said device further including photocell means positioned in the vicinity of said station and operatively connected to indicate the presence of a document in said station.

15. A document feeding device as defined in claim 14 further including a timing control photocell system, the plural elements of which are spaced between the discs of said vacuum roller means and positioned in line with the ports associated with said vacuum type discs, said photocell system being operatively connected to logic gating means to indicate the presence or absence of a document arrested on the surface of the stationary vacuum roller means, said logic gating means initiating movement of said vacuum roller means at predetermined times dependent respectively upon the conditions indicated by said photocell system.

16. A document feeding device as defined in claim 15 wherein said documents are mail flats.

17. A document feeding device as defined in claim 1 wherein a plurality of documents are dropped from said drop ledge means in serial fashion in a given cycle of operation,

said friction roller means attempting to maintain serial separation of said documents and delivering one document at a time to said vacuum roller means, the failure of said friction roller means to maintain said separation between a lead document and an immediately succeeding document permitting the leading edges of both documents to contact said vacuum roller means at said intersection point,

said vacuum roller means performing the separation of said last mentioned documents, the movement of said vacuum roller means transporting both said documents on its surface, said lead document being lifted from contact with the surface of said vacuum roller means by said succeeding document and lying in face-to-face contact when said latter document, said vacuum force associated with said vacuum roller means effectively acting upon only said succeeding document, said lead document moving ahead of said succeeding document and accelerating toward said movement vacuum takeaway belt means, the termination of movement of said vacuum roller means in response to the attainment of control of said lead document by the vacuum forces associated with said takeaway belt means permitting said lead document to be accelerated down said output ramp, while effecting the arresting of said succeeding document on the surface of said vacuum roller means.

18. A document feeding device comprising:

a drop ledge,

transport means for conveying the documents to be pushed off the ledge,

means incorporated in said ledge for sensing the leading edge of a lead document dropping therefrom, said sensing means being operatively connected to terminate the motion of said transport means,

moving friction means positioned in proximity to said drop ledge for receiving the documents dropping thereon and for transporting them on the surface thereof,

sensing means for detecting the arrival of the leading edge of said lead document at a particular point on said friction means surface, the motion of said friction means being terminated in response to said arrival,

vacuum roller means positioned in proximity to said friction means, said lead document being advanced to contact with said vacuum roller means upon the cessation of motion of said friction means, said vacuum roller means transporting said document on its surface and including means for applying a vacuum force to the document as it traverses a point on the circumference of said vacuum roller means, said force applying a continuous grip to said document as it is moved forward,

continuously moving takeaway transport means positioned in proximity to said vacuum roller means and in tangential relationship to said point on the circumference of said vacuum roller means and including an output ramp terminating in an insertion station, said takeaway transport means including vacuum means for applying a vacuum force to the document at a preselected location on said ramp, means for sensing the arrival of said document of said last mentioned location, the movement of said vacuum roller means being terminated by said last mentioned sensing means in response to the arrival of said document at said location, said document being acted upon simultaneously by the respective vacuum forces of said vacuum roller means and said takeaway transport means, the vacuum forces of the latter being of greater magnitude such that the document is stripped away from said vacuum roller means and accelerated down said ramp to said insertion station by said takeaway transport means.

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