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Shimizu

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[54] **PAPER FEEDING APPARATUS FOR USE IN PRINTING MACHINE**

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[52] **U.S. Cl.** **271/95,** 271/98

[51] **Int. Cl.** **B65h 3/08**

[58] **Field of Search** ..... 271/28, 27, DIG. 1, 26, 271/30, 31, 29

[56] **References Cited**

UNITED STATES PATENTS

2,714,006	7/1955	Layden	271/28
2,915,308	12/1959	Matzen	271/27 UX
3,682,470	8/1972	Takagi et al.	271/27

Primary Examiner—Evon C. Blunk

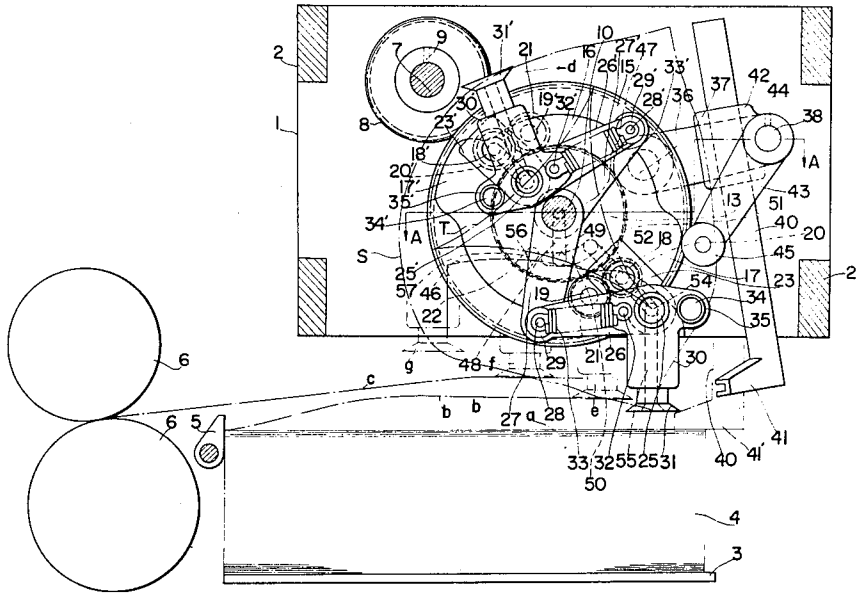
Assistant Examiner—Bruce H. Stoner, Jr.

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[57] **ABSTRACT**

A paper feeding apparatus for use in a printing machine in which the sheets of paper are fed into the printing machine one after the other with the use of a sucker device which is continuously rotated along a modified cycloid curve by means of planetary gear systems in cooperation with quadric chain mechanism, whereby the disadvantages inherent in a conventional paper feeding apparatus having a reciprocating sucker is substantially eliminated.

16 Claims, 4 Drawing Figures



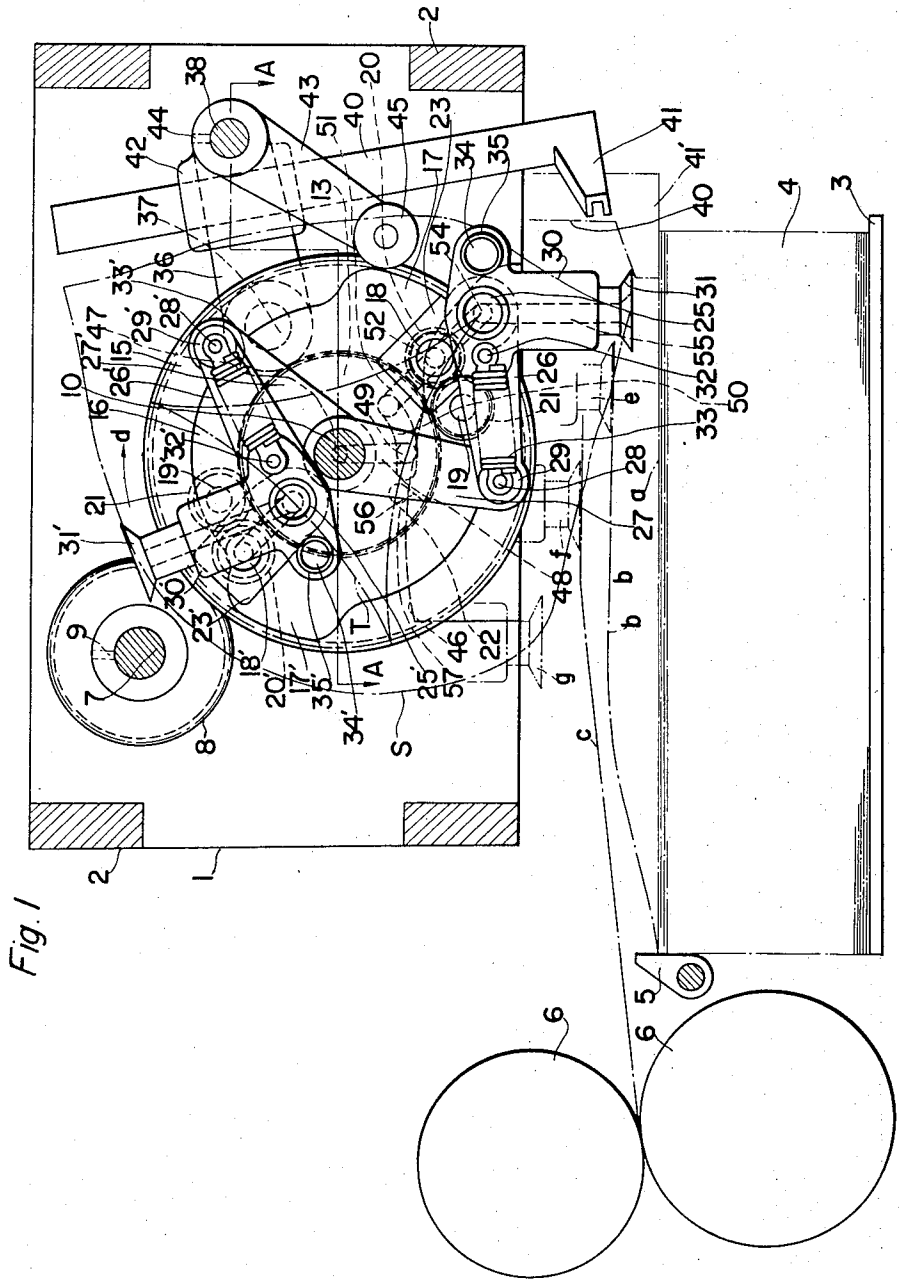


Fig. 1

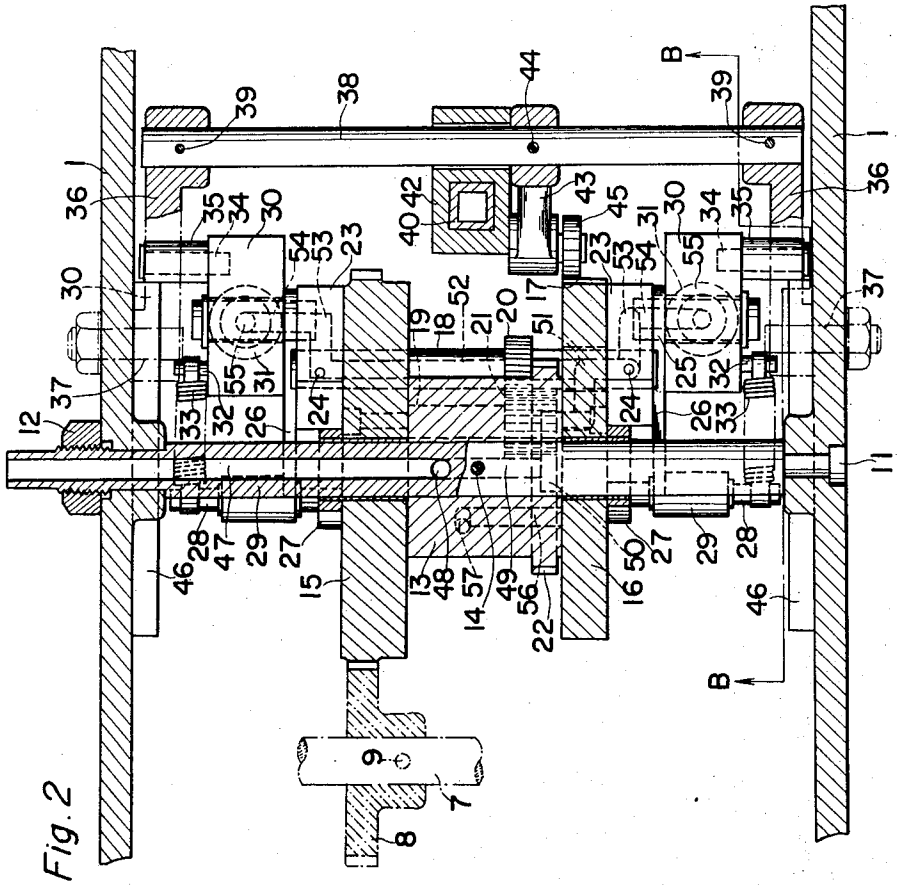

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Fig. 2

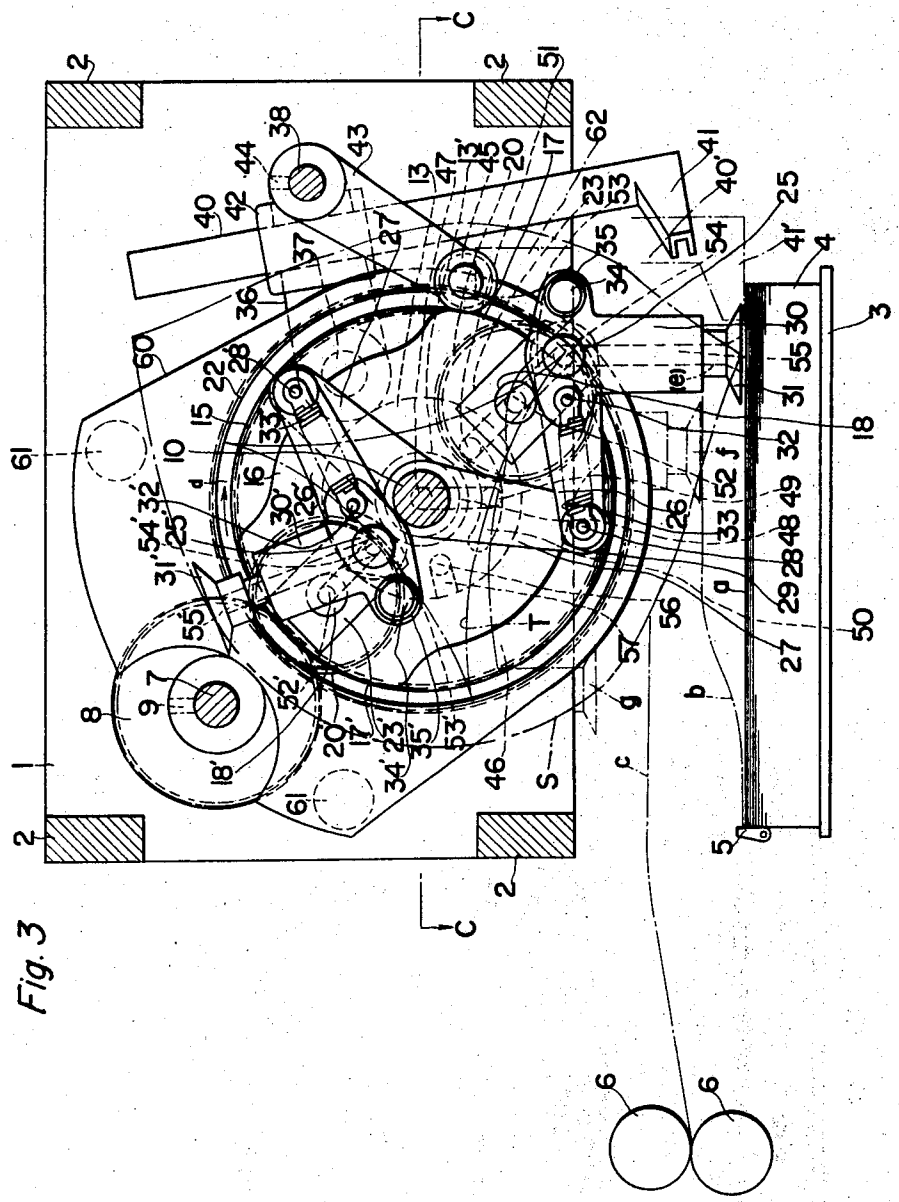


Fig. 3

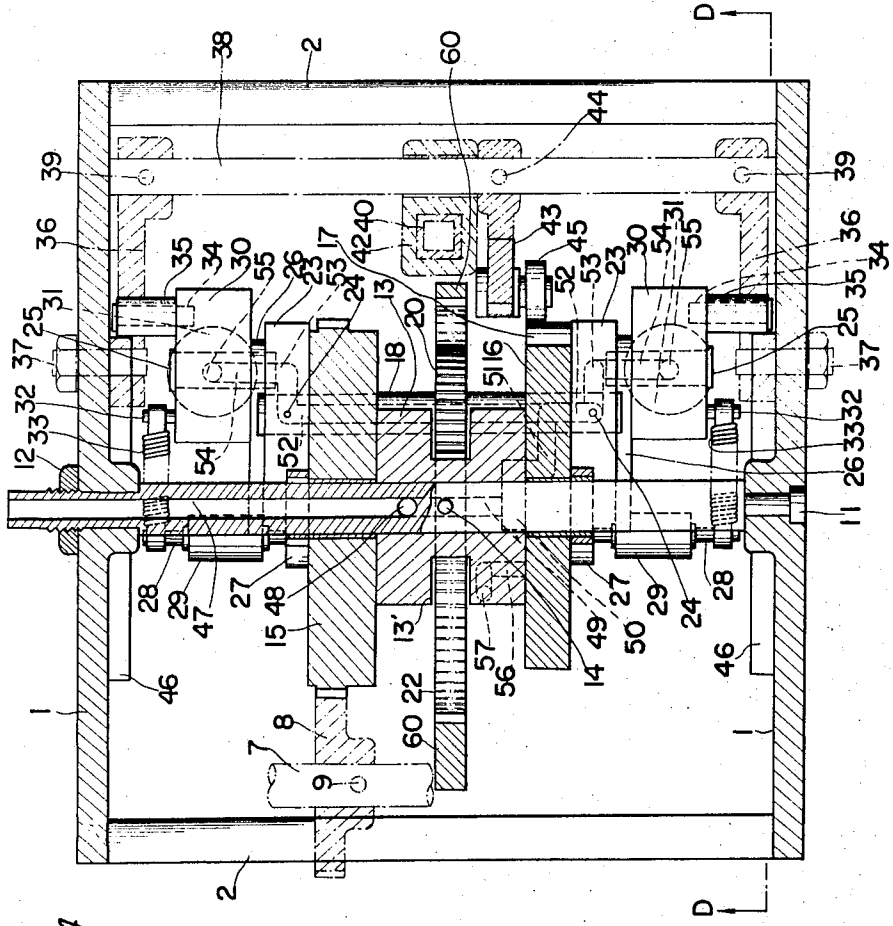

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Fig. 4

PAPER FEEDING APPARATUS FOR USE IN PRINTING MACHINE

The present invention relates to a paper feeding apparatus for use in a printing machine and, more particularly, to an apparatus for separating and forwarding a sheet from the top of the stacked sheets which comprises one or more sucker devices which are rotated and during the part of the rotation pick up and feed successive sheets of paper to rolls of a printing press as well as means for blowing air under the sheets as they are fed to the rolls.

In the conventional method for feeding sheets to a printing press a sucker picks up a sheet carries it forward to the rolls or transfers it to a second sucker which carries it forward to the rolls while at the same time air is usually blown under the sheet to keep it in a horizontal position until it is fed to the rollers. However the conventional art has considerable disadvantages since, the sucker which forwards sheets in this manner must return to the original pick-up position after each sheet has been taken into the rolls. In such a device there are not only mechanical difficulties, but, more important, the speed at which such a mechanism can feed sheets to the rolls is very limited because of the time required for the reciprocating motion of the sucker. It is possible to increase the speed of feeding the sheets by providing more than one sucker, but in this case the mechanism becomes very complicated and in practice usually only one forwarding sucker is employed because of problems of construction and maintenance. There is therefore a need for a sheet separating and forwarding device for a printing press which is mechanically simple and whose feeding speed can be increased without increasing mechanical, construction or maintenance problems.

It is the main object of the present invention to answer this need by providing an automatic paper feeding apparatus for separating and forwarding a sheet in which a sucker is connected by a lever or other means to a point on the periphery of an internal planetary gear so that the motion of the sucker is not reciprocal but follows the modified sine curve formed by a point on the periphery of an internal planetary gear, therefore it is possible to increase the speed of feeding sheets without any extra mechanical difficulty, either by increasing the speed of rotation of the planetary gear or by providing more than one planetary gear and sucker, so that feeding of sheets to the rolls is smooth and if necessary can be made continuous.

It is another object of the present invention to provide an apparatus as described above in which sheets are fed in succession to rolls smoothly by the sucker rotating by planetary gear systems in cooperation with quadric chain mechanism and so that they pass through the shortest distance along an approximately straight line between the pick-up and the rolls, resulting in that feeding operation is effective and economical.

It is a further object of the present invention to provide an apparatus as described above in which the various parts of the device are so arranged that a sucker picks up a sheet when the point on the periphery of the planetary gear to which the sucker is attached comes into contact with the sun gear, carries it forward to the rolls and releases it at the next contact of the said periphery point and sun gear while the sucker is always placed to face to the direct direction of the sheet, the motion of the sucker thus being fast as it approaches the sheet to be picked up, slower while it is transporting the sheet, and then fast again.

It is a still further object of the present invention to provide an apparatus as described above, in which the operation of suckers and means for blowing air such as a blow pipe are cooperatively connected so that the blow pipe is moved forward when a sucker picks up a sheet and stays in a forward position while the sheet being transported to the rolls and moves back when the sucker releases the sheet.

It is another further object of the present invention to provide an apparatus described above in which a compressor is provided for the operation of the air blower and suckers, the compressor being provided on its inlet side with a valve which controls two ports, one leading to a sucker and the other to the atmosphere and on its outlet side a similar valve controlling two ports, one leading to the atmosphere and the other to the air blower, the operation being that when a sucker is in the pick up and transporting positions the valves are adjusted to open the ports leading to te sucker and air blower respectively and at other times to open the ports leading to the atmosphere.

According to one preferred embodiment of the present invention at least two pairs of revolving suckers are provided for feeding paper to a printing press, each sucker being connected by means of a quadric-crank chain arrangement to an internal planet gear driven through an idle gear and a main shaft driven by any conventional means and revolving around a sun gear. Considering only one sucker the method of connection is that a lever is rotatably mounted on the shaft of the planet gear, so that the attached end revolves around the sun gear in a circular path together with the planet gear while the outer end also revolves but follows a series of cycloid curves, the number of curves per planet gear revolution depending on the ratio of the diameters of the sun gear and the planet gear, if, for example, the ratio is made 3 : 1 as in this embodiment, the number of such curves per planet revolution is **3.** A second lever is rotatably attached at one end to the outer end of the first lever and at its other end to a third lever, the other end of which is fixedly mounted on the main driving shaft, so that, there being connection between the main driving shaft and the planet gear shaft, the three levers effectively form a quadric-crank chain. The sucker is shaped in the form of a T, the suction pad being at the lower end of the long section, and it is pivotally mounted at the center of the cross section on the end of the second lever mounted on the outer end of the first lever, and one end of the cross section is connected by means of a spring to the end of the second lever which is attached to the outer end of the third lever, and on the other end of the cross section there is mounted a roller. In this arrangement, considering only one sucker, as the main shaft rotates it engages with an idle gear which causes the planet gear to revolve around the sun gear while rotating on its own axis, and also causes the third lever to turn around the main shaft, and as the planet gear revolves it also causes the first lever to revolve. One end of the sucker being mounted at the outer end of the first lever, the sucker follows the same path as this end during the revolution of the planet gear around the sun gear, i.e., it follows a series of cycloid curves, three for each revolution, the sucker also forming part of the quadric-crank chain ar-

rangement since it is also attached by a spring to the connection end of the second and third levers, whereby the sucker moves along an approximately straight line slanted from the beginning to the terminal. Suction force in the sucker for picking up a sheet of paper is provided as follows: There is a hole in the main driving shaft, one end of the hole being connected to an air compressor and the other end being connected to a hole in a fixed plate, and there is also a hole provided in the body of the sucker, the hole being open at the suction pad end of the sucker; connection between the hole in the sucker and the hole in the fixed plate, and therefore to the conventional compressor, is provided when a hole in a rotating cam plate mounted on and rotating with the main driving shaft comes into alignment with the two holes, and this alignment is arranged to take place only when it is necessary for the sucker to pick up and transport a sheet of paper to the rolls of the printing press. Since in the present embodiment the suckers are employed in pairs, each sheet of paper being picked up and transported by two suckers at the same time, there is further provided a hole in the planet gear shaft, to provide a permanent connection through which air can pass, a sucker being provided at each end of the gear shaft. As a sucker picks up a sheet of paper it is in a vertical downward position, but as it transports a sheet of paper to the rolls of the printing press it would normally move out of this vertical position; this displacement is prevented, however, by provision of a roller-guide cam for the roller mounted on the outer end of the cross section of the T formed by the sucker; the roller rides on the roller-guide cam which is so shaped that the sucker is held vertical for a constant distance within the range corresponding to a cycloid curve produced by the planetary gear system while it is transporting a sheet of paper by the roller riding on the roller guide and acting against the force of the spring attached to the sucker.

A further feature of this embodiment is that the blowpipe for blowing air to maintain sheets being transported in a horizontal position is caused to move backwards and forwards relative to the stack of paper through the action of a lever which is in contact with a large cam which has a large diameter and a small diameter and which is fixedly mounted on the main driving shaft, the cam being so positioned as to cause the blowpipe move forwards when a pair of suckers is picking up and transporting a sheet of paper and move backwards at other times.

Accordingly, the apparatus of the present invention offers outstanding advantages by the use of a rotating sucker since its operation is very efficient, and its construction is simpler than that of conventional devices. It also overcomes the disadvantages inherent in conventional devices having a sucker of reciprocating motions, that is to say the problems of increasing speed of operation. In conventional devices speed of operation is very low, and if it is wished to increase the speed the mechanism and maintenance of the machine become much more complicated whereas in the apparatus of the present invention speed can be increased as much as required, without any extra complications.

These and other objects and features of the present invention will become apparent from the following description taken in conjunction with preferred embodiments thereof with reference to the accompanying drawings, in which:

FIG. **1** is a schematic side sectional view, partially broken away and showing cross-sections taken along the line B—B in FIG. **2**, of an essential portion of a paper feeding arrangement and its associated parts according to one preferred embodiment of the present invention;

FIG. **2** is a cross-sectional view taken along the line A—A in FIG. **1**;

FIG. **3** is a similar view to FIG. **1**, partially broken away and showing cross-sections taken along the line D—D in FIG. **4**, according to another preferred embodiment of the present invention, and

FIG. **4** is a cross sectional view taken along the line C—C in FIG. **3**.

Before the description of the present invention proceeds, it is to be noted that, for the sake of brevity, like parts are designated by like reference numerals throughout the several views of the accompanying drawings. It is also to be noted that the concept of the present invention as well as applying to feeding apparatus herein disclosed as preferred embodiments can be aplied in any field of industry other than the newspaper printing industry, for example, in connection with a sheet of metallic foil, synthetic film, cloth or other like sheet materials if such sheet is stacked or piled as herein disclosed.

Referring to FIGS. **1** and **2**, a cubic frame including a pair or separated side boards **1** and **1** placed in parallel with an interspace, and four cross-pieces **2** mounted between the respective faced corners of the boards is attached to the body of the printing machine (not shown in the drawings) in a known manner so as to position above a feed table **3** on which there are placed a stack of sheets of paper **4** to be fed in. Above the table **3** there are provided a movable stopper **5** for detachably pressing the upper left-hand corner of the stacked sheets to prevent upper sheets of paper from disarranging at the end thereof and a pair of rolls **6** and **6** at the left of the stopper **5** for feeding the sheet of paper onto the printing place of the printing machine, the former being operated in connection with suckers described later while the latter rotates continuously by a conventional means (not shown). Also, as the high level of the stacked sheets falls a little on the table **3** during feeding operation, the table **3** is automatically raised up by a conventional means (not shown) so that the top sheet *a* of the stacked sheets is always maintained at the same height to obtain an invariable relation with the sucker and the stopper **5**.

In the arrangement so far described hereinbefore as well known to those skilled in the art, it is to be noted that the suckers into which the air is sucked are provided for picking up only the top sheet of the stacked sheets and for transporting it to the rolls so as to perform the sheet separating and forwarding operation of the top paper as hereinafter described, and the driving mechanism for driving the suckers is accommodated within the cubic frame.

In the upper left-hand side of the cubic frame there is provided a drive shaft **7** connected with a conventional driving means such as a motor (not shown) and rotatably journaled between the pair of side boards, at the middle of which there is provided a drive gear **8** hold by a pin **9**. As the drive shaft **7** is driven at the same speed of the printing drum of the printing press, the preferable operation is to feed the sheets of paper in accordance with the printing speed of the printing

press. At the center portion of the cubic frame a main shaft **10** is fixedly mounted between the pair of the side board with its one head **11** sunk into one board while the other end projects out of the other board and held firmly to the board by a nut **12** screwed on to the projecting part. At the middle portion of the main shaft **10**, there is provided a cylindrical main body **13** of small diameter fixedly held by a pin **14**; at the back of the main body **13**, a large diameter driven gear **15** is rotatably mounted on the main shaft **10**, which normally engages with the drive gear **8** to rotate in the direction of the arrow d as shown in FIG. **1**; at the front of the main body **13**, a cam plate **16** of large diameter is rotatably mounted on the main shaft **10**, at the periphery of which there is a pair of lobes **17** and **17'** symmetrically about the center of the main shaft **10'** and near the lobes there are provided two pair of side shafts **18, 19** and **18', 19'** each symmetrically provided about the center of the main shaft **10** with respect to one another rotatably mounted between the outer portion of the driven gear **15** and the lobe portion of the cam plate **16** outside of the main body **13**, thereby to cause the cam plate **16** to rotate around the main shaft **10** together with the driven gear **15** disregarding to the main body **13.** At the lower periphery of the main body **13** there is provided a sun gear **22** as one unit which is in mesh with two intermediate gears **21** and **21'** provided on one pair of the side shafts **19** and **19'**, each intermediate gear **21** or **21'** being in mesh with a planet gear **20** or **20'** fixedly provided on each of the other pairs of the side shafts **18** and **18'**, both ends of which are respectively projected beyond the driven gear **15** and the cam plate **16.** Thus, each planet gear **20** and **20'** engages with the sun gear **22** on the main body **13** through the respective intermediate gear **21** and **21'** and moves around the sun gear while being caused to revolve by rotation of the driven gear **15** and the cam plate **16.** In this embodiment of FIGS. **1** and **2**, the gear ratio between the planet gears **20** and **20'** and the sun gear **22** is made 1 : 3. A pair of holding plates **23** and **23'** are fixedly provided by pins **24** at both projecting ends of each side shaft **18** and **18'**, each of which free end is positioned to face to the same direction. At each free end of the holding plate **23** and **23'** there is provided a link **26** and **26'**, one of which is rotatably mounted on a large pin **25** fixedly provided on the free end of the holding plate **23** while the other end at its boss **29** and **29'** is rotatably mounted on the free end of an arm plate **27** rotatably provided by a pin **28** and **28'** on the main shaft **10**, whereby a set of the holding plate **23**, link **26** and arm plate **27** composes a quadric-crank chain mechanism.

A pair of suckers **30** and **30'** each having an approximately T shape in profile and respectively pivoted on the pins **25** and **25'** of the holding plate at their center portions. As there are provided tension springs **33** and **33'** each set between a pin **32** and **32'** provided on one side of the sucker and the pin **28** and **28'** of the arm plate **27** and **27'**, the sucker is always positioned so that one of its ends is pulled toward the pin **28** and **28'** of the arm plate by means of the resilient force of the spring **33** and **33'**. The sucker has a suction pad **31** and **31'** for suction of air at the middle of its end which faces the top sheet *a* of the stacked sheets, and a pin **34** at its other end on which a cam roller **35** is rotatably provided, the cam roller **35** being applied to contact with a cam **46** fixedly provided on the side board **1.** In this embodiment of FIGS. **1** and **2**, there are provided four suckers each pair provided at one side of two side shafts **18** and **18'**, respectively, and each side shaft **18** and **18'** has two suckers **30** and **30**, and **30'** and **30'** at its both ends held by respective holding plates **23** and **23**, and **23'** and **23'** which are in similar positions related to the top sheet of the stacked sheets with each other and in a symmetrical position about the axis of the main shaft **10** with the other suckers provided on the other side shaft while each holding plate provided with the sucker through the pin **25** and **25'** consists of each quadric-crank chain mechanism with the respective link and plate of which end is fixed on the main shaft **10.**

Along the inside of the side boards **1** and **1** a pair of arm rods **36** and **36** are rotatably pivoted on the respective side board at their one end by pins **37** and **37**, and a support rod **38** is held by pins **39** and **39** between their other ends. A blowpipe **40** is fixed to a metal fixture fixedly secured to the middle portion of the support rod **38** so as to freely rotate with the support rod **38** around the pins **37** and **37**, one end of which the opening is connected with a means (not shown) for blowing air such as a blower while the other end of which the opening **41** having a board section is positioned to face to the upper right hand corner of the stacked sheets at the back of the sucker. Adjacent to the metal fixture **42**, there is a lever **43**, the leading edge of which is fixedly secured on the support rod **38** by a pin **44**, while a roller **45** rotatably provided at the end of the lever **43** is always in contact with the cam plate **16** by means of pressing force of a spring (not shown); when this roller **45** is in contact with the lobe **17** of the cam plate **16**, the opening **41** of the blowpipe **40** is in the position away from the stacked sheets as shown by the solid line in FIG. **1** and, when it is in contact with the small radius portion of the cam plate, the opening **41** of the blowpipe **40** is in the position near to the stacked sheets as shown by the dotted line.

The pair of the fixed cams **46** and **46** provided in parallel at the bottom edge of both side boards **1** and **1** are gently sloped and rising from the right to the left at their upper surface, and the roller **35** and **35'** of the suckers **30** and **30** or **30'** and **30'** are always in contact with and rolling on the respective upper surface of the fixed cams by forced pressing of the springs, respectively, when the pair of suckers **30** and **30** or **30'** and **30'** move in the range around the fixed cams. When the driven gear **15** and the cam plate **16** are simultaneously rotated by the drive gear **8**, the planet gears **20** and **20'** move around the sun gear **22** while turning on its axis so that the side shafts **18** and **18'** move around the sun gear while allowing each holding plate **23** and **23'** to turn around on its axis. By such movement, since the gear ratio between the planet gear **20** and **20'** and the sun gear **22** is 1 : 3, the center of the pins **25** and **25'** in each holding plate follows three concave sine curves which substantially form a triangular cycloid orbit T as with an ideal line shown in FIG. **1.** The cam surface of the cam **46** provided along the base portion of the triangular cycloid orbit T are formed in such a manner that, when the pin **25** or **25'** travels on the base of the triangular cycloid orbit T, the cam guides the cam roller **35** or **35'** in coordination with the quadric crank chain mechanism and the spring **33** or **33'** so as to keep the sucker **30** or **30'** vertical, that is, to keep the suction

pad 31 or 31' facing the direct front of the top sheet of the stacked sheets in succession as shown in several views *e*, *f*, *g*, of the sucker pad described by ideal lines in FIG. 1. In addition, the line 26 or 26' serves to prevent the spring 33 or 33' from overstretching when the cam roller 35 or 35' is rolling on the cam surface of the cam 46.

In the arrangement so far described, the main shaft 10 is provided with a straight shaft hole 47 along the axis thereof, the outer end of which opening is connected with a conventional vacuum pump for sucking air (not shown), and the inner edge of which is connected with a hollow 50 of circular arc shape provided at the front side of the main body 13 through a vertical hole 48 and a lateral hole 49 which are provided in the main body 13. The cam plate 16 is provided with a pair of coupling holes 51 and 51' each adapted to connect at its outer edge with the hollow 50 of the main body 13 in the range of the arc shaped area of the hollow 50 during the rotation of the cam plate 16, and to always connect at its inner edge, during the rotation of the side shaft 18, with a shaft hole 52 which is provided in the side shaft 18 along its axis thereof and connected at its both ends with a pair of vertical holes 53 and 53 provided in the respective holding plates 23 and 23, each vertical hole 53 being connected with the lateral hole 54 provided in the respective pin 25. Each lateral hole 54 is connected with a vertical hole 55 provided in the sucker 30 and suction pad 31. In the main body 13, there is provided a lateral hole 56 a little away from the hollow 50, the back end of which opens to the outside of the main body 13 through a vertical hole 57, and the front end of which opens onto the front side of the main body 13 facing the back side of the cam plate 16 so as to connect with either one of the coupling holes 51 and 51' of the cam plate 16 during the rotation of the cam plate 16. When each one of the suckers 30 and 30' rotating and revolving through the action of the drive gear 8 comes into the position for picking up the top sheet of the stacked sheets, the corresponding coupling hole 51 of the cam plate 16 lines up with the front edge of the hollow 50 of the main body 13, and the vertical hole 55 of the corresponding sucker 30 and suction pad 31 lines up with the lateral hole 54, the vertical hole 53, the shaft hole 52, the coupling hole 51, the hollow 50, the lateral hole 49, the vertical hole 48 and then the shaft hole 47 in order, thus providing the suction force for the sucker 30 by means of the conventional vacuum pump. So long as the hollow 50 of arc shape is connected with the coupling hole 51, the suction operation of the sucker 30 continues, but stops when the coupling hole 51 is apart from the hollow 50. Thus, when the sucker 30 is caused by the rotation of the cam plate 16 to move to the position intermediate to the base portion of the triangular cycloid orbit T as shown by the dotted line *f* of FIG. 1, the vertical coupling hole 51 meets the lateral hole 56 of the main body 13, whereby air flows in from outside through the vertical hole 57 and causes the sucker 30 to lose its suction force. Upon the rotation of the cam plate 16, two sets of the pair of suckers are circulated in such a cycle that a pair of suckers are brought into suction operation while the other pair of suckers are non-operating, and, in turn, the latter enter into suction operation after the former have stopped, each suction pad of which being moved on a path S shown in FIG. 1.

The operation of the paper feeding apparatus of the construction as hereinbefore fully described will be mentioned hereinafter.

When the printing machine is operated together with the motor of drive gear 8, the drive gear 8 drives the driven gear 15 clockwise in the direction of the arrow *d* and the cam plate 16 follows the driven gear 15 and rotates in the same direction, whereby each planet gear 20 or 20' moves around the sun gear 22 together with the respective side shaft 18 or 18' while turning around on its own axis. Since the gear ratio of the planet gears 20 and 20' to the sun gear 22 is made 1 : 3, each pair of holding plates 23 and 23, and 23' and 23' fixed to the respective side shafts 18 and 18' go around on the triangular cycloid orbit T at their center points 25 and 25 and 25' and 25' at the same time. When two pins 25 and 25 or 25' and 25' of one pair of holding plates 23 and 23, or 23' and 23' reach the right edge of the base portion of the triangular cycloid orbit T, two suckers 30 and 30 or 30' and 30' secured by the respective pins 25 and 25, or 25' and 25' come close to the upper surface of the top sheet of the stacked sheets 4 on the right. Hereupon, the vertical coupling hole 51 of the cam plate 16 is in connection with the hollow 50 of the main body 13, and, thereby, the respective vertical holes 55 and 55, or 55' and 55' of two suckers 30 and 30, or 30' and 30' are in connection with the shaft hole 47 of the main shaft 10 so that the suckers 30 and 30, or 30' and 30' simultaneously take in air to produce the suction force, whereby the top sheet *a* of the stacked sheets 4 is lifted up by its right edge as shown in FIG. 1. Although the pair of two suckers are rotated around the main shaft 10 at the same time by the drive gear 8, the explanation mentioned hereinafter is, for the sake of brevity, directed to the operation with respect to one sucker 30 shown in FIG. 1.

When the sucker 30 moves from the right to the left, the cam roller 35 of the sucker 30 is brought to ride on the cam 46, and the sucker 30 is pulled to the left and its suction pad 31 is kept vertical in cooperation with the spring 33 and the quadric crank chain mechanism. As the cam roller 35 begins to ride on the cam surface of the cam 46 and the sucker 30 is in the position near the center of the base portion of the triangular cycloid orbit T as shown by the dotted line *e*, the cam roller 45 of the lever 43, which has passed on the lobe 17 of the cam plate 16, drops down to the smaller diameter portion of the cam plate 16 by the pressing force of the spring and the blowpipe 40 goes down with the lever 43 to the position shown by the dotted line 40' and blows out air from the broad section 41' thereof under the top sheet *b* sucked by the sucker 30, resulting in that the left edge of the top sheet *b* floated by the air easily passes over the stopper 5 and the top sheet *b* is taken to the left with the sucker 30. In addition, the stopper 5 can be shifted to detach from the sheets by the conventional driving mechanism (not shown) so as to permit the sheet to easily pass over the stopper when the sheet is brought forward by the sucker. When the sucker 30 goes further to the position shown by the dotted line *f*, the vertical coupling hole 51 of the cam plate 16 moves away from the end edge of the hollow 50 of the main body 13 lines up with the lateral hole 56 so that air flows in from outside and caused the sucker 30 to lose the suction force; thus, the sheet *c* held to the suction pad 31 of the sucker 30 is released. At this time, as the left edge of the sheet *c* gets to the contact

portion of the feed rolls **6** and **6**, the sheet *c* which has been released from the sucker **30** is fed to the printing mechanism through the feed rolls **6** and **6**. After the cam roller **35** moves further on the cam **46** and the sucker **30** shifts in the vertical position from the position *f* to the position shown by the dotted line *g*, when the cam roller **35** gets out of the cam **46** and the pin **25** reaches the left side and the cam roller **35** gets out of the cam **46**, the sucker **30** is quickly turned upward by the spring **33** to come back to its free position as shown by the other sucker **30'**. At this time, the cam roller **45** rides on the lobe **17'** of the cam plate and raises the blowpipe up to the position shown by the solid line, on which the air blowing operation of the blowpipe is stopped by the conventional control means in a known manner while the sucker **30'** comes to the position shown by the sucker **30** so as to repeat the above-mentioned feed operation. Thus, each suction pad of suckers is continuously circulated around the main shaft **10** on the path S shown in FIG. **1**.

Accordingly, the paper feeding apparatus of the present invention is provided with a plurality of suckers rotating around the main shaft at half of the speed of the drive gear **8** in one direction in a row with a constant interval between each other so as to operate for separating and forwarding the top sheet of the stacked sheets one after the other in succession, whereby the feeding operation can be carried out accurately and continuously at high speed even when the suckers are rotating at relatively slow speed.

Referring now to FIGS. **3** and **4** in which a second preferred embodiment of the present invention is shown, the only difference between the first and second embodiments resides in the construction of the planetary gear systems. In connection with the sun gear of the planetary gear systems, an internal gear is employed in the second embodiment, though the outer gear is employed in the first embodiment. In FIG. **3**, an internal sun gear **22** is formed in the center portion of a plane plate **60**, which is fixed at its end portion on the side board **1** through a pair of supporting bars **61**, so as to place at concentric position with the main shaft **10**, and is always in mesh with a pair of planet gears **21** and **21'** secured on the respective side shafts **18** and **18'** and placed inside of the internal gear **22**. The planet gear is rotated in which condition the inside portion thereof is inserted into a groove **13'** provided on the periphery of the main body **13**. Thus, each planet gear **21** and **21'** engages with and rotates around the sun gear **22** of the plane plate **60** while being caused to revolve by rotation of the respective side shaft together with the driven gear **15**. The gear ratio between the planet gears **20** and **20'** and the sun gear **22** is made 1 : 3. In addition, there is provided an auxiliary cam **62** fixed on the side board **1** at the right side of the cam **46**, which contacts with the cam roller **35** so as to guide the sucker **30** to the suction position in the vertical position. This embodiment of FIGS. **3** and **4** functions substantially in the same manner as in the foregoing embodiment without any reduction of the performance. Although the present invention has been fully disclosed in conjunction with the various preferred embodiments thereof, changes and modifications are apparent to those skilled in the art. For example, in the construction of the planetary gear systems, the gear ratio between the planet gears and the sun gear may be changed into preferred one other than 1 : 3. Also, the blowing operation of the blow pipe **40** can be associated with the suction operation of the sucker as well as the shifting operation of the stopper **5** for obtaining smoothly the forward movement of the sheet. In any way, the present invention is not to be limited by the embodiment, but such changes and modifications should be construed as included within the scope thereof unless otherwise departing therefrom.

What I claim is:

1. An automatic sheet feeding apparatus for use in a printing machine comprising: a main shaft, at least two suckers arranged in a row around said main shaft with a predetermined interval provided between each sucker, suction means connected with the respective sucker for sucking air from said suckers, and driving means for driving said suckers, said driving means including a planetary gear system consisting of a sun gear fixed at a concentric position with said main shaft and at least two planet gears each meshed with said sun gear and revolving therearound while rotating on its axis in one direction, link means operatively connected with each of said suckers, said link means including a first means for connecting each of said planet gears with a respective sucker and a second means operatively connected with said first connecting means for connecting each of said suckers with said main shaft, a cam means for guiding the movement of each of said suckers, said first and second connecting means being operatively interconnected with said cam means to face each of said suckers in the direction of a top sheet of stacked sheets for a predetermined constant distance, said cam means and said first and second connecting means enabling each of said suckers to travel along a cycloid curve produced by said planetary gear system with said predetermined constant distance corresponding to the range of said cycloid curve, and means for operatively connecting said suction means with each of said suckers to suck the top sheet of the stacked sheets for a predetermined period to separate it from the other sheets and forward it to the printing machine.

2. A sheet feeding apparatus according to claim **1**, wherein said sun gear comprises a fixed internally toothed gear.

3. A sheet feeding apparatus according to claim **1**, wherein said sun gear comprises a fixed externally toothed gear.

4. A sheet feeding apparatus according to claim **1**, wherein the gear ratio between the sun gear and the planet gear is made 1 : 3.

5. A sheet feeding apparatus according to claim **1**, wherein said means for operatively connecting said suction means with each of said suckers is operatively connected with said driving means, whereby said suction means is operated in accordance with the position of each of said suckers.

6. An automatic sheet feeding apparatus for use in a printing machine, comprising: a main shaft, at least two suckers arranged in a row around said main shaft with a predetermined interval provided between each sucker, suction means connected with the respective sucker for sucking air from said suckers, and driving means for driving said suckers, said driving means including a planetary gear system consisting of a sun gear fixed at a concentric position with said main shaft and at least two planet gears each meshed with said sun gear, each of said planet gears being operatively connected to a respective sucker and revolving around said

sun gear while rotating on its axis in one direction, link means operatively connected with said suckers, and a cam means for guiding the movement of each of said suckers, said cam means and said link means being operatively interconnected to face said suckers in the direction of a top sheet of stacked sheets for a predetermined contant distance, said cam means and said link means enabling each of said suckers to travel along a cycloid curve produced by said planetary gear system with said predetermined constant distance corresponding to the range of said cycloid curve, said link means including a first lever fixedly connected with a planet gear and rotatably connected with one of said suckers, a second lever operatively connected to said first lever rotatably secured on said main shaft, and a spring provided between said second lever and a respective sucker, whereby the top sheet of the stacked sheets is sucked by said sucker for a predetermined period to separate it from the other sheets and forward it to the printing machine.

7. An automatic sheet feeding apparatus for use in a printing machine comprising: a main shaft, at least two suckers arranged in a row around said main shaft with a predetermined interval provided between each sucker, suction means connected with the respective sucker for sucking air from the sucker, driving means for driving said sucker, said driving means including a planetary gear system consisting of a sun gear fixed at a concentric position with said main shaft and at least two planet gears each meshed with said sun gear and revolving there-around while rotating on its own axis in one direction, link means operatively connected with each of said suckers, said link means including a first means for connecting each of said planet gears with a sucker and a second means operatively connected with said first connecting means for connecting each of said suckers with said main shaft, said first and second connecting means being operatively interconnected with said cam means to face each of said suckers in the direction of a top sheet of stacked sheets for a predetermined constant distance, said cam means and said first and second connecting means enabling each of said suckers to travel along a cycloid curve produced by said planetary gear system with said predetermined constant distance corresponding to the range of said cycloid curve, means for blowing air under the sheet sucked by said sucker to promote the operation of the sucker, and means for operatively connecting said suction means with each of said suckers to suck a top sheet of the stacked sheets for a predetermined period to separate it from the other sheets and forward it to the printing machine.

8. A sheet feeding apparatus according to claim **7**, wherein said blowing means is operatively connected with a part of the driving mechanism so that it is operated in accordance with the position of the sucker.

9. An automatic sheet feeding apparatus comprising: a main shaft, a plurality of suckers disposed about said main shaft, means connected with each of said suckers for sucking air therefrom, means for driving said sucker including a first gear concentrically mounted with respect to said main shaft, a plurality of second gears each meshed with said first gear, link means operatively connected with each of said suckers, said link means including a first means for connecting each of said second gears with a respective sucker and a second means operatively connected with said first connecting means for connecting each of said suckers with said main shaft, said first and second connecting means being operatively interconnected with said cam means to move each of said suckers in the direction of a top sheet of stacked sheets for a predetermined constant distance, and means for operatively connecting said suction means with each of said suckers to suck said top sheet from the stacked sheets.

10. An automatic sheet feeding apparatus comprising: a main shaft, a plurality of suckers disposed about said main shaft, means connected with each of said suckers for sucking air therefrom, means for driving said sucker including a first gear concentrically mounted with respect to said main shaft, a plurality of second gears each meshed with said first gear, means for operatively connecting said second gears to a sucker, link means operatively connected with said first gear and said suckers, cam means for guiding the movement of said suckers, and means for operatively interconnecting said cam means with said means for connecting said first gear with said sucker, said suckers having an operative position and a free position, said first gear comprising a sun gear and said second gears comprising planetary gears meshing with said sun gear, said link means including a first lever rotatably connected with said sucker and fixedly connected with a planet gear, a second lever pivotally connected to said first lever and rotatably secured on said main shaft, and means between said second lever and said sucker for urging said sucker from said operable position to said free position, whereby each of said suckers is caused to move in the direction of a top sheet of stacked sheets for a predetermined constant distance to suck said top sheet from the stacked sheets.

11. A sheet feeding apparatus according to claim **10**, wherein said last mentioned means includes a spring disposed between said sucker and the point of pivotal connection of said first and second levers.

12. A sheet feeding apparatus according to claim **11**, wherein means are provided for aiding said suckers in separating the top sheet from the stacked sheets.

13. A sheet feeding apparatus according to claim **12**, wherein said last mentioned means includes a blower for blowing air under the sheet sucked by said sucker, and wherein means are provided for operatively interconnecting said blower with said means for driving said sucker to cause said blower to blow air under the top sheet when the sheet is sucked by said sucker.

14. A sheet feeding apparatus according to claim **13**, wherein said sun gear comprises a fixed internally toothed gear.

15. A sheet feeding apparatus according to claim **13**, wherein said sun gear comprises a fixed externally toothed gear.

16. A sheet feeding apparatus according to claim **10**, wherein said cam means includes a cam plate rotatably mounted on said main shaft, said cam plate being provided with a pair of lobes symmetrically disposed with respect to said main shaft, and a pair of fixed cams cooperable with said suckers.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,836,139 Dated September 17, 1974

Inventor(s) Shigeru Shimizu

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Title page, insert the following:

[30] Foreign Application Priority Data

August 26, 1971 Japan ... 65632/71

Signed and sealed this 17th day of December 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents