A paper feeding apparatus according to the present invention has a pickup roller, which includes a drive shaft disposed so as to cross a sheet tray and a plurality of roller parts intermittently attached to the drive shaft, and elastic supporting means, which substantially independently supports a plurality of exposed parts of the drive shaft so as to apply pressure towards a base plate of the sheet tray. In the paper feeding apparatus, respective exposed parts of the drive shaft, which has a narrow diameter and being flexible, are independently pressurized towards the sheet tray of the base plate, so that the respective roller parts contact tightly with the sheet paper substantially independently. Accordingly, sheets can be fed with high reliability by making the most of the flexibility of the drive shaft. The extremely slim and highly reliable paper feeding apparatus with the extremely slim pickup roller is provided. By stacking a plurality of these paper feeding apparatuses, a compact multitray can be provided.
Fig. 6A

Fig. 6B

Fig. 6C
Fig. 14
SHEET FEEDER AND PRINTER

TECHNICAL FIELD

[0001] The present invention relates to a paper feeding apparatus that can store a plurality of sheets and can feed the stored sheets one at a time, and to a multiple paper feeding apparatus in which paper feeding apparatuses are stacked on a plurality of levels.

RELATED ART

[0002] Among copiers and large-scale printers, there are devices in which a plurality of sheet trays or paper feeding apparatuses are stacked so that it is possible to freely select and print on sheets (that is cut paper or cut sheets) of different sizes and types. In such copiers and printers, sheets of different types and/or sizes are stored in advance in the paper feeding apparatuses, so that when the cut sheets to be printed upon are changed, it is possible to change the size and/or type of printed sheet easily by merely selecting the paper feeding apparatus storing the intended cut sheets as the paper feeding tray to be used.

[0003] To make it possible to select and supply a plurality of types of sheets of different sizes, paper qualities, and applications (for example, envelopes and cut sheets), and the like, there are paper feeding apparatuses (multiple paper feeding apparatuses) in which a plurality of paper feeding apparatuses are stacked in a multi tray structure. The stored number of one type of sheets is normally 100 or above. Accordingly, printers integrally provided with such paper feeding apparatuses are inevitably large and costly. For this reason, present printers that include multiple paper feeding functions are only provided as standalone large-scale copiers and laser printers for large-scale users.

[0004] Among small-scale users whose equipment is for personal use and/or who have a small print volume, there are users who print on sheets selected from a plurality of types of sheets in spite of having low numbers of each sheet type. During personal use, there are many cases where different sheets are used, such as sheets of different sizes, for example, B4 (257x364 mm) that is larger and B5 (182x257 mm) or postcard size (for example, 100x148 mm) that are smaller than normal A4 size (210x297 mm), sheets that are A4 size but are printed in portrait and landscape orientation, sheets of different qualities, such as glossy photographic paper as opposed to normal paper, and sheets of different thicknesses, such as envelopes as opposed to normal paper.

[0005] It is extremely troublesome to change the set sheets whenever a different type of sheet is used, so that there is demand for a personal printer in which many types of sheets are set in advance. If it were possible to make the individual paper feeding apparatuses, that is, the paper feeding trays slimmer, it would be possible to make a multiple paper feeding apparatus slimmer and therefore also possible to supply a multi tray-type printer suited to personal use. For example, if the thicknesses of the individual paper feeding apparatuses can be set at around 1 to 3 cm, it will be possible to realize a multiple paper feeding apparatus that can store around seven or eight types of sheets in a thickness of around 20 cm.

[0006] If the stored number of sheets is reduced, it is possible to make the sheet trays slimmer, but when the sheet trays are disposed, especially, the sheet trays are arranged in a stack, it is also necessary to consider the thicknesses of the pickup rollers that pick up sheets from the trays. That is, to dispose one sheet tray, a height corresponding to at least the diameter of one pickup roller and the thickness of the sheets is required, with the thickness required to store a mechanism for driving the pickup roller also being necessary. Accordingly, to realize a slim, compact multiple paper feeding apparatus (hereinafter referred to as a "multi tray"), it is important to reduce the diameter of the pickup roller. In particular, to realize a sheet tray with a thickness of around 1 to 3 cm as mentioned above, the pickup roller needs to be around several mm in diameter, which means that the pickup roller itself is inevitably flexible.

[0007] A paper feeding apparatus is known in which a movable bottom plate is provided on the bottom surface of a sheet tray and the bottom plate is pressed by the force of a spring against a pickup roller above. In this paper feeding apparatus, to press the maximum number of cut sheets that can be set against the pickup roller with sufficient force, the bottom plate is pressed with sufficient force to oppose the weight of the sheets. Accordingly, as the number of sheets falls, the force applied to the pickup roller becomes extremely large and the pickup roller needs to be sufficiently rigid to withstand such force. This construction can therefore be said to be unsuited to reducing the diameter of the pickup roller. In particular, in this method, since the force that acts between the pickup roller and the sheets varies with the thickness of the sheets, it is necessary to apply a large force to the bottom plate with a large spring so as to obtain a sufficient frictional force when there are a large number of sheets. On the other hand, since the frictional force becomes too great as the number of sheets falls, it is necessary to provide a separating apparatus with a complex construction to prevent a plurality of sheets from being supplied simultaneously.

[0008] A method that moves the pickup roller so as to press the sheets is superior in that the pressing force is unaffected by the weight of the sheets, so that the apparatus can be made compact. However, a certain amount of frictional force is necessary to feed a sheet, and for the pickup roller to press the sheets with the force required to obtain this frictional force, the pickup roller needs to have a certain degree of rigidity. Accordingly, there is a limit on how slim the pickup roller can be made, and it is not possible to use a pickup roller that is several mm or so in diameter and so has little rigidity. A mechanism for moving the pickup roller up and down for setting cut sheets in the sheet tray also becomes necessary.

[0009] For a paper feeding apparatus, it is important to increase reliability by preventing "multiple feeding" where a plurality of sheets are fed in an overlapping state and to avoid internal paper jams for the sheets.

[0010] For this reason, it is an object of the present invention to provide an extremely slim paper feeding apparatus that uses a pickup roller which is several mm or so in diameter and so cannot be especially rigid. To realize an extremely slim paper feeding apparatus, it is necessary to simplify the construction of the pickup roller periphery, and it is also an object of the present invention to provide a paper feeding apparatus that can reliably feed cut sheets one at a time, even when a simple construction is used. It is a further
object of the present invention to provide a highly versatile paper feeding apparatus where by simplifying the construction of the pickup roller periphery, a sheet width adjusting function can be added to the paper feeding apparatus without increasing the apparatus size so that cut sheets of different sizes can be easily set in a single paper feeding apparatus.

[0011] The ability to set cut sheets easily is also important, and if a complex mechanism is required for moving a pickup roller to set sheets, this can also cause increases in the size of the paper feeding apparatus. Accordingly, it is a further object of the present invention to provide a paper feeding apparatus which is extremely small but in which sheets can be set easily. It is yet another object of the present invention to provide a highly reliable paper feeding apparatus in which multiple feeding and paper jams can be avoided. The present invention also has objects of providing a compact multiple paper feeding apparatus where a plurality of small paper feeding apparatuses are arranged in a stack so that a desired type of sheet can be easily selected and of providing a more convenient, compact printing apparatus that uses such multiple paper feeding apparatuses.

DISCLOSURE OF THE INVENTION

[0012] For this reason, in the paper feeding apparatus of the present invention, a pickup roller that has a plurality of roller parts intermittently disposed on a drive shaft is used, and a plurality of exposed parts of the drive shaft of the pickup roller are supported independently inside the sheet tray so as to apply pressure toward the base plate of the sheet tray. To realize an extremely slim paper feeding apparatus, it is necessary to use a drive shaft whose diameter is extremely small at around several mm, so that the shaft cannot be made rigid and inevitably must be treated as a flexible shaft that flexibly deforms. However, if the drive shaft flexibly deforms, even if both ends of the drive shaft are pressed, it will not be possible to apply a predetermined force onto the sheets with roller parts along the length of the pickup roller, that is, in the sheet width direction, so that it will not be possible to transmit the paper feeding force to the sheets. Alternatively, the paper feeding force is transmitted to the sheets in an extremely unbalanced state, so that the sheets become wrinkled and it becomes no longer possible to feed sheets in a straight manner. This problem simply worsens if the force applied to the shaft is increased, and if the rigidity is increased by whatever method to eradicate this problem, a rigid member with an increased cross-sectional area inevitably has to be used, so that the thickness of the paper feeding apparatus is increased.

[0013] In the present invention, conversely by using the flexibility of the drive shaft and using elastic bodies, such as a plurality of springs, that move independently, short parts of the drive shaft, as represented by the roller parts, are set as units, and the respective roller parts are pressed in the direction of the base plate substantially independently. With this construction, the respective roller parts tightly contact the sheets independently, so that by using a pickup roller that uses a flexible drive shaft instead of a pickup roller that uses a highly rigid drive shaft, the contact area between the roller parts and the sheets and the contact length in the sheet width direction can be increased. Accordingly, by using a flexible pickup roller, it is possible to transmit a paper feeding force to the sheets more effectively, which increases the reliability of paper feeding and can eradicate problems such as skewing and wrinkling of the sheets.

[0014] In particular, when the sheets to be fed are items, such as envelopes, whose thickness can often be uneven, a flexible pickup roller will deform in accordance with the changes in thickness and so is more reliable than a highly rigid pickup roller. In addition, since the contact length and/or area can be increased, the force applied to the pickup roller can conversely be reduced. It is therefore possible to avoid unnecessary increases in the frictional force between the sheets, which makes it possible to reduce errors such as multiple feeding where a plurality of sheets are simultaneously fed.

[0015] In addition, an extremely simple mechanism, such as simple coil springs or plate springs, can press divisionally and independently the drive shaft by a plurality of parts thereof. Accordingly, it is sufficient to dispose an elastic (resilient) supporting means with a simple mechanism inside the sheet tray, so that the space occupied by the elastic supporting means can be made extremely small. This means that the thickness of the paper feeding apparatus can be made even smaller. When a sheet tray is full of set sheets, a simple construction such as coil springs or plate springs used as the elastic supporting means can contract and substantially fit into the thickness of the pickup roller, so that there is no interference between the set sheets and the elastic supporting means. Accordingly, it is possible to use an extremely slim sheet tray with only enough thickness to cover the space for setting sheets and the space occupied by a slim pickup roller of around several mm in size, so that an extremely slim design can be used for the paper feeding apparatus as a whole.

[0016] In addition, it is sufficient to dispose an elastic supporting means with a simple mechanism inside the sheet tray, so that the construction of the periphery of the pickup roller can also be simplified. This means that a sheet width adjusting plate that slides in the sheet width direction on the surface of the base plate of the sheet tray can be installed without increasing the size of the paper feeding apparatus, so that when sheets of different sizes and widths are used, such sheets can be set easily using the sheet width adjusting plate. By doing so, it is possible to increase the versatility of the paper feeding apparatus.

[0017] Also, by disposing a drive shaft so as to cross the sheet tray, it is possible to dispose a driving mechanism, such as a motor, outside the sheet tray, so that space taken up by the driving mechanism, such as a motor and gears, does not need to be included in the internal dimensions of the sheet tray of a paper feeding apparatus. This means that the capacity of the sheet tray can be increased, and the paper feeding apparatus can be made even slimmer. In addition, by disposing the drive shaft so as to cross the sheet tray, the pickup roller will reliably contact sheets of any size that fit inside the sheet tray, so that sheets can be fed with high reliability.

[0018] Therefore, a paper feeding apparatus according to the present invention includes: a sheet tray that is capable of storing a plurality of sheets and includes, at a front thereof, a separation wall that is struck by an edge of the sheets in a paper feeding direction; a pickup roller including a drive shaft disposed so as to cross the sheet tray and a plurality of roller parts intermittently attached to the drive shaft; elastic supporting means for substantially independently supporting a plurality of exposed parts of the drive shaft so as to apply
pressure toward a base plate of the sheet tray; and a driving mechanism that drives the drive shaft of the pickup roller and is disposed on the outer surface side of the sheet tray.

[0019] This paper feeding apparatus uses a method where sheets are pressed by the pickup roller by independently pressing the drive shaft toward the base plate of the sheet tray, so that even if the number of sheets inside the sheet tray changes, there is no change in the pressing force of the pickup roller on the sheets. This point makes the paper feeding apparatus very reliable. A sheet is fed with the drive shaft supported with a simple elastic supporting means, the pickup roller will contact the sheet. However, since the feeding of sheets is carried out after the starting of print by a printing mechanism, the pickup roller that contacts the sheet will act as a load. To reduce this load, a clutch that rotates in a single direction, such as a one-way clutch, may be provided in the driving mechanism.

[0020] According to the paper feeding apparatus of the present invention, as described above, it is possible to realize a highly reliable paper feeding apparatus with an extremely fine pickup roller. This means that by stacking a plurality of paper feeding apparatuses as a multiple paper feeding apparatus and adding a tray selecting/driving function, it is possible to provide an extremely compact multiray in which a plurality of types of sheets can be selected and fed. A printing apparatus that includes a multiple paper feeding apparatus and a printing mechanism that prints on a sheet fed by the multiple paper feeding apparatus allows users to select and use a plurality of types of sheets and is extremely compact and easy to use.

[0021] So long as the sheets are of a size that fits in the sheet tray, the paper feeding apparatus of the present invention can feed sheets of any size and type with high reliability. Accordingly, by setting the width of the sheet tray equally for a plurality of paper feeding apparatuses, it is possible to provide a multiple paper feeding apparatus that functions like a single tray. By providing, in the respective paper feeding apparatuses, a sheet width adjusting plate that moves on a surface of the base plate of the sheet tray to set various types of sheets with different widths on a same side, out of a left side and a right side, of the respective sheet trays, it is possible to automatically set the width to be printed with one side of the sheet trays as a reference. Also, since the driving mechanisms are disposed outside the respective paper feeding apparatuses, by providing two types of paper feeding apparatuses where the driving mechanisms are disposed on one of the left and right outer surfaces and stacking such paper feeding apparatuses alternately, it is possible to provide a more compact multiple paper feeding apparatus where the driving mechanisms of upper and lower paper feeding apparatuses do not interfere.

[0022] In the paper feeding apparatus of the present invention, the drive shaft is supported by an elastic supporting means that has independent coil springs or the like, so that the entire pickup roller swings toward the base plate of the sheet tray. The pickup roller is also susceptible to moving forwards and backwards, so that the position at which the pickup roller contacts the sheets can become unstable when the elastic supporting means is constructed so as to support the drive shaft so as to swing in a direction of the base plate about a support point at some distance above the base plate, it is possible to support the drive shaft so that the position in the front-back direction and angle at which the pickup roller contacts the sheets is stabilized without preventing the drive shaft from independently moving toward the base plate, so that the paper feeding direction of the respective roller parts can be stabilized.

[0023] As one construction that elastically supports the drive shaft so as to be able to swing, it is possible to use an elastic supporting means including a plurality of frames that support the drive shaft so that the drive shaft swings and a plurality of elastic bodies that apply pressure to the exposed parts of the drive shaft or to the frames toward the base plate of the sheet tray. As another construction, it is possible to use, as the elastic supporting means, plate springs disposed with parts that elastically deform extending in the paper feeding direction, that is, the front-back direction. The plate springs of this aspect extend in the paper feeding direction, so that the modulus of elasticity corresponding to the up-down displacements of the drive shaft is reduced and it is possible to supply to the drive shaft a comparatively weak pressing force that is less varied relative to up-down displacements of the drive shaft. Accordingly, the drive shaft can be pressed with a small and substantially fixed force. By doing so, multiple feeding where a plurality of cut sheets are fed can be prevented more reliably. In addition, the plate springs of this aspect may be springs that are bent back at parts thereof. By using such plate springs, it is possible to support the drive shaft so as to be able to swing with the bent back point as the center point.

[0024] In the paper feeding apparatus of the present invention, the individual roller parts are pressed with a comparatively weak force, so that cut sheets can be inserted into the sheet tray without lifting up the pickup roller. If the elastic supporting means is a swinging mechanism, at the setting, the front ends of the sheets strike the frames for swing or plate springs and push up the pickup roller, so that it becomes even easier to set the sheets. When sheets are fed, by making the parts that attach the frames to the exposed parts of the drive shaft, or the parts that attach or link the plate springs to the exposed parts of the drive shaft, rise in an upwards direction for the sheet tray from the base plate, on an opposite side to the base plate, it is possible to prevent interference between the cut sheets and the elastic supporting means. In addition, by setting the gap or distance provided by the linking parts or connecting parts within the diameter of the roller parts, it can be ensured that the roller parts contact the front end of the uppermost sheet. Accordingly, by driving the pickup roller after sheets have been set, it is possible for the roller parts to automatically ride up onto the uppermost sheets, so that sheets can be fed in order starting from the uppermost sheet. That is, the paper feeding apparatus should preferably include linking members or connecting parts that connect the elastic supporting means and the exposed parts of the drive shaft on an opposite side to the base plate with a distance no greater than a diameter of the roller parts between elastic supporting means and the exposed parts. Such connecting parts may be integrally formed with the elastic supporting means.

[0025] For the roller parts to automatically rise up onto the uppermost sheet, roller parts that are eccentric or noncircular should preferably be used. Since the position at which the roller parts contact the sheets changes as the roller parts rotate, by rotating the roller parts, the sheet that contacts the outer circumferential surface of the roller parts is automa-
cally fed under the roller parts, or the roller parts ride up onto the sheet, so that the roller parts automatically move onto the uppermost sheet.

[0026] In the paper feeding apparatus of the present invention, the pickup roller extends so as to cross the sheet tray, so that when sheets that are narrower than the width of the sheet are set and the number of remaining sheets becomes low, there is the possibility of the flexible pickup roller deforming and contacting the base plate of the sheet tray. For this reason, the roller parts of the pickup roller and the base plate should preferably be prevented from interfering with one another by forming a channel into which the roller parts fit or being received in the base plate so as to face the roller parts.

[0027] The elastic supporting means that supports the pickup roller can be attached to an upper wall provided above the sheet tray. Also, when the paper feeding apparatuses are designed to be used in a stack, it is possible to attach the elastic supporting means of a lower paper feeding apparatus to a rear surface of the base plate of the sheet tray. Also, when the paper feeding apparatuses are designed to be used in a stack, it is effective to form a channel into which the roller parts of a lower paper feeding apparatus fit or being received in the rear surface of the base plate of the sheet tray so as to face the roller parts. It is therefore possible to withdraw the roller parts of the lower paper feeding apparatus to the channel formed in the rear surface of the sheet tray of the upper paper feeding apparatus, so that the space for storing sheets can be further increased.

[0028] In the paper feeding apparatus of the present invention, convex parts formed so as to widen in the paper feeding direction or concave parts formed so as to narrow in the paper feeding direction should preferably be formed on the separation wall of the sheet tray. If such convex parts or concave parts are provided, when the roller parts rotate and feed sheets, the front ends of the sheets will deform along the concave and convex parts of the separation wall. The concave parts of the separation wall are pointed, that is, the concave parts that are recessed downwards become narrower in the paper feeding direction, so that the front end part of the sheet held in the concave parts are deformed by the concave parts so as to become convex toward the base plate, with the widths of the parts that have deformed to become convex becoming gradually narrower as the sheet is fed. Compared to a conventional method where the front end of the sheet contact a flat separation wall, the resistance generated in accordance with this deformation and the friction generated at the corners or edges of the concave parts are larger and more stable. In addition, this resistance increases toward the front end part (part on the paper feeding side) of the separation wall, which is ideal for separating sheets. When feeding a first sheet by rotating the roller parts, this resistance and friction act as resistance on the lower second sheet and prevent the second sheet from moving, so that the first sheet is reliably separated. By providing concave parts that narrow or are tapered off in the paper feeding direction at positions substantially corresponding in the paper feeding direction to the roller parts of the pickup roller, it is possible for the resistance of the separation wall to act more effectively on the second and following sheets.

[0029] In addition, with concave parts that are tapered off, resistance is generated while deforming the front end of the fed sheet. Accordingly, even if the sheets have been left in the tray for a long time and the shape of the front ends has assumed the shape of the separation wall, when a paper feeding force acts, the shape of the front end of the sheets will change due to the convexes and concaves of the separation wall, so that resistance for separating the sheets is reliably produced and there is still an effect even when the sheets change over time.

[0030] When the sheets are fed by the pickup roller, to make the sheets deform in accordance with the convexes and concaves of the separation wall, both ends of the sheets should preferably not enter the concave parts and the width of the sheet path should preferably not widen. Also, if concave parts are positioned at the ends of the sheets in the sheet width direction, there is also the possibility of the sheets contacting or catching on the walls of the concave parts that narrow in the paper feeding direction, resulting in the resistance becoming too great. Accordingly, it is preferable to provide convex parts at positions that are struck by the ends, in the sheet width direction, of the sheets of the respective sizes set in the sheet tray. Also, in the case where a sheet width adjusting plate moves for each size, it is preferable to provide a mask plate that moves together with the sheet width adjusting plate and forms a part for raising an end of the respective types of sheets in the sheet width direction at a front surface of the separation wall.

[0031] Although it is possible to prevent multiple feeding during paper feeding by producing an appropriate resistance using the separation wall, to obtain the suitable force, it is necessary to appropriately set the angle of the separation wall to the base plate of the sheet tray and to make the front ends of the sheets strike the separation wall at an appropriate angle. The angle between the separation wall and the base plate of the sheet tray is normally set at 90° or above, but by setting this kind of angle, a difference is produced in the separating function according to the amount of sheets remaining in the sheet tray. That is, when the pickup roller contacts an upper surface of the sheets stacked in the sheet tray and feeds sheets, if the pickup roller hardly moves in the paper feeding direction in spite of moving up and down in accordance with the amount of sheets, since the separation wall is inclined by an angle of 90° or above, a distance from the separation wall to the position contacted by the pickup roller in a state where sheets do not remain in the sheet tray will be smaller than a distance from the separation wall to the position contacted by the pickup roller in a state where sheets remain in the sheet tray.

[0032] To prevent multiple feeding when the front ends of the sheets strike the separation wall, it is necessary for the front ends of the sheets to be pressed onto the separation wall with a certain amount of force using the stiffness (rigidity) of the sheets so as to use a reaction from the separation wall. Accordingly, the distance between the separation wall and the pickup roller cannot be made large. This means that the difference of the distance between the separation wall and the pickup roller is significant between when the front ends of the sheets strike a front end part of the separation wall in the paper feeding direction with a large number of sheets remaining in the sheet tray and when the front ends of the sheets strike a back end part of the separation wall in the paper feeding direction with few sheets remaining in the sheet tray. In the former case, the distance is longer and the sheets have low rigidity, so that
separation is difficult, while in the latter case, the distance is shorter and the rigidity of the sheets is high, so that it is easy for paper jams to occur.

[0033] For this reason, in the present invention, a first angle between a front end part of the separation wall in the paper feeding direction and the base plate of the sheet tray is smaller than a second angle between a back end part of the separation wall in the paper feeding direction and the base plate of the sheet tray. By doing so, the angle of the separation wall and the, sheet becomes smaller when the ends of the sheets strike a front end part of the separation wall in the paper feeding direction, so that it becomes easier to separate the sheets. On the other hand, the angle of the separation wall and the sheet becomes larger when the ends of the sheets strike a back end part of the separation wall in the paper feeding direction, so that paper jams are prevented. In addition, for a separation wall with convex parts, a first angle between front end parts of the convex parts in the paper feeding direction and the base plate of the sheet tray should preferably be smaller than a second angle between back end parts of the convex parts in the paper feeding direction and the base plate of the sheet tray. It is therefore possible to provide a highly reliable paper feeding apparatus that can feed sheets one at a time without being affected by the number of sheets set or remaining in the sheet tray. Such separation wall or convex parts where the angle differs between the front end parts and the back end parts include combinations of surfaces with different angles or curved surfaces where the angle between the front end part and the back end part differs.

[0034] If the sheets have high rigidity (stiffness), as described above, it is possible to make the distance between the separation wall and the parts contacted by the pickup roller longer, so that the difference between when there are many remaining sheets in the sheet tray and when there are few remaining sheets can be reduced. The difference in resistance when the front ends of sheets strike the separation wall is also large, so that multiple feeding is easier to avoid. In addition, since a balanced force is provided to sheets when feeding the sheets, there is no bending or skewing and it is also difficult for paper jams to occur. Since the sheets are bent in the sheet width direction, the rigidity can be increased even for thin sheets. However, by bending the sheets, the contact area between the sheets and the pickup roller falls, so that the driving force cannot be effectively transmitted to sheets. As a result, there is the problem that it is not possible to feed sheets with high reliability. However, with the paper feeding apparatus of the present invention, since the pickup roller is flexible, the pickup roller also bends so as to substantially assume the bent shape of the sheets and it becomes possible to make the pickup roller contact sheets with a uniform pressure in the sheet width direction, even for bent sheets. By doing so, it is possible to apply an approximately uniform paper feeding force in the paper feeding direction to sheets in a state where the sheets are made effectively rigid or stiff by bending the sheets. Accordingly, it is possible to provide a paper feeding apparatus that has even higher reliability in spite of being a slim paper feeding apparatus.

[0035] As the method of bending the sheets, the sheets may be concave or convex on the pickup roller side. As the sheet tray, it is possible to use a tray whose entire base plate is curved or a tray where only the end parts of the base plate in the sheet width direction are inclined or curved. When the sheets are bent so as to be concave on the pickup roller-side, it is possible to provide bending parts that are located at side walls of the sheet trays and/or the side wall-sides of the base plate and support the sheets set in the sheet tray so that parts near both ends bend in the sheet width direction, with at least one of these side walls being movable in the sheet width direction. On the other hand, when the base plate of the sheet tray is curved, if the sheets are placed on one side, there is the possibility of the direction of movement of a sheet becoming skewed after feeding. Accordingly, it is preferable for both sides of the sheet tray to move symmetrically about the center in the sheet width direction and for the sheets to be fed from the center of the sheet tray. In this way, even if the side walls of the sheet tray move in the sheet width direction, a flexible drive shaft is used, so that it is possible for the drive shaft to bend in accordance with the bending realized by the movement of the side walls.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] FIG. 1 is a diagram schematically showing the construction of a printing apparatus on which a multiple paper feeding apparatus according to the present invention has been mounted.

[0037] FIG. 2 is a side elevation of the multiple paper feeding apparatus shown in FIG. 1.

[0038] FIG. 3 is a plan view showing one paper feeding apparatus out of the two types of paper feeding apparatuses.

[0039] FIG. 4 is a plan view of the other paper feeding apparatus.

[0040] FIG. 5 is an exploded view schematically showing the paper feeding apparatus shown in FIG. 3.

[0041] FIG. 6A to 6C show how the pickup roller of the paper feeding apparatus swings in accordance with the number of cut sheets set in the sheet tray, with FIG. 6A showing the state where there are many cut sheets, FIG. 6B showing the state where there are few cut sheets, and FIG. 6C showing the state where there are no cut sheets left.

[0042] FIG. 7A to 7C are diagrams showing how the pickup roller rides up onto the uppermost cut sheet, with FIG. 7A showing the state where cut sheets have been set in the sheet tray, FIG. 7B showing the state where the pickup roller has started to rotate, and FIG. 7C showing the state where the pickup roller has ridden up onto the uppermost cut sheet.

[0043] FIG. 8 is a perspective view showing the peripheral parts of the separation wall of the paper feeding apparatus.

[0044] FIGS. 9A and 9B schematically show the interrelationship between the roller parts of the pickup roller and the concave parts of the separation wall, with FIG. 9A being a view from a surface side of the convex parts or concave parts and FIG. 9B being a view from a front side of the convex parts or concave parts.

[0045] FIG. 10 is a diagram showing an example where a channel into which the roller parts of a lower paper feeding apparatus being received is formed in a rear surface of a sheet tray of a paper feeding apparatus.
FIG. 11 is a diagram showing the appearance of a printer equipped with a different multiple paper feeding apparatus.

FIG. 12A to 12C show examples of paper feeding apparatuses that bend sheets set in the sheet tray and feed the sheets using a flexible pickup roller, with FIG. 12A showing an example where the entire base plate of the sheet tray is curved, FIG. 12B showing an example where a sheet width adjusting plate with a bending part is attached to the base plate shown in FIG. 12A, and FIG. 12C showing an example where bending parts are provided near both ends of a flat base plate.

FIG. 13 is a side elevation of the multiple paper feeding apparatus shown in FIG. 11.

FIG. 14 is a perspective view showing the sheet tray and outer case of the multiple paper feeding apparatus shown in FIG. 11 after removal from a printer.

FIG. 15 is a plan view showing one paper feeding apparatus that constructs the multiple paper feeding apparatus shown in FIG. 11.

FIG. 16 shows the respective sheet trays of the multiple paper feeding apparatus shown in FIG. 11 when viewed from above.

FIGS. 17A and 17B are diagrams for explaining the construction of the separation wall of the sheet tray shown in FIG. 11, with FIG. 17A showing the state where there are many cut sheets set in the sheet tray and FIG. 17B showing the state where there are few cut sheets set in the sheet tray.

BEST MODE FOR CARRYING OUT THE INVENTION

The present invention is described in more detail below with reference to the attached drawings. FIG. 1 schematically shows a printer with a multiple paper feeding apparatus, that is, a multitray including paper feeding apparatuses according to the present invention. The printer 1 includes a multitray 10 in which two types of paper feeding apparatuses 20 and 30 are alternately stacked on seven levels, with the respective paper feeding apparatuses 20 and 30 being capable of storing a plurality of sheet like papers (sheets), that is, cut sheets 2. The printer 1 also has a printing unit 3 that prints on the cut sheets 2 supplied from the multitray 10. The printing unit 3 includes a paper feeder 5, an ink jet-type printing head 6, and a discharge feeder 7. The printing unit 3 also includes a control unit 8 that receives print data and commands from a computer 9 that is a host, and controls the printing head 6, the feeders 5 and 7, and the multitray 10 based on the received information.

The multitray 10 has a construction where the two types of paper feeding apparatuses 20 and 30 are alternately stacked on an outer case 11 that is erected substantially vertically. The respective paper feeding apparatuses 20 and 30 are disposed so as to be substantially vertically inclined with paper feeding openings 29 at the bottom, and the cut sheets 2 outputted from the respective paper feeding apparatuses 20 and 30 are supplied to the printing unit 3 with a lower wall 11a of the outer case 11 as a sheet guide. In the following description, the direction in which the paper feeding apparatuses 20 and 30 are stacked on the outer case 11 is set as the “up-down direction” and the paper feeding direction of the paper feeding apparatuses 20 and 30 is set as the “front-back direction”. In more detail, the direction of the printing unit 3 shown in FIG. 1 is set as “upwards” and the direction of the paper feeding openings 29 is set as “forwards”.

FIG. 2 schematically shows the multitray 10 by way of a side elevation. The constructions of the paper feeding apparatuses 20 and 30 are schematically shown by plan views in FIG. 3 and FIG. 4. In addition, the main components of a paper feeding apparatus 20 are shown in FIG. 5 by way of an exploded diagram. Apart from the difference in the left-right positions at which driving mechanisms 41 are disposed, the paper feeding apparatuses 20 and 30 have the same arrangement and so will be described focusing on the paper feeding apparatus 20. The paper feeding apparatus 20 has a sheet tray 25 including a base plate 21, a left side plate 22, a right side plate 23, and a front plate 24. The front plate 24 is a separation wall that is struck by a paper feeding direction edge or front edge of the cut sheets 2. The uppermost cut sheets 2 stacked inside the tray 25 are separated one sheet at a time by the separation wall 24 and are fed to the printing unit 3 in the paper feeding direction F to the front with an upper part of the separation wall 24 as the paper feeding opening 29. The back B side of the sheet tray 25 is open, so that cut sheets 2 can be set. Cut sheets 2 that are larger than the sheet tray 25 are set in a state where parts of the cut sheets 2 stick out from the back B.

The width of the sheet tray 25 is design in accordance with the size of the largest cut sheets to be set in the sheet tray 25. In the present embodiment, the sheets set in the sheet tray 25 are referred to in general as “cut sheets”, but so long as the sheets can be fed to the printing unit 3 and printed upon one at a time, the sheets are not limited to paper sheets, and may be envelopes, medicine bags, receipts, medicine memo books, drug records, and the like. The concept of “cut sheet” or “sheet” in this specification refers to every medium that can be printed upon by the printing unit 3. The cut sheets 2 may be disposed with their length aligned in the front-back direction or aligned in the sheet width direction. In either case, the direction that is perpendicular to the front direction F that is the paper feeding direction is referred to in this specification as the “sheet width direction W”.

A sheet width adjusting plate 26 that slides in the sheet width direction W and can set a distance between itself and the right side plate 23 at the paper width of predetermined cut sheets 2 is provided on the base plate 21 of the sheet tray 25. Accordingly, in a sheet tray 25 in which sheets 2 of A4 size (210x297 mm) can be set, by moving the sheet width adjusting plate 26, it is possible to set cut sheets 2 of a size such as A5 (148x210 mm) or B5 (182x257 mm) that is smaller than A4 size or cut sheets 2 of a nonstandard receipt size (102x160 mm) or the like. It may also be possible to set cut sheets 2 of a larger size than A4, such as B4 size (257x364 mm). This means that the paper feeding apparatuses 20 are extremely versatile in that sheets 2 of different sizes or widths can be set easily. A part 37 that is concave or cut away toward the front F is formed in a right side plate 23, and so that cut sheets 2 that are shorter than the length of the base plate 21 can be set in the sheet tray 25 or taken out with the cut sheets 2 being held from above and below.
A pickup roller 32 that feeds the stored cut sheets 2 is disposed in an upper part of the sheet tray 25 so as to cross the sheet tray 25 along the separation wall 24. The pickup roller 32 includes a drive shaft 33 that extends in the sheet width direction W so as to cross the sheet tray 25 and a plurality of rollers (roller parts) 34 that are intermittently attached to the drive shaft 33. The drive shaft 33 can slide or swing up and down inside slots 36 formed so as to extend up and down in the left side plate 22 and the right side plate 23, and moves up and down in accordance with the number of cut sheets 2 set in the sheet tray 25. A right end 33r of the drive shaft 33 that passes through the right side wall 23 is coupled to a driving mechanism 41 that is disposed along the right wall 23 and is driven by a motor 42. In the paper feeding apparatus 20, the driving mechanism 41 is disposed on an outside 23a of the right side wall 23, but as shown in FIG. 4, in the paper feeding apparatus 30, the driving mechanism 41 is disposed on an outside 22a of the left side wall 22, with a left end 33l of the drive shaft 33 being coupled to the driving mechanism 41. Aside from the positions of the driving mechanisms 41, the paper feeding apparatuses 20 and 30 have the same arrangement.

As shown in FIG. 2, in the multilay 10 having the paper feeding apparatuses 20 and 30 alternately stacked, the driving mechanisms 41 are laid out alternately on the left and right sides. The respective driving mechanisms 41 include the driving motor 42 that is fixed to the side wall 22 or 23, and a wheel train (gear train) 44 that connects the motor 42 and the drive shaft 33, with a gear 43 that is the part that transmits power from the wheel train 44 to the drive shaft 33 being a one-way clutch 43 that transmits rotation in only one direction from the driving side to the driven side. The one-way clutch 43 transmits a driving force to the drive shaft 33 so that the pickup roller 32 rotates in a direction that feeds the cut sheets 2. Accordingly, if a cut sheet 2 is pulled by the feeder 5 or 7 of the printing unit 3 in a manner that rotates the pickup roller 32 faster than the rotational velocity provided by the driving mechanism 41, the one-way clutch 43 will freewheel so that the pickup roller 32 rotates in a substantially unloaded state.

As the one-way clutch 43, it is possible to use a clutch type that uses a ratchet or the like, or to use a ball clutch in which a ball and spring are used. A ball clutch is a favorable selection since there is extremely little noise during freewheeling. The concept of a “one-way clutch” in the present specification includes all one-way transmission mechanisms of other types, such as planet gears.

The driving mechanism 41 is attached so as to swing up and down on the side wall 22 or 23 about a shaft 45a of a gear disposed closest to the motor. Accordingly, when the pickup roller 32 moves up and down in accordance with the amount of cut sheets 2, the driving mechanism 41 also swings up and down about the shaft 45a in accordance with the movement of the pickup roller 32. As shown in FIG. 2, the height of the driving mechanism 41 in the up-down direction is slightly larger than the height of the sheet tray 25 (the heights of the side walls 22 and 23) and when the pickup roller 32 moves up and down, the driving mechanism 41 moves up and down beyond the range of the sheet tray 25. If the driving mechanisms 41 were all disposed in the same direction, the driving mechanisms 41 of paper feeding apparatuses 20 and 30 above and below do interfere with one another, but in the present embodiment, the driving mechanisms 41 are disposed alternately on the left and right sides, so that the driving mechanisms 41 of paper feeding apparatuses 20 and 30 above and below do not interfere. This means that as shown in FIG. 2, the driving mechanism 41 moves smoothly in accordance with the up-down movement of the pickup roller 32, so that power is reliably transmitted from the motor 42 to the pickup roller 32.

As shown by the exploded view in FIG. 5, the pickup roller 32 of the present embodiment has rollers 34, which are made of rubber or the like and are around 2 to 5 mm in diameter, intermittently attached onto the flexible drive shaft 33 whose diameter is around 1 to 5 mm, so that the parts of drive shaft 33 are intermittently exposed. The exposed parts 35 are independently supported from above, that is, an opposite side to the base plate 21 of the sheet tray 25, by a plurality of plate springs 51, that are elastic (resilient) supporting means, and the pickup roller 32 is pressed toward the base plate 21. The paper feeding apparatus 20 is provided with four plate springs 51 whose front ends are divided into two to form bearing parts 51d that independently hold the exposed parts 35 of the drive shaft 33, and an upper plate 52 that crosses the sheet tray 25 above the sheet tray 25 in the sheet width direction W so as to connect upper ends of the side walls 22 and 23, with the plate springs 51 being fixed to a rear surface of the upper plate 52.

The individual plate springs 51 include parts (first extending parts) 51b that extend in the back direction B from a part 51a that is fixed to the plate 52 and parts (second extending parts) 51c that are bent back at a backward position 51i so as to extend in the front direction F, with the front end parts 51d of the parts 51c that extend forwards being attached to the exposed parts 35 of the drive shaft 33 as bearings. Hook parts 51h that catch on slits 51a formed in the plate 52 are formed on the bent back parts 51i, so that the bent back parts 51i do not sag toward the base plate 21 and interfere with the sheets 2. Connecting parts 51e connect the parts 51c that extend in the front direction F and the bearing parts 51d for the drive shaft 33 are formed so as to be inclined downwards from front tips 51g of the plate springs, and when viewed from the drive shaft 33, form raised parts. This means that the connecting parts 51e function as connectors that connect the plate springs 51 and the drive shaft 33 on an opposite side to the base plate 21 while maintaining a space (distance) between the plate springs 51 and the drive shaft 33. The connecting parts 51e can be formed integrally with the plate springs 51 or the connecting parts 51e can be constructed of separate, non-elastic members, such as plastic members.

FIG. 6A to 6C show the up-down swinging of the pickup roller 32 inside the sheet tray 25. The pickup roller 32 is attached to the plate 52 via the plate springs 51 with the plate springs 51 in a bent back state so that the pickup roller 32 is attached to the front ends of the second extending parts 51c that extend in the front direction F. Accordingly, although there is some displacement due to elastic deformation of the plate springs 51, for the most part the pickup roller 32 is swung up and down about the bent back parts 51i by the second extending parts 51c of the plate springs 51. The individual rollers 34 of the pickup roller 32 are therefore supported by the slim and flexible drive shaft 33 and from the upper plate 52 by the plate springs 51 so as to move
substantially independently in an elastic state, so that the rollers 34 move in the up-down direction in a substantially flexible manner. On the other hand, the rollers 34 are supported so as to swing by the second extending parts 51c that extend in the front direction F, so that hard to move in the front-back direction, and the rollers 34 contact the cut sheets 2 at a predetermined position on the sheets 2 in a state where the rollers 34 face forwards F.

[0065] FIG. 6A shows a state where the sheet tray 25 has been filled with approximately the maximum permitted number of cut sheets 2. The individual plate springs 51 elastically deform and press the drive shaft 33 from a plurality of positions toward the base plate 21 of the sheet tray 25 in a state, when viewed from a side of the right side plate 23, where the plate springs 51 are substantially parallel with the base plate 21 of the sheet tray 25. Accordingly, the individual rollers 34 firmly contact the sheets 2 and the paper feeding force can be reliably transmitted. In the shape of the plate springs 51, the bearing parts 51d are connected to the second extending parts 51c via the connecting parts 51e, so that the second extending parts 51c elastically deform without contacting the sheets 2. The plate springs 51 therefore do not interfere with the sheets 2.

[0066] The plate springs 51 are extremely thin and fit into a slimmer space than the pickup roller 32. Accordingly, no extra space is needed for the mechanism that presses the pickup roller 32 downwards. The mechanism for driving the pickup roller 32 is disposed outside the sheet tray 25, so that inside the sheet tray 25, it is sufficient, in addition to sheets, to provide the small-diameter pickup roller 32 and the plate springs 51 that elastically support the pickup roller 32. The plate springs 51 fit into the thickness of the pickup roller 32, so that if the diameter of the pickup roller 32 is made small, a corresponding reduction can be made in the thickness of the sheet tray 25, and the number of sheets that can be stored is also increased. Extremely slim designs can therefore be used for the paper feeding apparatuses 20 and 30. The construction of the pickup roller periphery inside the sheet tray 25 is also extremely simple, so that when a sheet width adjusting plate 26 provided inside the sheet tray 25 is moved, there is little interference with other components. This means that a sheet width adjusting plate 26 can be incorporated easily without increasing the size of the paper feeding apparatus.

[0067] The bearing parts 51d are designed to support the exposed parts 35 of the drive shaft 33, so that the bearing parts 51d can be disposed within the thickness of the roller parts 34. Accordingly, the bearing parts 51d do not interfere with the sheets 2. This means that all of the space (in the thickness direction) of the sheet tray 25, aside from the space occupied by the roller parts 34, can be used to store the sheets 2. Accordingly, it is possible to provide a paper feeding apparatus 20 that can store a large number of sheets in spite of being slim. The pickup roller 32 does not need to press on the sheets 2 uniformly and only needs to transmit the paper feeding force to the sheets 2, so that there are no functional disadvantages if the roller parts 34 are provided intermittently.

[0068] FIG. 6B shows a state where the number of stored cut sheets 2 has fallen. The pickup roller 32 is pressed downwards by the plate springs 51 so as to swing up and down in accordance with the amount of sheets 2 and contacts the uppermost sheet 2 with a suitable force. More specifically, the plate springs 51 elastically deform and the first extending parts 51b that extend in the back direction B swing slightly downwards about the parts 51a of the plate springs 51 that are attached to the plate 52 and the second extending parts 51c that extend in the front direction F rotate about the bent back parts 51a at the back B of the first extending parts 51b. The drive shaft 33 that is supported by the plate springs 51 slides downwards inside the slots 36 formed in the left and right side plates 22 and 23 of the sheet tray 25. In the present embodiment, the second extending parts 51c are longer than the first extending parts 51b, so that the displacement of the second extending parts 51c is greater.

[0069] The plate springs 51 whose shapes extend forward and backward can be produced with elongated plate parts and are therefore plate springs with a low modulus of elasticity (elastic constant), so that a stabilized force with comparatively little fluctuation with respect to the up-down displacement of the pickup roller 32 can be applied. The applied force is also reduced. By using plate springs with bent back shapes as in the present embodiment, it is possible to make the plate parts even longer, so that the modulus of elasticity can be reduced and the pickup roller 32 can be pressed downwards with a more stable force.

[0070] The exposed parts 35 of the drive shaft 33 are grasped by the individual bearing parts 51d of the plate springs 51 and pressed downwards, and as the drive shaft 33 is a slim, flexible shaft, the individual rollers 34 situated between the exposed parts 35 are independently suspended from the upper plate 52 so as to be substantially free to move up and down. Accordingly, the respective rollers 34 tightly contact the sheets 2 in an independent state that is largely unaffected by other rollers 34, resulting in favorable contact. This means that the paper feeding force can be easily transmitted to the sheets 2. In particular, when sheets such as envelopes and medicine bags that do not have a fixed thickness have been set, even if there are differences in thickness, the respective rollers 34 will move up and down in accordance with such differences, so that the driving force can be transmitted to the sheets extremely efficiently. Accordingly, it is possible to feed the sheets reliably regardless of the type of sheets.

[0071] Since reliable contact is made with the sheets by all of the rollers 34 positioned above the sheets 2, there is little possibility of paper feeding problems where the paper feeding direction is tilted or the sheets become wrinkled. In particular, according to the method of the present embodiment, even when a long drive shaft is used to handle sheets with large widths such as A3, by merely increasing the positions at which the drive shaft is independently suspended, it is possible to ensure that all of the rollers 34 positioned above the wide sheets reliably contact the sheets. This means that it is possible to avoid paper feeding problems such as wrinkling of the sheets without this being affected by the length of the drive shaft or the width of the sheets.

[0072] Also, by having the individual rollers 34 reliably contact the sheets 2, the contact area is also increased, so that even if the force applied by the respective rollers 34 is small, the desired paper feeding force can be transmitted to the sheets 2. Accordingly, since excessive pressure does not
need to be exerted, it is possible to reduce the friction between sheets, so that multiple feeding problems can be easily prevented. The paper feeding apparatus 20 is designed so that the pickup roller 32 applies pressure in the direction of the cut sheets 2 from above, so that compared to the method where sheets are pressed from the opposite side, the force applied to the pickup roller 32 can be reduced as described above. Accordingly, the force that presses upon the sheets in the paper feeding apparatus 20 can be extremely small, so that the strength of the component members, such as the plate springs 51 can be reduced. This means that in terms of the paper feeding apparatus 20 as a whole, the weight can be reduced and the paper feeding apparatus 20 can be provided at low cost.

[0073] FIG. 6C shows a state where the inside of the sheet tray 25 is empty. The pickup roller 32 that is pressed downwards by the plate springs 51 moves in accordance with the remaining amount of sheets 2 and reaches the base plate 21 when there are no sheets 2 left. Accordingly, the cut sheets 2 can be reliably picked up right up to the final sheet. When sheets 2 that are smaller than the sheet tray 25 are set, the drive shaft 33 is flexible and the individual roller parts 34 are independently suspended, so that when there are sheets 2 left, the roller parts 34 that do not contact the sheets 2 directly contact the base plate 21, which can cause rotational problems for the pickup roller 32. For this reason, in the sheet tray 25 of the present embodiment, a channel 57 is provided in the base plate 21 at a position facing the roller parts 34 so that even in this case, the roller parts 34 do not contact the base plate 21. Accordingly, even when small-sized sheets 2 are stored, the sheets can be reliably fed until the final sheet without the pickup roller 32 coming into contact with the base plate 21.

[0074] The drive shaft 33 is driven via the one way clutch 43. This means that even if the pickup roller 32 is constantly pressed towards the base plate 21 so as to press the sheets 2, when a cut sheet 2 outputted from the paper feeding apparatus 20 is being fed by the platen roller or the feed roller 5 of the printer 1, the one way clutch 43 will freewheel. The pickup roller 32 therefore hardly provides any load. It is also possible to provide a mechanism that releases a pickup roller 32 when a state in which the sheets are being fed on the printing unit 3 side has been reached. However, as it will be necessary to divide the space inside the sheet tray 25 to enclose such a mechanism, to make the sheet tray 25 more slim and compact and to store as many sheets 2 as possible inside the sheet tray 25, a simple mechanism that uses a one way clutch as in the present embodiment is suitable.

[0075] In the paper feeding apparatus 20, the sheet tray 25 can be easily replenished with sheets 2 without releasing the pickup roller 32. This is shown in FIG. 7A to 7C. As shown by the enlargement in FIG. 7A, rollers 34 that are oval-shaped in cross section are used in the pickup roller 32 of the paper feeding apparatus 20. With oval-shaped rollers 34, as shown in FIG. 7A, if the rollers 34 rotate with the front ends 2a of the replenished cut sheets 2 in contact with the outer circumferential surface 34a of the rollers 34, as shown in FIG. 7B, the position at which the rollers 34 contact the cut sheets 2 changes and the rollers 34 ride up onto the cut sheets 2. Accordingly, the replenished cut sheets 2 are successively inserted under the rollers 34. This means that after the tray 25 has been replenished with the cut sheets 2, by merely driving the pickup roller 32 in the same way as normal, the pickup roller 32 is automatically set on a surface on the uppermost pickup roller 32.

[0076] Accordingly, as shown in FIG. 7C, after the cut sheets 2 have been replenished, by driving the pickup roller 32 in the same way as normal, it is possible for the pickup roller 32 to ride up onto the uppermost cut sheet 2f and for the cut sheet 2f to be inserted without using a release mechanism and any special mechanism for lifting the pickup roller 32. This effect can be obtained with roller shapes where the rollers 34 move up and down during rotation or where the position at which the rollers 34 contact the cut sheets 2 changes in the front-back direction during rotation. The present invention is therefore not limited to oval-shaped rollers, and the same effect is obtained by a pickup roller that uses noncircular rollers such as eccentric rollers or D-shaped rollers.

[0077] For the rollers 34 to ride up onto the sheets 2 when rotated, it is necessary for the front ends 2a of the replenished cut sheets 2 to contact at least the outer circumferential surfaces 34a of the rollers 34 when the sheets 2 are inserted with the rollers 34 as stoppers. Accordingly, with the pickup roller 32, the total size (total length) of the bearing parts 51d of the plate springs 51 and the connecting parts 51e that rise upwards from the bearing parts 51d is set within a range of rotation of the rollers 34, for example, no greater than the length of the major axis in the case where the rollers 34 are oval-shaped. With this arrangement, when a large number of sheets 2 are replenished, the front ends 2a strike the plate springs 51 and move the pickup roller 32 upwards together with the plate springs 51. Due to the raised parts 51e, the front end 2a of the uppermost sheet will definitely strike the pickup roller 32. Therefore, by driving the pickup roller 32, the pickup roller 32 is moved onto the uppermost sheet 2f and feeds the sheets in order. When the pickup roller 32 has ridden up onto the uppermost sheet 2f, due to the raised parts 51e, the second extending parts 51e that are the main parts of the plate springs 51 move to a position away from the cut sheets 2 as shown in FIG. 7C, so that there is no interference between the cut sheets 2 and the plate springs 51. Accordingly, the sheets 2 are fed smoothly.

[0078] When a large amount of sheets 2 are replenished, it is also possible to insert forcibly the sheets while the front ends 2a of upper part of the sheets 2 contact the plate springs 51 and the rollers 34 and move the pickup roller 32 upwards forcibly. However, when sheets are inserted forcibly using this method, the front end parts of the sheets 2 are strongly pressed onto the separation wall 24 and deform, so that the resistance received from the separation wall 24 becomes unstable, which has some risk of adversely affecting the separation function for sheets. In the paper feeding apparatus according to the present embodiment, by merely driving the pickup roller 32, the sheets can be automatically set in a state where the sheets 2 can be sent in the direction of the separation wall 24 with a suitable force and fed. Accordingly, the forced setting method of the sheets 2 where the pickup roller 32 is pressed upwards is not required.

[0079] FIG. 8 shows an enlargement of the periphery of the separation wall (front plate) 24, and FIGS. 9A and 9B schematically show the interrelationship between concave parts provided in the separation wall 24 and the rollers 34. As shown in FIG. 8 and FIG. 9A, a plurality of triangular
convex parts 64 that widen in the paper feeding direction F upwards and to the front are disposed at a fixed pitch on the separation wall 24. These convex parts 64 are disposed corresponding to positions in front of the exposed parts 35 of the drive shaft 33, therefore, concave parts 61 that become narrower toward the front F are formed by adjacent convex parts 64 in front F of the individual rollers 34. When the rollers 34 rotate to feed the cut sheets 2, the front ends 2a of the cut sheets 2 are pressed down and sink into the respective concave parts 61, and as shown in FIG. 9B, are subjected to resistance from the edges or corners 62 of the concave parts 61 or the convex parts 64. The concave parts 61 become narrower towards the front F, so that when the front ends 2a of the cut sheets 2 are fed forwards, the parts that strike the corners 62 change and the resistance received from the corners 62 becomes stronger.

Accordingly, the cut sheet 2 is subjected to resistance received when the front end 2a contacts surfaces 64a of the convex parts 64 and the resistance received due to being pressed onto the corners 62. In the case of the uppermost sheet 2f, once the front end 2a becomes separated from the separation wall 24 and is freed due to factors such as the stiffness of the sheet when the front end 2a is fed, the sheet 2f is outputted from the paper feeding opening 29 by the pickup roller 32. The lower sheets 2 are pressed by the sheets above so that the front ends 2a are not freed, and also receive the resistance due to the two causes described above and so are not outputted from the paper feeding opening 29. In particular, the further the sheet positioned directly below the uppermost sheet that is susceptible to being conveyed together with the uppermost sheet 2 moves forward, the larger the frictional force that acts on the sheet due to the concave parts 61, so that the uppermost sheet can be reliably separated. In addition, the concave parts 61 that become narrower towards the front F are formed in front F of the individual rollers 34 by adjacent convex parts 64, so that the resistance that acts on the sheets 2 so as to separate the uppermost sheet is substantially uniform in the sheet width direction. Accordingly, out of the cut sheets fed by the rotation of the rollers 34, it is possible to feed only the uppermost cut sheet 2 reliably and with a straight orientation, so that a highly reliable paper feeding apparatus can be realized.

Although the durability of the cut sheets 2 varies in accordance with the paper quality or material, when the front ends of the cut sheets 2 are set in an inclined state in the paper feeding apparatuses 20 and 30 in contact with the separation wall 24, as shown in FIG. 1, as time passes, the front end parts will deform to assume the shape of the separation wall 24. Accordingly, the sheets may be no longer be subject to resistance due to contact between the separation wall 24 and the front ends 2a of the sheets and the separation of sheets becomes unstable. However, with the method of the present embodiment where the cut sheets 2 are pressed onto the edges 62 of the concave parts 61 or the convex parts 64, even if the front ends 2a of the cut sheets 2 are deformed, as the sheets 2 advance towards the front F, the forms of the concave parts 61 change, so that resistance is caused on the front ends 2a of the cut sheets by the corners 62 of the concave parts 61. Hence, the sheets can be reliably separated even if the cut sheets have been set for a long time, so that a great improvement can be made in the separating function for cut sheets.

[0082] In this separation method, it is important to make it possible for the front ends 2a of the cut sheets 2 to deform along the corners 62 of the concave parts 61. It is important to maintain the cut sheets in a state where the ends in the sheet width direction W are pressed and deformation becomes easy. That is, it is preferable to arrange the rollers 34 and the convex parts 64 in parts that correspond to both side ends of the cut sheets 2. This is because to feed the sheets evenly without skewing the cut sheets 2, it is preferable to provide the driving force at both ends. The ends 2g in the sheet width direction W should preferably be guided by the convex parts 64 so that both ends 2g do not get lost in the concave parts 61. If both ends 2g of the cut sheets 2 enter the concave parts 61, the sheets will strike walls 63 of the concave parts 61 that become narrower in the paper feeding direction, and if the sheets 2 are conveyed in the front F in this state, the widths of the concave parts 61 become narrower, so that both ends 2g can catch on the walls 63, the cut sheets 2 can become wrinkled, and a paper jam may be caused.

[0083] In the paper feeding apparatus 20, to store various types of cut sheets 2 of different widths, the sheet width adjusting plate 26 that slides in the sheet width direction W on the base plate 21 is provided. The distance between the right side plate 23 and the sheet width adjusting plate 26 is adjusted in accordance with the size of the sheets 2. Accordingly, even for cut sheets of different widths, the position of the right end will definitely be determined uniformly by the right side plate 23, so that the right end of the separation wall 24 is a convex part 64 shaped as half a triangle, so that the edge 2g of the cut sheets 2 in the sheet width direction W is prevented from catching or sinking. The left ends of the cut sheets 2 vary in accordance with the cut sheets set in the paper feeding apparatus 20. The rollers 34 and the convex parts 64 or the concave parts 61 are aligned at different intervals in the sheet width direction W in consideration of the widths of the sheets that are expected to be used, so that it is possible to design the sheet tray 25 in advance so that a roller 34 and a convex part 64 will be disposed at the left end of the sheets. If a concave part 61 is unavoidably disposed at the left end of the cut sheets 2, by providing a mask plate 65 at the left end of the sheet width adjusting plate 26, it is possible to cover and hide the concave part 61. That is, since the sheet width adjusting plate 26 sets the left end of the cut sheets 2, by providing the mask plate 65 at the front of the sheet width adjusting plate 26, even if a concave part 61 is disposed at the left end of the cut sheets 2, the concave part 61 will be naturally covered and hidden by the mask plate 65. By doing so, it is possible for the separated sheet 2 to be fed in an even straighter manner. In view of the space occupied by the mask plate 65 and the riding upward of the end of the sheet 2, the mask plate 65 should preferably be formed thinly.

[0085] Sliding the sliding plate 26 in accordance with the size of the sheets 2 to set the size against to the fixed one of
the side plates as a standard position, which may be the left side plate 22 instead of the right side plate 23, is a preferable adjustment method for determining the range printed by the printing unit 3. Once the sheet size set in the paper feeding apparatus 20 and the standard position have been determined, with the present embodiment, the printing unit 3 automatically calculates the printing position with the right side plate 23 as a standard. Accordingly, it is not necessary to automatically detect the position of the sheet width adjusting plate 26, so that the interface between the multitray 10 and the printing unit 3 can be simplified.

[0086] Using this method, the position of the edges 2g of the left end of sheets 2 change according to the sheet size set in the paper feeding apparatus 20. If the sizes set in the paper feeding apparatus 20 are limited in advance, it is possible to dispose a convex part 64 at the position struck by the edges 2g of the sheets. However, there can be limits on the number of concave parts 61. Also, it is not possible to cope when the sizes of the sheets 2 are not determined. The mask plate 65 that moves in the sheet width direction W above the convex parts 64 together with the sheet width adjusting plate 26 has the merit that the left ends 2g of cut sheets of all widths will definitely ride up onto the mask plate 65. It becomes possible to efficiently use the resistance of the concave parts 61, and to prevent wrinkling of the cut sheets 2 and the convex parts 64 that can cause paper jams from the outset.

[0087] In one example of a mechanism where the mask plate 65 is moved together with the sheet width adjusting plate 26, as shown in FIG. 5 and FIG. 8, the sheet width adjusting plate 26 and the mask plate 65 are linked by an arm 69 that passes below the base plate 21 of the sheet tray 25 and two slits 67 and 68 that extend in the sheet width direction W are provided so that the arm 69 can slide in the direction W together with the sheet width adjusting plate 26. In this way, it is possible for the mask plate 65 to move together with the sheet width adjusting plate 26.

[0088] The paper feeding apparatus according to the present embodiment has been described with reference to the paper feeding apparatus 20. In the paper feeding apparatus 30, the positions of the motor and the driving mechanism 41 are changed, but the rest is almost the same. In the multiple paper feeding apparatus (multitrays) 10 of the present embodiment, the two types of paper feeding apparatuses 20 and 30 are stacked alternately on seven levels, with the respective paper feeding apparatuses 20 and 30 having the same widths of the sheet tray 25. For this reason, as shown in FIG. 2, the driving mechanisms 41 disposed on the outer surfaces of the individual paper feeding apparatuses 20 and 30 are laid out alternately on the left and right sides, so that the driving mechanisms 41 that are thicker than the sheet trays 25 can be disposed so as to span two paper feeding apparatuses in the up-down direction. It is possible to design a compact multitray 10 in which a plurality of slim paper feeding apparatuses 20 and 30 are stacked without being affected by the thickness of the driving mechanism 41.

[0089] Also, the respective paper feeding apparatuses 20 and 30 described above can also be used separately as extremely slim paper feeding apparatuses. Accordingly, by combining a paper feeding apparatus with a slim printing unit 3, for example, a printing mechanism that uses a thermal head, it is possible to provide a compact printer that is extremely slim. On the other hand, when the premise is that the paper feeding apparatuses construct the multitray 10, as shown in FIG. 10, instead of providing the upper plate 52 for supporting the pickup roller 32, it is possible to support the pickup roller 32 of a lower paper feeding apparatus on the rear side of the tray 25 of an upper paper feeding apparatus 20.

[0090] In an embodiment shown in FIG. 10, the exposed parts 35 of the drive shaft 33 of the pickup roller 32 are supported independently with respect to a rear surface 21b of the base plate 21 of an upper tray 25 by highly rigid frames 74 in the form of arms or plates so as to be able to swing. In addition, by hanging the frames 74 with elastic members 72, such as coil springs, plate springs, and rubber members, so as to elastically apply pressure downwards, the exposed parts 35 are independently suspended. It is also possible to directly attach the elastic members 72 to the exposed parts 35 in place of the frames 74. The frames 74 are connected to the shaft 32 in the same way as the plate springs 51 described above, and are provided with the same construction as described above aside from the plate springs 51 elastically supporting the shaft 32.

[0091] Non-oval shaped rollers 38, such as D-shaped rollers, and eccentric rollers 39 are used as the roller parts of the pickup roller 32, and operate in the same way as the oval-shaped rollers 34 described above. A channel 71 for receiving the rollers is formed in the rear surface 21b of the base plate 21 of the upper sheet tray 25 and by withdrawing the rollers into the channel 71 even slightly when replenishing the sheets, the number of cut sheets that can be stored is increased further.

[0092] FIG. 11 shows the appearance of a different example of a multiple paper feeding apparatus and an ink jet printer 1a on which this multiple paper feeding apparatus is mounted. In this multiple paper feeding apparatus 10a, the paper feeding apparatuses 80 and 90 are alternately stacked on seven levels, and in the sheet trays 25 of the respective paper feeding apparatuses 80 and 90, the sheets 2 are set in a state where the sheets are bent in the sheet width direction W so as to be concave on the pickup roller 32 side.

[0093] The paper feeding apparatus 100 shown in FIG. 12A holds sheets 2 in a bent state in the sheet tray 25 whose base plate 21 (the back surface plate of the sheet tray 25 or a plate that supports the entire sheets) is curved. When the sheets 2 are bent in the sheet width direction W, it becomes difficult to bend the sheets 2 in the paper feeding direction and the sheets are placed in a more rigid state where the so-called “stiffness” of the sheets is increased. By feeding the sheets 2 in this state using the pickup roller 34, it becomes difficult for the sheets 2 to bend in the paper feeding direction, so that the sheets are outputted in a straight manner from the sheet tray 25, there is no skewing and distorting inside the printer 1a, and paper jams hardly occur. In addition, overlapping cut sheets 2 are separated by resistance received by the front ends 2a from the separation wall 24 and then fed, and by increasing the rigidity of the cut sheets 2, the resistance received by the overlapping sheets from the separation wall 24 also increases, so that it is possible to prevent multiple feeding where a plurality of sheets are fed in an overlapping state. By forming the convexes and concaves described above on the separation wall 24, it is possible to provide a large resistance to the
lower sheet when sheets are overlapping, and by increasing the rigidity of the sheets, the difference in resistance between the overlapping sheets on top of one another is further increased, so that sheets can be separated more reliably.

In the present invention, a flexible pickup roller 32 equipped with a flexible drive shaft 33 is used, and intermittently exposed parts 35 of the drive shaft 33 are independently suspended by the springs 51 or 72 so as to press the sheets 2. This means that across the cut sheets 2 that bend the drive shaft 33 extending in the sheet width direction W, the drive shaft 33 is bent so as to assume the shape of the cut sheets 2, so that the respective rollers 34 supported on the drive shaft 33 can contact the curved surface of the cut sheets 2 in a substantially uniform manner. The plurality of pickup rollers 34 intermittently attached to the drive shaft 33 can apply a paper feeding force that is substantially uniform in the sheet width direction to the cut sheets 2 that are bent in the sheet width direction W, so that the sheets 2 in the bent state can be fed with a uniform force without skewing. As a result, the cut sheets 2 that are in a highly rigid state are reliably subjected to a force in the paper feeding direction, and as described above, after a sheet has been reliably separated at the separation wall 24, the sheet is supplied in a straight manner to the printer.

The flexible pickup roller 32 can bend in a convex shape and in a concave shape, and the sheets 2 can also be bent in a convex shape or a concave shape on the pickup roller 32-side according to the direction of curvature of the base plate 21 of the sheet tray 25, and in either case the bent sheets 2 can be pressed substantially equally by the flexible pickup rollers 32 that are independently suspended. Also, in the paper feeding apparatus 100 in which the base plate 21 is curved, as shown in FIG. 12B, by moving sheet width adjusting plates 26 symmetrically about the center in the sheet width direction W with respect to sheets 2 of different widths, it is possible to always feed the sheets 2 towards the printer from the center of the sheet tray 25. This is because in the case where the base plate 21 is curved, when a sheet 2 is supplied from one end of the sheet tray 25, the center of gravity of the sheet may become minutely displaced due to the center of the sheet tray being lower, which makes it easy for the paper feeding direction to become off-center with respect to the center of the sheet tray 25. This is also the case when the base plate 21 of the sheet tray 25 is curved in a convex shape.

The paper feeding apparatuses 80 and 90 shown in FIG. 12C are each equipped with a sheet tray 25 whose base plate 21 is flat, with bending parts 27 that support the sheets 2 set in the sheet tray 25 so that the peripheries of both ends of sides of the sheets 2 are bent in the sheet width direction W, being provided on the base plates 21 near the side walls 22 and 23. These bending parts 27 are inclined or curved surfaces that extend along the side walls 22 and 23, with both ends of the cut sheets 2 being placed on these bending parts 27 and raised upwards so that the entire cut sheets 2 are bent in the sheet width direction W. A partition plate or sheet width adjusting plate 26 that moves across the base plate 21 of the tray 25 in the sheet width direction and composes a side wall for guiding the edge of the sheets 2 inside the tray 25 is also provided, with a bending part 27 also being provided on an inside of the sheet width adjusting plate 26. Accordingly, when sheets 2 of different sizes are set, it is possible to make an adjustment by moving the sheet width adjusting plate 26, with the bending part 27 moving together with the sheet width adjusting plate 26 so that both ends of the sheets 2 are supported so as to be bent. This means that in the sheet tray 25, the sheets can be supported in a bent state regardless of the size of the sheets set. In addition, the base plate 21 is flat, so that there is no displacement of the center of gravity even if the sheets 2 are disposed on one side, and the problem that occurs with the trays described above whose base plates 21 are curved does not happen. Accordingly, one of the side walls, in the present embodiment the side wall on the opposite side to the fixed side wall 23, which is a reference or standard point, is moved as the sheet width adjusting plate 26 to adjust the size, so that it is easy to control the position at which the print data is set in the printer.

It is therefore possible to set the sheets 2 in a convex or concave state with respect to the pickup roller 32, but in a sheet tray 25 that has a flat base plate 21, the cut sheets 2 should preferably be set in a concave state with respect to the pickup roller 32. By doing so, it is easy to control the print position in the printer. In addition, a flat base plate 21 is advantageous when stacking a plurality of paper feeding apparatuses 80 and 90 in the multitray (multiple paper feeding apparatus) 10. However, with paper feeding apparatuses 100 whose base plates 21 are curved, if the curvature of the base plates 21 is the same, there are no problems when stacking a plurality of the paper feeding apparatuses 100.

As shown in FIG. 12B and FIG. 12C, when the tray width is adjusted using a partition plate or sheet width adjusting plate 26 and small sheets 2 are set, there are roller parts 34 that do not contact the surface of the sheets 2, but since the flexible drive shaft 33 is independently suspended, the drive shaft 33 bends in accordance with the curved state of the sheet tray 25 realized when the sheet width adjusting plate 26 has moved, and a number of roller parts 34 that contact the sheets 2 contact the surface of the sheets 2 in a substantially uniform manner. This means that it is possible to feed the sheets 2 in a bent state with a uniform force and without skewing, regardless of the size of the sheets.

FIG. 13 schematically shows the multitrays 10a by way of a side elevation. FIG. 14 shows a state where an outer case (outer frame) 11 on which the paper feeding apparatuses 80 and 90 are mounted has been removed from a printer by way of a perspective view. FIG. 14 shows the apparatuses minus the pickup rollers and the driving units. The multitray 10a of the present embodiment is, constructed by alternatingly stacking two types of paper feeding apparatuses 80 and 90, both of whose base plates 21 are flat but whose driving mechanisms 41 are attached in different directions. The respective paper feeding apparatuses 80 and 90 are disposed in a slightly inclined state so that the paper feeding openings 29 are at the bottom. The outer case 11 includes a base support part 11a, in which are formed a plurality of bearing parts 11b for supporting the respective paper feeding apparatuses 80 and 90 in a state inclined by a predetermined angle, and a side support part 11c that supports the paper feeding apparatus 80 or 90 that is positioned furthest to the outside. In addition, wheels 11d are attached to the base support part 11a of the outer case 11, which support part of the weight of the multitrays 10a and also make it possible to slide the entire multitrays for attachment to and detachment from the printer main body 1b.
FIG. 15 shows the paper feeding apparatus 80 by way of a plan view. The paper feeding apparatus 90 is the same except the direction of the driving mechanism 41 attached. FIG. 16 shows a view of the paper feeding apparatuses 80 and 90 have been set and stacked on the outer case 11, focusing on the base plates 21 and separation walls 24 of the sheet trays 25. In FIG. 16, although only the paper feeding apparatus 80 on the second level from the front is shown as including a pickup roller 32, pickup rollers 32 are attached in the same way to the other paper feeding apparatuses 80 and 90.

In the base plates 21 of the sheet trays 25 in the paper feeding apparatuses 80 and 90, the peripheries of the side walls 22 and 23 are inclined so that the side wall 22 and 23-sides are higher in the up-down direction or towards the front, with these inclined parts forming the bending parts 27 that bend the sheets 2 in the sheet width direction W. This means that when the sheets 2 are set in the sheet tray 25, the peripheries of both ends of the sheet 2 in the sheet width direction W bend along the bending parts 27, so that the entire sheets bend in the sheet width direction W. In this case, the sheets 2 bend in a form that is convex towards the base plate 21 and concave on the pickup roller 32-side. Accordingly, by merely inserting thin sheets 2 into the trays 25 of the paper feeding apparatuses 80 and 90, the cut sheets 2 bend by an appropriate amount in the sheet width direction W, so that the strength of the sheets in the paper feeding direction is improved. The sheets 2 set in the trays 25 are placed in a rigid state with favorable stiffness and can be reliably fed while being separated one sheet at a time by the pickup roller 32.

A thin, flexible shaft is also used in the paper feeding apparatuses 80 and 90 of the present embodiment as the drive shaft 33 of the pickup roller 32. As examples, as the flexible shaft 33, it is possible to use metal wire with a diameter of around 1.2 mm that can be a single core wire or a stranded wire like brake wire. It is also possible to use a plastic shaft with a diameter of around 1 to 3 mm as the flexible shaft 33. These kinds of drive shaft 33 are flexible and the plurality of exposed parts 35 are independently suspended by the plate springs 51, so that the drive shaft 33 deforms across the sheets 2 held in a bent state in the sheet tray 25. That is, the flexible pickup roller 32 bends in accordance with the sheets 2 and the roller parts 34 supported on the shaft 33 contact the sheets 2 with a substantially uniform pressure. This means that a substantially uniform paper feeding force can be applied to the sheets 2 in a bent state, so that a force that is appropriately distributed on the sheets 2 in the bent state acts on the sheets which can be fed reliably. Accordingly, there is no centralizing of a paper feeding force at certain parts which can cause slim sheets to wrinkle or cause the sheets to be outputted in a skewed state, and the sheets 2 can be fed in a substantially straight manner in the paper feeding direction F in a bent state with high rigidity.

The plurality of exposed parts 35 of the drive shaft 33 of the pickup roller 32 are respectively attached to the upper plate 52 by one plate spring 51 each. The plate springs 51 function so as to support the pickup roller 32 in a state that rotates or swings towards the base plate 21 in accordance with the number of sheets set in the sheet tray 25 and to elastically support the shaft 33 at a plurality of positions so as to follow the shape of the sheets. Also, as shown in FIG. 10, the respective driving mechanisms 41 of the paper feeding apparatuses 80 and 90, including the motors 42, are arranged so as to swing, so that the wheel trains for transmitting the driving force are simplified. As shown in FIG. 10, the driving mechanisms 41 including the motors 42 can be attached to hook parts 48 provided on both sides of the sheet tray 25 so as to be able to swing, with the paper feeding apparatuses being used as the paper feeding apparatuses 80 and 90 by selecting one of the sides.

Inside the sheet tray 25, it is possible to attach the sheet width adjusting plate 26 so as to be slidable on the base plate 21, so that it becomes possible to adjust the sheet width of the sheet tray 25 in accordance with the width of the cut sheets 2 with the right side plate 23 as a reference. Support arms 28 whose length can be extended upwards in several stages from the sheet tray 25 are attached to the base plate 21, so that in cases where the sheets 2 stick out of the sheet tray 25, the sheets 2 can be supported by the support arms 28.

An inclined construction 27 for bending the ends of the sheets 2 in the sheet width direction also is attached to the sheet width adjusting plate 26. This means that even small sheets with a narrow width where the edges are supported by the adjusting plate 26 can be set in the sheet tray 25 in a bent state. Accordingly, with the multi-tray 10A of the present embodiment, it is possible to set sheets 2 of various sizes, and the respective sheets can be reliably separated one at a time and fed to the printer. If the sheets 2 are A4 size, the rigidity can be sufficiently increased by bending the sheets by around 5 mm. If the size of the sheets is smaller, the curvature value given above or less is sufficient. This means that even if the cut sheets 2 are stored in the sheet tray 25 in a bent state, a sufficient amount of sheets 2 can be stored in the sheet tray 25 without a large increase in the thickness of the sheet tray 25.

The sheet trays 25 of the paper feeding apparatuses 80 and 90 of the present embodiment are provided with separation walls 24 in which the concave parts 61 and the convex parts 64 are formed. Accordingly, the sheets 2 fed by the pickup roller 32 are separated one sheet at a time mainly by the resistance received by the sheet front ends 2a from the surfaces 64a of the convex parts 64 and the resistance received by being pressed on the corners 62. At this time, since the bent sheets 2 that are still strike the concave parts 61 and the convex parts 64 in a straight manner, the upper sheet 2f can easily slide and pass the separation wall 24 while the lower sheets strike the separation wall 24 and tend to be subjected to a large resistance. Accordingly, increasing the rigidity by bending the cut sheets 2 is effective in preventing the multiple feeding of sheets 2.

In addition, the convex parts 64 of the present embodiment have sloped surfaces split into two levels, with an angle θ1 made between the base plate 21 and the front end parts of the convex parts 64, that is, a surface 81 on the paper feeding direction F side being smaller than an angle θ2 made between the base plate 21 and back end parts of the convex parts 64, that is, a surface 82 close to the base plate 21. As shown in FIG. 17A and 17B, the separation wall 24 that includes the convex parts 64 is inclined by more than 90° with respect to the base plate 21 of the tray 25 so that a suitable resistance is produced for the front ends of the
sheets 2. When there are many sheets 2 in the sheet tray 25, the distance L1 (see FIG. 17A) between the separation wall 24 and the position where the pickup roller 32 contacts the sheets 2 is longer than the distance L2 (see FIG. 17B) between the separation wall 24 and the position where the pickup roller 32 contacts the sheets 2 when there are few sheets 2 in the sheet tray 25. When there are many sheets remaining in the sheet tray 25, the distance L1 between the separation wall 24 and the position where the pickup roller 32 contacts the sheets 2 is long, so that the rigidity of the sheets 2 is lower, the sheets are relatively easily bend towards the paper feeding opening 29 after striking the separation wall 24, and there is the possibility of sufficient resistance for separating overlapping sheets 2 not being obtained. On the other hand, when the remaining number of sheets is low for the sheet tray 25, the distance L2 between the separation wall 24 and the position where the pickup roller 32 contacts the sheets 2 is short, so that the rigidity of the sheets 2 is higher, so that it is relatively difficult for the sheets 2 to bend towards the paper feeding opening 29 after striking the separation wall 24, which can cause a paper jam.

[0108] In the case shown in FIG. 17A, the separation function is improved by reducing the angle θ1 of the surfaces 81 on the front end-sides of the convex parts 64 and in the case shown in FIG. 17B, the occurrence of paper jams is prevented by increasing the angle θ2 of the surfaces 82 on the back end-sides of the convex parts 64. It is also effective to provide a difference in angle between the front end-side and the back end-side of the separation wall 24 in sheet trays 25 equipped with a separation wall 24 with no convexes and concaves. The separation wall 24 may be split into two levels with inclined surfaces 81 and 82 being provided to change the angle between the front end-side and back end-side in the paper feeding direction, but it is also possible to form this kind of difference in angle using a curved surface. When the sheets 2 are set in the sheet tray 25 in the multiple paper feeding apparatus 10a of the present embodiment, the sheets bend in the sheet width direction W so that the rigidity in the paper feeding direction increases, and in the cases shown in FIGS. 17A and 17B, both of the distances L1 and L2 between the separation wall 24 and the pickup roller 32 can be increased. Accordingly, the difference between the distances L1 and L2 between the separation wall 24 and when few sheets remain is reduced and it is possible to separate and feed the sheets one at a time with greater stability. In this way, increasing the stiffness of the sheets 2 is important in order to supply the stability from the paper feeding apparatus, with it being possible to make the sheets stiff by merely bending the sheets 2 to a certain degree in the sheet width direction.

[0109] In the multiple paper feeding apparatuses 10 and 10a shown in FIG. 1 and in FIG. 11, the paper feeding apparatuses are stacked in an inclined state, and the paper feeding apparatuses may be stacked on top of one another in a horizontal state. In the case of a desktop-type printer or fax machine, it is possible to reduce the apparatus footprint by arranging a plurality of paper feeding apparatuses in an inclined state and the height can also be reduced. Accordingly, a multiple paper feeding apparatus (multitray) in which a plurality of paper feeding apparatuses are combined in an inclined state is suited to use with a small-scale printer, such as an ink jet printer or other printer for personal use. It is possible to set small amounts of various different sheets and it is possible to print on items of various materials and shapes without having to change the set type of sheets every time. As one example, sheets that are often put to personal use, such as A4, B5, postcard, and envelopes, can be simultaneously set and printing can be carried out after selecting the appropriate sheets. In addition, sheets such as medicine bags, receipts, and invoices used in a pharmacy can be set in advance in the multitray and printing can be carried out after selecting the appropriate sheets.

[0110] In the multiple paper feeding apparatus vertically stacking a plurality of paper feeding apparatuses placed horizontally, since the individual paper feeding apparatuses almost reach the limit on how slim such apparatuses can be made, as the entire multiple paper feeding apparatus, it is possible to provide a multitray which has a low height and setting a variety of sheets simultaneously. This type of multitray requires larger horizontal space compared to the above type, and so is suited to a standalone printing apparatus such as a laser printer or a copier.

[0111] As described above, the paper feeding apparatus of the present invention and a multitray arranged by stacking the paper feeding apparatuses can be applied to, not limited to an ink jet-type printer, all the types of printers including a laser printer and others. In addition, the paper feeding apparatus and multitray can be applied, not limited to a printer, to a printing apparatus such as a copier and a facsimile machine.

[0112] Industrial Applicability

[0113] As described above, the present invention provides a highly reliable paper feeding apparatus that is extremely slim and uses a thin pickup roller of around several mm in size. By stacking this paper feeding apparatus, it is possible to provide a compact, highly reliable multitray, which can be applied to a copier for office. A general purpose printer is provided by incorporating the multitray with a desktop printer, facsimile machine or the like, in which sheets of different sizes or widths can be select and print.

1. A paper feeding apparatus comprising:
   a sheet tray that is capable of storing a plurality of sheets and includes, at a front thereof, a separation wall that is struck by an edge the plurality of sheets in a paper feeding direction;
   a pickup roller including a drive shaft disposed so as to cross the sheet tray and a plurality of roller parts intermittently attached to the drive shaft;
   elastic supporting means for substantially independently supporting a plurality of exposed parts of the drive shaft so as to apply pressure towards a base plate of the sheet tray; and
   a driving mechanism that drives the drive shaft of the pickup roller and is disposed on the outer surface side of the sheet tray.
2. A paper feeding apparatus according to claim 1, wherein the driving mechanism drives the drive shaft via a one-way clutch.
3. A paper feeding apparatus according to claim 1, wherein the drive shaft of the pickup roller is a flexible shaft.
4. A paper feeding apparatus according to claim 1, wherein the elastic supporting means supports the drive shaft so as to swing in a direction of the base plate about a support point at some distance above the base plate.

5. A paper feeding apparatus according to claim 4, wherein the elastic supporting means includes a plurality of frames that support the drive shaft so that the drive shaft swings and a plurality of elastic bodies that apply pressure to the plurality of exposed parts of the drive shaft or the plurality of frames towards the base plate.

6. A paper feeding apparatus according to claim 4, wherein the elastic supporting means includes a plurality of plate springs for supporting the plurality of exposed parts of the drive shaft with elastically deform parts extending in the paper feeding direction.

7. A paper feeding apparatus according to claim 1, further comprising connecting parts that connect the elastic supporting means and the plurality of exposed parts of the drive shaft on an opposite side of the base plate with a distance no greater than a diameter of the plurality of roller parts.

8. A paper feeding apparatus according to claim 1, wherein the plurality of roller parts are eccentric or noncircular.

9. A paper feeding apparatus according to claim 1, wherein a channel in which the plurality of roller parts are received is formed in the base plate of the sheet tray so as to face the plurality of roller parts.

10. A paper feeding apparatus according to claim 1, wherein the sheet tray is stackable, and a channel in which roller parts of a sheet tray on a lower level are received is formed in a rear surface of the base plate of the sheet tray so as to face the roller parts.

11. A paper feeding apparatus according to claim 1, wherein convex parts formed so as to widen in the paper feeding direction and/or concave parts formed so as to narrow in the paper feeding direction are formed on the separation wall.

12. A paper feeding apparatus according to claim 11, wherein a plurality of types of sheets of different widths are set in the sheet tray and the convex parts are formed at parts of the separation wall that are struck by ends in a sheet width direction of respective types of sheets.

13. A paper feeding apparatus according to claim 11, wherein the concave parts of the separation wall are formed at positions substantially corresponding in the paper feeding direction to the plurality of roller parts of the pickup roller.

14. A paper feeding apparatus according to claim 13, wherein a plurality of types of sheets of different widths are set in the sheet tray and parts of the separation wall that are struck by ends in a sheet width direction of respective types of sheets are non-concave parts.

15. A paper feeding apparatus according to claim 11, further comprising:

   a sheet width adjusting plate that moves on a surface of the base plate of the sheet tray to set a plurality of types of sheets of different widths; and

   a mask plate that moves together with the sheet width adjusting plate and forms parts for raising ends of the respective types of sheets in a sheet width direction at a surface of the separation wall.

16. A paper feeding apparatus according to claim 1, wherein a first angle between a front end part of the separation wall in the paper feeding direction and the base plate of the sheet tray is smaller than a second angle between a back end part of the separation wall in the paper feeding direction and the base plate of the sheet tray.

17. A paper feeding apparatus according to claim 11, wherein a first angle between front end parts of the convex parts in the paper feeding direction and the base plate of the sheet tray is smaller than a second angle between back end parts of the convex parts in the paper feeding direction and the base plate of the sheet tray.

18. A paper feeding apparatus according to claim 3, wherein the sheet tray supports sheet set in the sheet tray so that at least parts near both ends in a sheet width direction bend in the sheet width direction.

19. A paper feeding apparatus according to claim 18, wherein the sheet tray supports the plurality of sheets set in the sheet tray so that a pickup roller-side of the plurality of sheets are bent in a concave manner.

20. A paper feeding apparatus according to claim 18, further comprising bending parts that are located at side wall sides of the base plate of the sheet tray and support the sheet so that at least parts near both ends bend in the sheet width direction.

21. A paper feeding apparatus according to claim 20, wherein at least one of side walls of the sheet tray moves together with one of the bending parts in the sheet width direction.

22. A paper feeding apparatus according to claim 18, wherein the base plate of the sheet tray is curved and both side walls of the sheet tray symmetrically move about a center in the sheet width direction.

23. A printing apparatus, comprising:

   a paper feeding apparatus according to claim 1; and

   a printing mechanism that prints on a sheet fed from the paper feeding apparatus.

24. A multiple paper feeding apparatus in which a plurality of paper feeding apparatuses according to claim 1 are stacked.

25. A multiple paper feeding apparatus according to claim 24, wherein the plurality of paper feeding apparatuses are of equal width.

26. A multiple paper feeding apparatus according to claim 24, wherein respective paper feeding apparatuses include a sheet width adjusting plate that moves on a surface on the base plate of the sheet tray to set various types of sheets with different widths on one side, out of a left side and a right side, of the respective sheet trays.

27. A multiple paper feeding apparatus according to claim 24, wherein respective paper feeding apparatuses have the driving mechanism disposed on an outer surface on
either a left or a right side and paper feeding apparatuses with driving mechanisms disposed on different outer surfaces are alternately stacked.

28. A printing apparatus, comprising:
a multiple paper feeding apparatus according to claim 24; and
a printing mechanism that prints on a sheet fed from the multiple paper feeding apparatus.

29. A paper feeding apparatus comprising:
a sheet tray that is capable of storing a plurality of sheets and includes, at a front thereof, a separation wall that is struck by an edge of the plurality of sheets in a paper feeding direction; and
a pickup roller disposed so as to cross the sheet tray, wherein the edge of the plurality of sheets remaining in the sheet tray strike the separation wall, and a first angle between a front end part of the separation wall in the paper feeding direction and the base plate of the sheet tray is smaller than a second angle between a back end part of the separation wall in the paper feeding direction and the base plate of the sheet tray.

30. A printing apparatus, comprising:
a paper feeding apparatus according to claim 29; and
a printing mechanism that prints on a sheet fed from the paper feeding apparatus.

31. A paper feeding apparatus comprising:
a sheet tray that is capable of storing a plurality of sheets and includes, at a front thereof, a separation wall that is struck by an edge of the plurality of sheets in a paper feeding direction; and
a pickup roller disposed so as to extend along the separation wall, wherein convex parts formed so as to widen in the paper feeding direction and/or concave parts formed so as to narrow in the paper feeding direction are formed on the separation wall.

32. A paper feeding apparatus according to claim 31, wherein the pickup roller includes a drive shaft disposed so as to cross the sheet tray and a plurality of roller parts intermittently attached to the drive shaft and the concave parts of the separation wall are formed at positions substantially corresponding in the paper feeding direction to the roller parts of the pickup roller.

33. A paper feeding apparatus according to claim 31, wherein a first angle between front end parts of the convex parts in the paper feeding direction and the base plate of the sheet tray is smaller than a second angle between back end parts of the convex parts in the paper feeding direction and the base plate of the sheet tray.

34. A printing apparatus, comprising:
a paper feeding apparatus according to claim 31; and
a printing mechanism that prints on a sheet fed from the paper feeding apparatus.

35. A paper feeding apparatus comprising:
a sheet tray that is capable of storing a plurality of sheets and supports the plurality of sheets set in the sheet tray so that at least parts near both ends in a sheet width direction bend in the sheet width direction; and
a flexible pickup roller, intermittent parts thereof are independently pressurized by a plurality of springs, disposed so as to cross the sheet tray.

36. A paper feeding apparatus comprising:
a sheet tray that is capable of storing a plurality of sheets and supports sheet set in the sheet tray so that at least parts near both ends in a sheet width direction bend in the sheet width direction;
a flexible pickup roller disposed so as to cross the sheet tray; and
bending parts that are located at side wall sides of a base plate of the sheet tray and support the plurality of sheets set in the sheet tray so that at least parts near both ends bend in the sheet width direction.

37. A paper feeding apparatus according to claim 35, wherein a base plate of the sheet tray is curved.

38. A printing apparatus, comprising:
a paper feeding apparatus according to claim 35; and
a printing mechanism that prints on a sheet fed from the paper feeding apparatus.

39. A printing apparatus, comprising:
a paper feeding apparatus according to claim 36; and
a printing mechanism that prints on a sheet fed from the paper feeding apparatus.

40. A paper feeding apparatus according to claim 1, wherein
the driving shaft is a metal stranded wire.

41. A paper feeding apparatus according to claim 35, wherein the flexible pickup roller includes a drive shaft made of a metal stranded wire.

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