The invention relates to an apparatus and friction singler for singling sheet material, such as bank notes or the like, having a sheet magazine for receiving a stack of sheets, a picking device with a singling cylinder or the like that has one or more friction elements for contacting and conveying the sheets to be singled from the sheet magazine, and a retaining device forming with the singling cylinder a singling gap through which sheets to be singled from the sheet magazine are conveyed successively.

To permit reliable singling by the friction wheel singler after long operating times and under different conditions, the retaining force and the feed force on the sheets to be singled are set and/or regulated independently of each other in the area of the singling gap for singling the sheet material.
DEVICE AND METHOD FOR SEPARATING SHEET-TYPE PRODUCTS

[0001] This invention relates to a friction singler for singling sheet material, such as bank notes or the like, comprising a sheet magazine for receiving a stack of sheets, a picking device with a singling element, such as a singling cylinder or the like, having one or more friction elements for contacting and conveying sheets to be singled from the sheet magazine, and a retaining device forming with the singling element a singling gap through which sheets to be singled from the sheet magazine are conveyed successively. Moreover, the invention relates to a corresponding method for singling sheet material.

[0002] There are different technical concepts for singling stacks of sheets such as bank-note bundles in such a way that the singled bank notes can be supplied to a test sensor system that determines authenticity, qualitative nature, denomination or other characteristic properties of the bank notes.

[0003] The present application deals with the concept of friction singlers. In a friction wheel singler, the friction elements of a singling cylinder, for example, are on the surface of a bank note of a bank-note stack, the thus contacted bank note being conveyed in a transport direction due to friction by rotation of the singling cylinder, while the other bank notes of the bank-note stack are retained by a retaining device. The retaining device and the singling cylinder form for this purpose a singling gap through which the bank note is conveyed. To ensure that the bank note contacted by the singling cylinder is conveyed and the other bank notes of the bank-note stack retained, the singling cylinder must exert on the bank note in the singling gap a singling force, hereinafter also referred to as the feed force, that is greater than the retaining force exerted on said bank note by the retaining device on the opposite side of the singling gap. The retaining device can be realized e.g. as a freely rotating retaining roll or a retaining pad.

[0004] To adjust the ratio of feed force, i.e. singling force, to retaining force to a desired fixed value, the singling cylinder can be provided with friction elements whose friction linings have a substantially higher coefficient of friction than the corresponding friction linings of the retaining device, the ratio of coefficients of friction being e.g. about 2:1.

[0005] It has turned out to be disadvantageous in this procedure that the different friction materials of the singling cylinder and retaining device sometimes show very different operating characteristics, for example with respect to resistance to environmental influences, moisture absorption, temperature coefficient, aging and wear resistance. This may lead to different service lives and influences the ratio of friction, which can lead to singling errors including multiple picks, whereby more than one sheet is grasped and conveyed by the singling cylinder.

[0006] To avoid these problems, a friction wheel singler has been developed wherein the same friction material, or friction material with the same coefficient of friction, is used for singling cylinder and retaining device. This concept is described in the applicant’s non-published patent application DE 100 08 135.5. Since like friction materials are used for the singler and the retaining means in this case, the ratio of friction of the friction materials is less influenced by parameters such as wear resistance and the like and the service life of the friction wheel singler increases at constant singling quality.

[0007] To ensure, despite the use of substantially the same friction material for retaining and singling, that the force of the singling cylinder acting on the sheet material to be singled is sufficiently higher than the force exerted by the retaining device, it is provided that the contact area between the sheet material and the friction elements of the singling cylinder is substantially greater than the contact area between the sheet material and the friction areas of the retaining device. Preferably, half of the effective surface of the retaining device is formed by a material with a negligibly small coefficient of friction, so that the ratio of active surfaces with friction material is about 2:1. Because of the like friction materials, this ratio simultaneously determines the ratio of frictional forces between singling cylinder and retaining device. If a singling cylinder is used with circumferential grooves that are engaged by a retaining roll, this means e.g. that the number of frictional edges in contact with the singled sheet to be transported is twice as great for the singling cylinder than for the retaining rolls.

[0008] Although this system is improved over known systems, it might possibly lead under some circumstances to different wear and degrees of soiling of the friction materials after long operating times due to the different functions as retaining and singling elements, making it necessary to replace the friction elements if the singling quality is not to suffer.

[0009] On these premises, it is the problem of the present invention to provide a friction singler for singling sheet material and a corresponding singling method that can minimize the danger of singling errors after long operating times.

[0010] This problem is solved by a friction singler having the features of claim 1 and a method having the features of claim 23. The further claims describe advantageous embodiments.

[0011] The invention is thus based on the finding that friction singlers can still single reliably after long operating times and under different ambient conditions if the retaining force and the feed force are set and/or regulated independently of each other in the area of the singling gap. Setting refers here to fixing the force at a given value, and regulation to varying such a set value, in particular also changing the value of the force in dependence on certain operating parameters such as singling quality.

[0012] While the friction elements must be replaced in known friction singlers when there are signs of abrasion or other signs of wear after long operation, such fluctuations in quality can be compensated in the inventive solution by the independent adjustment of the retaining and singling forces without any need to replace the friction elements. The retaining force and the feed force can each be set continuously or step-by-step within a range.

[0013] This has the further advantage that, in contrast to the known systems explained above, the friction materials best suited for the particular function can be used in an inventive friction singler without these necessarily having to
be the same friction materials or friction materials with a fixed difference in coefficient of friction.

[0014] While in known friction singlers the ratio of retaining force to singling force is fixed, the inventive solution moreover allows the ratio of forces to be set optimally for bank notes of different quality.

[0015] In a preferred embodiment, a retaining element such as a retaining skid or retaining roller and in addition a pressure element such as a pressure skid or pressure roller are present in the area of the singling gap, whereby the pressure element should have a lower coefficient of friction with respect to the bank note than the retaining element. If in this case e.g. the distance of the two elements from the singling cylinder is adjusted independently of each other, this permits the ratio of forces in the singling gap to be changed.

[0016] If the retaining device and/or the pressure device can engage grooves in the singling cylinder surface in the area of the singling gap, the abovementioned distance variation also includes the case that the penetration depth in the grooves, referred to hereinafter also as the mesh, can be varied to permit the retaining and feed forces to be set independently of each other in controlled fashion.

[0017] This is due to the fact that, at given geometrical dimensions and materials, the retaining force can be increased within a certain range by increasing the penetration depth of the retaining device in the grooves of the singling cylinder, and the feed force within a certain range by increasing the penetration depth of the pressure device in the grooves of the singling cylinder.

[0018] Since in known systems, e.g. according to DE 100 08 135.5, the retaining roll has both the function of a retaining element and a pressure element due to the division into frictional and smooth surface areas, only the absolute values of retaining force and feed force can be changed simultaneously by changing the mesh of retaining roll and singling cylinder due to the principle of force and counterforce, without the ratio of said forces being adjustable by varying the mesh.

[0019] In contrast, the above-described embodiment allows a separation of retaining and pressure functions since separately settable elements are present for the retaining function and the pressure function, so that not only the absolute values of the forces but also the ratio thereof can be changed in desired fashion.

[0020] According to a further preferred embodiment, the forces can also be regulated independently of each other by varying the rotating-speed of a retaining roll as the retaining device to change the retaining force. This embodiment is based on the surprising finding that, with certain elastomers, frictional force is not independent of speed, as would be expected, but can be changed in practice by varying speed, e.g. rotating speed in the case of retaining rolls. The use of casting polyurethanes has turned out to be particularly suitable.

[0021] Since this effect only appears on the frictional surface areas and not the areas with a smooth surface, the retaining rolls known in the art according to DE 100 08 135.5 could also be used. Said known systems need only be altered so that the speed of said retaining rolls can be selected in controlled fashion to permit the retaining force to be set by varying the rotating speed and, independently thereof, the feed force by varying the mesh with the singling cylinder.

[0022] An additional, especially preferred way of independently varying the retaining and feed forces in friction singlers can be given by using a suction apparatus as the retaining device of the friction singler to suck the sheets to be retained by a vacuum in the area of the singling gap.

[0023] In this case, the retaining force can be regulated e.g. by varying the vacuum. The feed force can moreover be changed independently thereof if the suction apparatus can engage a groove in the singling cylinder and the feed force can be varied by changing the mesh of suction apparatus and singling cylinder.

[0024] These embodiments are based on the surprising finding that the different and usually separate solutions of singling by means of suction apparatuses, on the one hand, and by means of friction singling, on the other hand, can also be combined to construct an apparatus with high singling efficiency.

[0025] In the following, the invention will be described by way of example by a few embodiments with reference to the enclosed drawings, in which:

[0026] FIG. 1 shows schematically a cross section of a friction wheel singler in the area of the singling gap perpendicular to the singling direction of the bank notes according to a first example;

[0027] FIG. 2 shows schematically a cross section of a friction wheel singler along the singling direction of the bank notes according to a second example, and

[0028] FIG. 3 shows schematically a cross section of a friction wheel singler in the area of the singling gap perpendicular to the singling direction of the bank notes according to a third example.

[0029] FIG. 1 shows a cross section through the picking device and the retaining device of a friction wheel singler according to a first embodiment. The cross section is located in the area of the singling gap and perpendicular to the transport direction of the bank notes that are transported in a direction perpendicular to the sheet plane.

[0030] Since the supply of bank notes from stacking area to singling gap and further transport of singled bank notes from singling gap to a test or deposit device are known in the art and described e.g. in DE 100 08 135.5, a representation and precise description of the corresponding components of the friction wheel singler are omitted for clarity’s sake.

[0031] The inventive friction wheel singler according to FIG. 1 is characterized in particular by the construction of the retaining device and the picking device.

[0032] The picking device includes singling cylinder 1, which can be constructed in the way known in the art. The structure shown in FIG. 1 corresponds for example to that described in detail in DE 100 08 135.5. In particular, one can see grooves 2 extending over the total circumference in the transport direction of the bank notes, and the bar-shaped protruding areas limited by grooves 2. To effect e.g. sequential singling, said bar-shaped protruding areas are designed as friction segments 3 only over part of the circumference of
singlying cylinder 1, while the other circumferential areas have a smooth surface. Thus, bank note 5a located in the area of the singling gap is singled, i.e. transported on singly in the picking direction, only when rotation of singling cylinder 1 causes the surface areas with friction segments 3, as shown in FIG. 1, to come in contact with bank note 5a there so that the latter is pulled along in the picking direction by frictional action.

[0033] The picking device further includes a pressure unit with two pressure skids 4 connected in a U shape by firm connection bar 5 and adapted to engage associated circumferential grooves 2 in singling cylinder 1, specifically the two middle circumferential grooves 2 in FIG. 1. Skids 4 have in particular in the lower area coming in contact with the bank notes to be singled a smooth surface, e.g. of metal or plastic, whose coefficient of friction is lower than that of customarily used bank notes 5a and friction segments 3 of singling cylinder 1.

[0034] The pressure of bank note 5a to be singled on the surface of singling cylinder 1 and thus the feed or singling force can be increased within certain limits by reducing the distance of skids 4 from the singling cylinder and in particular increasing the penetration depth of the underside of pressure skids 4 in grooves 2.

[0035] As mentioned above, this pressure function is performed simultaneously by the retaining roll also serving as a retaining element in the known apparatus according to DE 100 08 135.5, since said roll has circumferential areas protruding over the circumference with a friction surface (retaining function) and ones with a smooth surface (pressure function).

[0036] To produce the inventive functional separation and thus separate setting or regulation of retention and feed, however, the pressure element according to FIG. 1 is not a fixed or rigidly connected element of the retaining device. The latter comprises two retaining skids 6 extending parallel to each other and rigidly interconnected by connection bar 7.

[0037] The two retaining skids 6 have, at least at lower end areas 8, a friction surface that can engage associated grooves 2 (the grooves disposed on the outside left and right in the example of FIG. 2) to regulate the retaining force on bank note 5a located between retaining skid 6 and singling cylinder 1.

[0038] The coefficient of friction of friction areas 4 must be greater than that of the surface of pressure skids 8. This coefficient of friction of friction areas 8 may correspond to that of friction segments 3 of singling cylinder 1, as in the known apparatus, but the inventive solution also makes it possible to use materials with different coefficients of friction for the singling cylinder and the retaining skids.

[0039] Skids 4, 6 with connection bars 5, 7 of pressure and/or retaining elements can be produced in one piece or also in several pieces to permit separate replacement of individual skids.

[0040] As mentioned above, a peculiarity of the arrangement of FIG. 1 is that the functions of retention and pressure are divided over different components which can be set separately to regulate the retaining force and feed force separately. This is brought about in particular by making retaining skids 6, on the one hand, and pressure skids 4, on the other hand, vertically adjustable with respect to singling cylinder 1 independently of each other.

[0041] For this purpose, the adjusting device of the friction wheel singler firstly comprises fastening device 9 firmly connected with retaining skids 6 by connection bar 7. Fastening device 9 is connected with rack rod 10 firmly positioned in the singling apparatus and extending in the vertical direction. In a way not shown in detail and known in the art, fastening device 9 can be displaced vertically on rack rod 10 in the direction of double arrow 11 and, after a desired position is set, fastened in this position, e.g. by a screw fixing device.

[0042] Therefore, displacing fastening device 9 in the vertical direction along rack rod 10 makes it possible to set and change the distance of retaining skids 6 from singling cylinder 1 and thus also the extent of penetration depth of skids 6 in associated grooves 2 in singling cylinder 1.

[0043] For pressure skids 4, on the other hand, the adjusting device comprises separate fastening device 11. Pressure skids 4 are rigidly connected by their horizontally extending connection bar 5 with vertically extending fastening pin 12 roughly in the form of a turning fork, pin 12 being fastened to connection bar 7 of the retaining device in vertically adjustable fashion by screw 13. This screw connection makes it possible for pin 12 and thus pressure skids 4 to be adjusted vertically with respect to retaining skids 6.

[0044] Since fastening device 11 of pressure skids 4 is thus actually connected with fastening device 9 of retaining skids 6 but nevertheless vertical adjustment of pressure skids 4 relative to retaining skids 6 is possible by vertical adjustment of pin 12, the retaining force and feed force can be adjusted and set independently of each other.

[0045] For carrying out an example of the inventive method, the apparatus according to FIG. 1 is used as follows.

[0046] A stack of bank notes is inserted into the input pocket (not shown) of the friction wheel singler, and at least lowermost bank note 5a to be singled next is transported to singling cylinder 1 into the area of the singling gap, which is formed by the opposite areas of singling cylinder 1 and pressure and retaining elements 4, 6.

[0047] When singling cylinder 1 has turned, controlled by the adjusting device, so far that the area of friction segment 3 has turned into an effective position, i.e. into the area of the singling gap, as shown in the cross section of FIG. 1, the feed force distinctly predominates over the retaining force for friction segment 3 effective on the singling gap, so that sheet 5a to be singled is conveyed through the singling gap in a direction perpendicular to the sheet plane of FIG. 1.

[0048] The predominance of the feed force is determined, inter alia, by the fact described above in connection with the prior art according to DE 100 08 135.5 that the number of active frictional edges of the singling cylinder in the area of grooves 2 which are in contact with bank note 5a to be singled is greater than that of retaining and pressure skids 4, 6.

[0049] After passing the singling gap, bank note 5a is supplied by a connected transport system to a test device and subsequent bin. The singling and conveyance of the bank notes is not limited to a special orientation of the bank notes
from the input pocket to the bin. Thus, longitudinal and/or transverse singling or conveyance can be used.

[0050] When friction segment 3 has moved out of the area of the singling gap in the course of further rotation of singling cylinder 1, the retaining forces predominate that are exerted by friction areas 8 of retaining skids 6 on next bank note 5a to be singled now located there, since in this state singling cylinder 1 is in contact with bank note 5a only with its smooth surface areas having a negligibly small coefficient of friction. Next bank note 5a is thus not singled but retained until friction segment 3 of singling cylinder 1 becomes effective at the singling gap again.

[0051] The retaining force and feed force can in this case be set independently of each other as follows, to guarantee reliable singling under changing operating and/or material conditions.

[0052] In preferred fashion, fastening device 9 of retaining skids 6 is first displaced in the vertical direction along rack rod 10 into a position suitable for attaining a desired retaining force and fixed in this position. To set the pressure force and thus the feed force independently thereof, a fine adjustment of pair of pressure skids 4 is then performed by vertical adjustment with the aid of pin 12 relative to retaining skids 6. This permits the contact force between singling cylinder 1 and bank note 5a or between retaining and pressure skids 4, 6 and bank note 5a at the contact area at the top edges of grooves 2 and thus the retaining and feed forces to be varied independently of each other.

[0053] FIG. 2 shows in cross section a friction wheel singler according to a second example. Since the singler is constructed substantially as described in DE 100 08 135.5 except for the features stated in the following, a detailed description of these components known in the art will be omitted.

[0054] In particular, singling cylinder 1 and retaining roll 14 have, as known in the art, circumferential grooves that are disposed mutually offset and adapted in their width so that retaining roll 14, which is formed to be vertically adjustable, can engage the grooves in singling cylinder 1 to increase the frictional forces. The structure of singling cylinder 1 can correspond e.g. to that of the embodiment according to FIG. 1.

[0055] Due to the suitable symmetric division of its surface into frictional friction areas 8 and smooth sliding areas, retaining roll 14 exerts only half as great a frictional force on bank note 5a to be singled as friction segment 3 of singling cylinder 1, whereby friction areas 8 of retaining roll 14 and friction segments 3 of singling cylinder 1 consist of the same friction material. The frictional material used, in particular for friction areas 8 of retaining roll 14, is a casting polyurethane, which shows the basically unexpected dependence of frictional force on rotating speed of retaining roll 14.

[0056] The inventive singling apparatus according to FIG. 2 is characterized in particular by the fact that not only singling cylinder 1 but also retaining roll 14 is controlled by adjusting device 15 that can set the rotating speed thereof to a desired, variable value.

[0057] For carrying out a second example of the inventive method, the apparatus according to FIG. 2 is used as follows.

[0058] A stack of bank notes 5 is placed in input pocket 16 of the friction wheel singler in longitudinal format. Lowermost bank note 5a to be singled next thus lies with its transverse side against singling cylinder 1. The force with which bank-note stack 5 deposited in sheet magazine 16, which is formed here as an oblique guiding plate, acts on singling cylinder 1 is determined by gravity alone and therefore depends on the weight and thus substantially the height of bank-note stack 5.

[0059] With the help of feed rolls 18 likewise provided with friction segments, the bank notes are preferably pushed to singling gap 19 at a speed corresponding to the transport speed of the bank note after singling. Singling gap 19 is formed by the opposite surface areas of singling cylinder 1 and retaining roll 14.

[0060] When singling cylinder 1 has turned, controlled by adjusting device 15, so far that the area of friction segment 3 has turned into an effective position, i.e. in the area of singling gap 19, the feed force distinctly predominates over the retaining force, as in the first example, so that sheet 5a to be singled is conveyed through singling gap 19. When friction segment 3 has moved out of the area of singling gap 19 in the course of further rotation of singling cylinder 1, the bank note present there is retained until friction segment 3 of singling cylinder 1 becomes effective at singling gap 19 again.

[0061] The retaining force and feed force can be set independently of each other in this embodiment according to FIG. 2 as follows.

[0062] As known in the art, the feed force, i.e. singling force, is set by the circumferential grooves of retaining roll 14 with smooth surface areas slightly engaging associated grooves 2 of singling cylinder 1 for increasing the pressure force on the bank note to be singled.

[0063] Since frictional surface areas 8 of retaining roll 14 simultaneously engage the associated circumferential groove of singling cylinder 1 during this process, the retaining force on the bank note to be singled will in this case also increase in the same way.

[0064] In other words, the absolute value of both the retaining force and the feed force can be changed in this procedure known in the art, but the ratio of these two forces is unaffected by the change of mesh and remains constant.

[0065] Thus, to decouple the change of the two forces, retaining roll 14 is controlled by adjusting device 15 so that it turns at a desired rotating speed acting against the transport direction of the bank notes. Due to the surprisingly ascertainment of speed dependence of frictional force in customers, the frictional force can in this case be additionally influenced by varying the rotating speed of retaining roll 14 independently of the feed force, since the smooth surface areas of retaining roll 14 made e.g. of steel, which press bank note 5a to be singled against singling cylinder 1, do not show this speed dependence.

[0066] The feed force can thus be set and changed independently of the retaining force by a combination of changing the mesh of retaining roll 14 and singling cylinder 1 and varying the rotating speed of retaining roll 14.

[0067] It should be noted that retaining roll 14 and singling cylinder 1 can also be constructed and mounted such
that retaining roll 14 can be operated in free running mode after a basic adjustment and is only controlled by adjusting device 15 to rotate at a predetermined speed when e.g. signs of wear lead in ongoing operation to changes in singling quality that necessitate an adaptation of the forces.

[0068] A third embodiment of an inventive friction wheel singler is shown in FIG. 3. The representation is selected in a cross-sectional plane perpendicular to the transport direction of bank note 5a to be singled in the area of the singling gap. In this embodiment, the principle of friction singling is combined with that of suction singling.

[0069] The picking device here has singling cylinder 1' shown in a detail view which has, in the middle area, circumferential groove 2' extending over the total circumference and in the transport direction of bank note 5a. As known in the art, it further has friction segments 3' over part of its circumference. As in the preceding embodiments, singling cylinder 1' can alternatively be equipped over its complete circumference with a friction lining if continuous singling of bank notes without any distance between individual bank notes is desired.

[0070] In addition, the friction wheel singler has pressure element 22 designed e.g. as a pressure skid, whose width is selected so that it can dip into groove 2' of singling cylinder 1'. For this purpose, pressure element 22 is designed to be vertically adjustable in the direction of double arrow H by an adjusting device (not shown). To be able to act as a pressure element, it has a smooth surface with a coefficient of friction substantially lower than the coefficient of friction segment 3' of singler 1' with respect to bank note 5a to be singled.

[0071] Changing the distance of pressure element 22 from singling cylinder 1' can change the contact force and thus feed force on bank note 5a located between said elements 1', 22.

[0072] Retention is attained in this case by pressure element 22 simultaneously exerting a suction function on bank note 5a located in the area of the singling gap. For this purpose, pressure device 22 comprises suction channel 20 that is connected with a vacuum source such that a vacuum and thus a suction effect can be exerted on bank note 5a through channel opening 21 on the underside of pressure element 22.

[0073] Regulating the vacuum acting in suction channel 20 in the area of suction opening 21 can consequently set the retention of bank note 5a in the area of singling gap 19 to a desired value.

[0074] In other words, in this embodiment according to FIG. 3, varying the mesh of pressure element 22 and singling cylinder 1' can thus change the feed force, and varying the air pressure in suction channel 20 can set the retaining force independently thereof.

[0075] Since only one component, pressure element 22, must be used here to permit both retaining force and singling force, i.e. feed force, to be set, this structure is especially simple mechanically. Because the singling principle is still based on friction singling and no suction singling is used, the air singling cylinders of mechanically complicated construction that are customarily used in suction singling can moreover be omitted.

[0076] Besides the examples stated above, further embodiments are of course conceivable, some of which will be explained by way of example.

[0077] Although all above-described cases use a friction wheel singler, i.e. a singler having a singling cylinder with friction segments, it is possible for the friction elements of the picking device to be mounted not on a rotatable singling cylinder but on a different element such as an endless band or the like. The only essential point for the functioning of the picking device is that the friction areas of the singling element are moved at a desired speed in the transport direction of the bank note in the area of the singling gap.

[0078] This principle can be realized in mechanically especially simple fashion by using a rotatable singling cylinder, but the subject matter of the present invention also includes other constructions that meet the aforementioned condition.

[0079] It should be emphasized in addition that the arrangement of the retaining device and pressure device is not limited to the embodiment shown in FIG. 1. Thus, the skids need e.g. not necessarily have a curvature adapted to the surface of singling cylinder 1 but can also be formed straight on the side facing singling cylinder 1.

[0080] In addition, the pressure and/or retaining skids, the number of which is also not limited to the shown number of two each, can for example also be designed as pivotally mounted rolls or the like. This arrangement is expedient in particular for the retaining devices for increasing the frictional surface area or edges of the retaining device coming in contact with the bank notes to be singled by rotation of an associated retaining roll and thereby distributing the wear over a greater area.

[0081] While the embodiment according to FIG. 1 further shows the case that the pressure skids are fastened in vertically adjustable fashion to the retaining device and the latter in vertically adjustable fashion to rack 10, a construction is alternatively conceivable in which the pressure skids are mounted on the rack themselves and the retaining skids analogously fastened in vertically adjustable fashion to the pressure device. In this case, the forces would thus be set by first moving the pressure skids to a desired position, fixing them and then finely adjusting the position of the retaining skids.

[0082] As a further alternative it is conceivable for fastening devices 9 and 11 of retaining device and pressure element to be decoupled completely from each other and for both fastening devices to be fastened directly to rack 10.

[0083] With respect to FIG. 1 the case was described that the vertical adjustment of the pressure and retaining devices is effected with the aid of fastening devices 9 and 11. This adjustment can be effected manually. Alternatively it is conceivable for it to be effected automatically, e.g. by electromechanical control.

[0084] In addition, it should be made clear that the different principles for providing the inventive effect of independent regulation of retaining force and feed force that have been described with reference to the figures might also be combined with each other. For example, one might consider combining the embodiments of FIGS. 1 and 2 by replacing the retaining skids according to FIG. 1 by a retaining roll having a frictional circumferential surface and varying the retaining force additionally or alternatively to the vertical adjustment of said retaining wheels with respect to the singling cylinder by also varying the rotating speed of said retaining roll.

[0085] Although the need to readjust the rotating singling cylinder is strongly dependent on the geometrical dimensions of the
components of the retaining and picking devices and in addition the operating conditions such as bank note quality, wear of singling components and the like, the following strategies have proved expedient in test series conducted by the applicant for preventing gaps and/or double picks during singling.

[0086] In this connection the configuration of the embodiment according to FIG. 1 with vertically adjustable separate pressure and retaining elements will be dealt with by way of example. If gaps occur in this case, the mesh of the retaining means should be reduced and that of the pressure skids with the singling cylinder increased. In case of double picks, the mesh of the retaining means should be increased and that of the pressure skids reduced. If gaps and double picks occur simultaneously, as is possible e.g. with very sticky bank notes, the mesh of the retaining means and to a lower extent also the mesh of the pressure skids should be increased.

[0087] The need to readjust the singler can be determined e.g. by the following two strategies, which have in particular the advantage that they can also be performed automatically with the aid of an associated control unit.

[0088] Regulation can be effected firstly with reference to average singling quality. For this purpose, the singling quality is e.g. checked by a suitable sensor system for gaps, double picks or other features. The sensor system can include for example thickness measurement or image digitization in the area of the singling gap. Evaluation of singling quality permits conclusions to be drawn on the necessary setting e.g. of the height or penetration depth of the pressure and retaining skids with respect to the grooves of the singling cylinder.

[0089] Said readjustment in dependence on evaluated singling quality can be performed in this concept after a certain number of singling processes, e.g. after singling of about 1,000 bank notes. For this purpose, the sensor signals are detected and evaluated over a relatively long time period for all or at least some of the singling processes, and then the skids readjusted, if required, to increase singling efficiency.

[0090] Alternatively, said readjustment can be performed for each individual bank note. This method involves detecting e.g. inside or immediately before the singling gap whether a gap or double pick is to be expected, and immediately readjusting the skids to obtain an optimal singler throughput.

[0091] The present invention thus makes it possible for a friction singler to reliably sing single after long operating times and under different ambient conditions since the retaining force and feed force on the sheets to be singled can be set independently of each other in the area of the singling gap for singling the sheet material.

1. A friction singler for singling sheet material such as bank notes or the like comprising:
   a sheet magazine (16) for receiving a stack of sheets (5),
   a picking device (1, 1', 4, 22) with a singling element, such as a singling cylinder (1, 1') or the like, the singling element having one or more friction elements (3, 3) for contacting and conveying the sheets (5a) to be singled from the sheet magazine (16), and
   a retaining device (6, 14, 22) forming with the singling element (1, 1') a singling gap (19) through which sheets (5a) to be singled from the sheet magazine (16) are conveyed successively, characterized by an adjusting device (9, 11, 15) for setting and/or regulating a retaining force exerted by the retaining device (6, 14, 22) on the sheets (5a) to be singled and a feed force exerted by the picking device (1, 1', 4, 22) on the sheets (5a) to be singled independently of each other in the area of the singling gap (19) for singling the sheet material.

2. A friction singler according to claim 1, characterized in that the values of the retaining force and the feed force are variable continuously or step-by-step within a range.

3. A friction singler according to claim 1 or 2, characterized in that the retaining device (6, 14, 22) has one or more friction areas (4) for contacting the sheets (5a) to be singled from the sheet magazine (7).

4. A friction singler according to claim 1, characterized in that the retaining device (6, 14, 22) has, for contacting the sheets (5a) to be singled, at least one retaining element (6, 14) opposite the singling element (1) in the area of the singling gap (19), such as a retaining wheel (14) or retaining skid (6) with the friction areas (8).

5. A friction singler according to any of the above claims, characterized in that the singling gap (19) further comprises a pressure element (4, 22) opposite the singling element (1) in the area of the singling gap (19), such as a pressure wheel or pressure skid (4, 22) with one or more sliding areas, the coefficient of friction of the sliding areas being smaller than the coefficient of friction of the friction elements of the singling element (1, 1').

6. A friction singler according to claims 3 and 5, characterized in that the coefficient of friction of the sliding areas is further smaller than the coefficient of friction of the friction areas of the retaining device (6, 14).

7. A friction singler according to claim 5 or 6, characterized in that the distance of the retaining element (6, 14) from the singling element (1) and the distance of the pressure element (4, 22) from the singling element (1) are capable of being set and/or regulated independently of each other in the area of the singling gap (19).

8. A friction singler according to any of claims 5 to 7, characterized in that the adjusting device (9, 11, 15) comprises a first fastening device (9) for fixing the variable position of the retaining element (6) with respect to the singling element (1) and/or a second fastening device (11) for fixing the variable position of the pressure element (4) with respect to the singling element (1).

9. A friction singler according to any of claims 5 to 8, characterized in that the adjusting device (9, 11, 15) has an adjusting element (12, 13) connected both with the retaining element (6) and with the pressure element (4), so that moving the retaining element with respect to the picking device with the aid of the adjusting element simultaneously moves the pressure element and/or moving the pressure element with respect to the picking device with the aid of the adjusting element simultaneously moves the retaining element.

10. A friction singler according to any of claims 3 to 9, characterized in that the friction elements (3) of the singling element (1) and the friction areas (8) of the retaining device (6) have friction material with a substantially equal coefficient of friction, and the contact area between the friction elements (3) of the singling element (1) and a sheet (5a) to be singled is substantially greater than the contact area.
between the friction areas (8) of the retaining device (6) and the sheet (5a) to be singled in the area of the singling gap (19).

11. A friction singler according to any of the above claims, characterized in that the friction elements (3) of the singling element (1, 1') are formed over the full or a limited circumference of the singling element.

12. A friction singler according to any of the above claims, characterized in that the singling element (1, 1') has one or more grooves (2) extending in the conveying direction of the bank notes (5a) to be singled in the area of the singling gap (19).

13. A friction singler according to claim 12, characterized in that the retaining device (6) is formed so that it can engage the grooves (2) of the singling element (1, 1') in the area of the singling gap (19) to set the retaining force.

14. A friction singler according to claim 12 or 13, characterized in that the pressure element (4, 22) is formed so that it can engage the grooves (2) of the singling element (1, 1') in the area of the singling gap (19) to set and/or regulate the feed force.

15. A friction singler according to any of the above claims, characterized in that the frictional engagement of the retaining device (6, 14) and of the pressure element (4, 22) in the grooves (2) of the singling element (1, 1') in the area of the singling gap (19) are capable of being set and/or regulated independently of each other.

16. A friction singler according to any of the above claims, characterized in that the retaining device comprises, for contacting the sheets (5a) to be singled from the sheet magazine (16), a suction apparatus (20) with one or more suction openings (21) for sucking the sheets (5a) to be singled in the area of the singling gap (19) by a vacuum.

17. A friction singler according to claim 15, characterized in that the adjusting device sets and/or regulates the vacuum in the area of the suction openings (21) for setting and/or changing the retaining force.

18. A friction singler according to claims 12 and 15, characterized in that the suction apparatus is formed so that, at least in the area with the suction openings (21), it can engage the at least one groove (2) of the singling element (1') for setting and/or regulating the feed force.

19. A friction singler according to claim 3, characterized in that the retaining device comprises a retaining roll (14) with the friction areas (8), and the adjusting device (15) is designed so that it can set and/or regulate the rotating speeds of the singling element (1) and the retaining roll (14) independently of each other for independently setting feed force and retaining force.

20. A friction singler according to any of the above claims, characterized by a sensor device to permit at least one physical feature to be measured during the singling process for detecting the singling quality.

21. A friction singler according to claim 20, characterized by a control device connected with the adjusting device for evaluating the measured values of the sensor device after a number of singling processes to detect a need for readjusting the retaining device and/or the picking device to prevent undesirable gaps or multiple picks or the like during ongoing singling.

22. A friction singler according to claim 20 or 21, characterized by a control device connected with the adjusting device for evaluating the measured values of the sensor device during an ongoing singling process to detect a need for readjusting the retaining device and/or the picking device during the ongoing singling process to prevent undesirable gaps or multiple picks or the like during ongoing singling.

23. A method for singling sheet material, such as bank notes or the like, of a stack of sheets (16) wherein a singling element, such as a singling cylinder (1, 1') or the like, having one or more friction elements (3, 3') contacts a sheet (5a) to be singled from a stack of sheets (16) and exerts a feed force thereon to convey the sheets (5a) successively from the stack of sheets (16) through a singling gap (19), a retaining force being exerted by a retaining device (6, 14, 22) on the sheets (5a) to be singled on the side of the singling gap (19) opposite the singling element (1, 1') to retain sheets yet to be singled so that only one sheet at a time is singled, characterized in that the retaining force and the feed force on the sheets (5a) to be singled are set and/or regulated independently of each other in the area of the singling gap (19) for singling the sheet material.

24. A method according to claim 23, characterized in that the values of the retaining force and the feed force are changed continuously or step-by-step within a range.

25. A method according to claim 23 or 24, characterized in that the distance of the retaining element (6) from the singling element (1) and the distance of a pressure element (4) from the singling element (1) are set and/or regulated independently of each other in the area of the singling gap (19).

26. A method according to any of claims 23 to 25, characterized in that the retaining force is set and/or regulated by setting and/or varying a vacuum in the area of the singling gap (19).

27. A method according to any of claims 23 to 26, characterized in that the rotating speeds of the singling element (1) and a retaining roll (14) are set and/or regulated independently of each other.

28. A method according to any of claims 23 to 27, characterized in that are detected and evaluated for a number of singling processes to detect a need for readjusting the retaining force and/or feed force to prevent undesirable gaps or multiple picks or the like during ongoing singling [sic].

29. A method according to any of claims 23 to 27, characterized in that measuring data on singling quality are evaluated during an ongoing singling process to detect a need for readjusting the retaining force and/or feed force during the ongoing singling process to prevent undesirable gaps or multiple picks or the like during ongoing singling.