

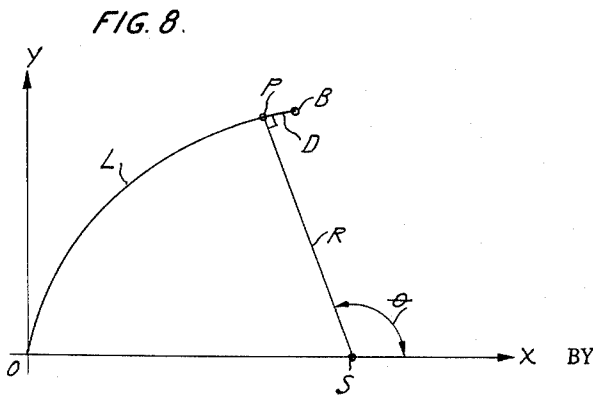
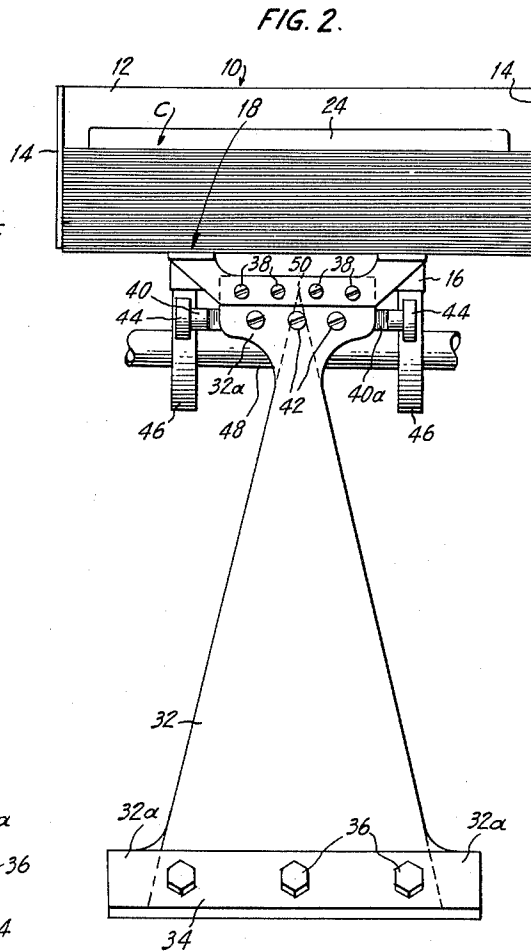
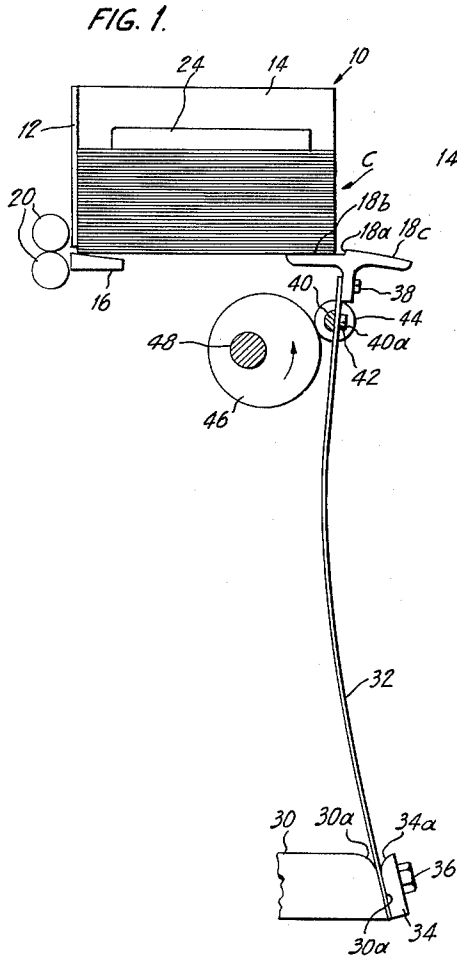
Aug. 18, 1964

G. D. CERF ETAL
CARD-FEEDER MECHANISM

3,145,023

Filed June 18, 1962

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

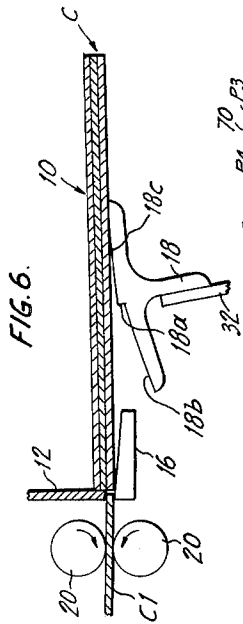


FIG. 6.

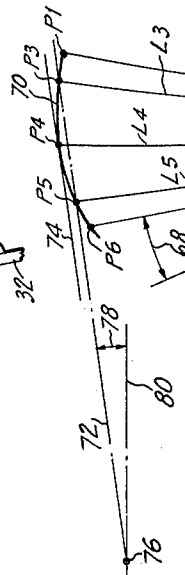


FIG. 7.

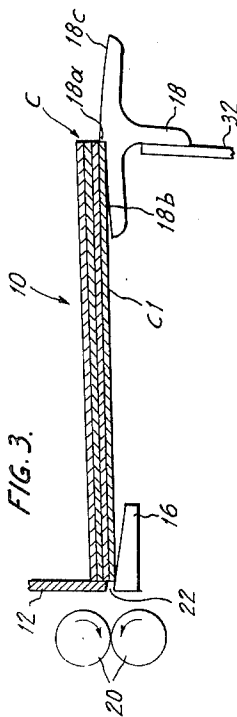


FIG. 3.

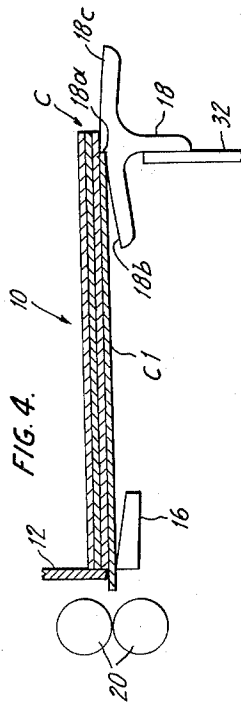


FIG. 4.

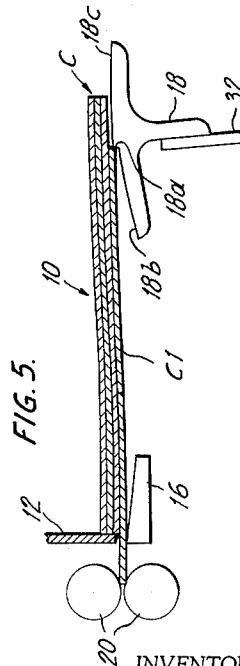


FIG. 5.

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CARD-FEEDER MECHANISM

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Filed June 18, 1962, Ser. No. 203,259
16 Claims. (Cl. 271-41)

This invention relates generally to machinery for handling cards and other sheet-like material, and it particularly concerns a data-tabulating card-feeder utilizing a picker knife mechanism.

In various applications it may be necessary for successive sheet-like pieces of stiff material, such as cards, to be advanced along a feed path by a rapidly reciprocating advancing device. One such situation occurs in tabulating card machinery such as card punches or readers, which must pick tabulating cards one by one from a supply stack and deliver them in succession along a feed path to the operating station where they are read or punched. The device which picks the cards from the stack, the picker knife, shuttles back and forth, extracting one card from the stack on each cycle. This device must be capable of operating at high speeds so as to provide a rapid stream of cards, since in data-processing applications time is of great importance.

In the past the suspensions used for picker knife mechanisms have been subject to sliding friction resulting in wear, a problem which is accentuated at high operating speeds. Usually the rapidly reciprocating picker knife has been movably supported on structures incorporating various linkages, pivots, rails, and other types of guides subject to sliding friction. In addition, such structures are often complex, require close tolerances, and consequently are expensive and difficult to manufacture. Maintenance may also be costly and troublesome, since in operation such structures generally require lubrication and adjustment, and are subject to occasional failures. An additional disadvantage is that such equipment usually exhibits a certain amount of looseness, causing backlash. Among the principal objects of this invention, therefore, is the provision of a card-feeder incorporating a picker knife suspension which is free of sliding friction, avoids critical tolerances, is simple and inexpensive to make and maintain, requires no lubrication or adjustment, is resistant to failure, and alleviates backlash.

But the card-feeder must not only operate at high speeds; it must do so while simultaneously providing a reliable card feed which does not skip or damage the cards. Accordingly, it is a further object of this invention to provide a card-feeder which is reliable at high speeds, and is not subject to misfeed or card-mutilation.

An additional disadvantage of some past picker knife mechanisms using cam drives has been that, in addition to the picker knife suspension, a spring return mechanism is required to provide the restoring force for making the picker knife follow the cam; and often such structures are subject to many of the disadvantages of friction-prone mechanisms listed above. It is therefore an additional object of this invention to provide a card-feeder picker knife suspension which offers inherent spring return action without the necessity for additional structures.

Still further objects of this invention are to provide a card-feeder picker knife mechanism which is of low mass, and which provides accurate control of the card-feeding trajectory.

In accordance with an illustrative embodiment of this invention, there is provided a material-advancing mechanism comprising a support, at least one flexible mounting member secured to the support and projecting in a selected direction therefrom, and a material-advancing device mounted on the projecting part of the mounting mem-

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ber, the latter being sufficiently bendable to permit the material-advancing device to move relative to the support through a material-advancing motion in a direction transverse to the selected direction.

The foregoing brief summary, as well as additional features of the invention, are more fully developed in the following detailed description, together with the accompanying drawings, in which:

FIG. 1 is a side elevational view, with parts in section, of a card-feeder and picker knife mechanism in accordance with this invention;

FIG. 2 is a rear elevational view of the aforesaid mechanism;

FIGS. 3 to 6 are a sequence of fragmentary side elevational views, similar to that of FIG. 1, illustrating the aforesaid mechanism in various consecutive positions of its operating cycle;

FIG. 7 is a geometric diagram illustrating certain features of the aforesaid mechanism;

And, FIG. 8 is a rectangular coordinate graph illustrating further features of the aforesaid mechanism.

Referring specifically to the drawings, FIGS. 1 and 2 show a portion of a card-handling machine including a gravity feed card hopper 10 having a front wall 12 and a pair of side walls 14. This hopper is designed to hold a stack of up to some maximum number of data-tabulating cards C, the individual cards each lying substantially horizontally and the stack rising substantially vertically within the hopper 10. The bottom of the hopper is substantially open, thus exposing the lowermost card C₁. However, the hopper 10 includes a throat plate 16 upon which the forward part of the stack rests, and the rearward part rests upon a picker knife 18, which is bifurcated as seen in FIG. 2. Forwardly of the stack is a pair of counter-rotating feed rollers 20 which cooperate to deliver the cards C one-by-one to another location (e.g. the operating station, not shown, of the card-handling machine). Such delivery occurs after a card is initially moved out of the stack and into the grip of the rollers 20.

Performing this initial movement, as well as supporting the rear part of the stack of cards C, are the functions of the picker knife 18. Each half of the latter has a "blade" in the form of a slight step 18a formed in its upper surface 18b, c. The vertically rising wall of the step 18a faces forwardly and constitutes a card-edge-engaging surface which, upon forward motion of the picker knife 18, abuts against the rear edge of the lowermost card C₁, as seen in FIG. 3, and drives that card forwardly through an appropriately positioned exit space 22 between the lower edge of the hopper front wall 12 and the throat plate 16, and on out of the hopper 10, as seen in FIG. 4, until it eventually meets both the feed rollers 20, as seen in FIG. 5, at a point near the juxtaposition of the rollers 20 and a short distance forward of the exit space 22. The feed rollers 20, counter-rotating as indicated by the arrows in FIG. 6, thereupon grip the card C₁, continue drawing it out of the stack, and then send it on to its destination, the remaining travel being of no relevance to an understanding of the mechanism of this invention.

This stroke of the picker knife is continuously repeated, and on each cycle thereof the card which is then in the lowermost position C₁ is moved out of the stack of cards C, after which the remainder of the stack in the gravity feed hopper 10 drops down and the process is repeated in this manner for each following card. A weight 24 may be placed on top of the card stack to assure that there is always enough pressure to keep the cards C moving down through the hopper 10, and also to press the individual cards flat so that they mate properly with the blade 18a and with the exit opening 22. In order to assure that only one card C is picked on each cycle, the height of the blade 18a is slightly

less than the thickness of a standard data card, while the height of the exit opening 22 is between one and two such thicknesses.

The structure for mounting the picker knife 18 and driving it through its card-moving stroke includes a support 30, which may be part of the frame of the larger card-handling machine. This support is formed with a flat clamping surface 30a, to which the lower end of a member 32 is clamped by means of a clamping bar 34 and several bolts 36. The member 32 is a flexure spring consisting of a flat, flexible metal leaf, the elongated upper portion of which rises free of the support 30 and carries the picker knife 18, which is secured to the upper tip thereof by several bolts 38. The broader dimensions of the leaf 32 define a relatively flat plane which is substantially vertically oriented, and thus is practically perpendicular to the forward, substantially horizontal direction of the picker knife stroke. Therefore, the free upper portion of the leaf 32 can be bent elastically in either direction, essentially perpendicular to the plane defined thereby, i.e. forwardly and backwardly, to allow the picker knife 18 a latitude of movement in those directions, while acting as a kind of guide in that it limits motion parallel to the plane defined thereby, i.e. vertically and also sidewardly (with respect to the view of FIG. 2). It will be appreciated that the leaf 32 thus provides a dynamic suspension and guide for the moving picker knife 18, yet the strictly flexural movement of this suspension is entirely free of sliding friction, and it makes unnecessary any linkages, pivots, rails, or other types of guides inherently subject to sliding friction. Since it is thus free of frictional wear, the picker knife suspension of this invention is better able to withstand high speed picker knife operation, without any lubrication or adjustment of the leaf 32. Moreover, this leaf has a simpler shape than most linkages, rails, guides, etc. and does not require as close tolerances as such structures generally do, so that it is easier and less expensive to manufacture; simply stamping the required leaf shape from a sheet of suitable thickness and composition suffices. As a further advantage, the fact that the mounting leaf 32 is firmly bolted both to the support 30 and the picker knife 18 means that there can be little looseness and backlash in this suspension, as compared to structures employing various kinds of movable joints.

Also carried on the upper portion of the leaf 32 is a cam-follower assembly including a double-ended stub shaft 40 secured to the leaf 32 just below the picker knife 18 by several bolts 42, and a pair of cam-follower rollers 44 rotatably mounted at either end of the stub shaft 40. Acting against these cam-follower rollers 44 to cycle the picker knife 18 through its card-moving stroke are a pair of cams 46 fastened to a cam drive shaft 48 powered by the conventional main drive (not shown) of the card-handling machine. Under the influence of this cam drive, the picker knife 18 and its mounting leaf 32 are repeatedly reciprocated forwardly and rearwardly through the successive operating positions illustrated by FIGS. 1 and 3 to 6, in that order.

As an additional feature of the invention, the leaf 32 is sufficiently springy and resilient so that it inherently provides the restoring spring force which forces the cam-follower rollers 44 against their drive cams 46 and thereby returns the driven cam-follower, picker knife, mounting member assembly forwardly after each rearward driving stroke of the cams. Thus no additional spring return structure is necessary to provide such restoring force.

In order for the leaf to provide adequate spring restoring force through all phases of its cycle of reciprocation, including the phase of minimum flexure, it is maintained in a flexed condition over the entire range of its operating stroke. The clamping surface 30a is slanted forwardly so that the part of the leaf 32 immediately adjacent the support is aimed too far forward.

Then the cam drive 46, 48 is positioned in front of the leaf 32, but located far enough back to keep the latter flexed rearwardly (and thus exerting a restoring force) even at the forward limit of the card-moving stroke (FIG. 6).

In order to simplify the problems of design, the leaf is made substantially in the form of an isosceles triangle having its base at the lower end and its apex 50 at the upper end, as shown by the dashed lines superimposed on FIG. 2. The only variations from the triangular shape are the tabs 32a added where necessary for fastening to the support 30, picker knife 18, and cam-follower shaft 40. The purpose of this shape is to concentrate the mass of the leaf 32 as much as possible toward the immobilized lower end thereof. This more evenly distributes the flexing stresses over the length of the leaf 32, and reduces the amount of mass which must be moved back and forth over the greater distances traveled by the free upper end of the leaf. As a result, in calculating the cam and spring forces required to reciprocate the mechanism at the speeds desired, the effective mass of the leaf 32 may be considered the approximate equivalent of a mass one-fifteenth the actual mass of the leaf, but concentrated at the apex 50 of the triangle. Carrying further the simplification of the design calculations, the masses of the picker knife 18, cam-follower assembly 40, 44, and their respective fasteners 38 and 42 are so placed as to center about a horizontal line passing through the triangle apex 50. In addition, the cam-follower shaft 40 is formed with a flat surface 40a abutting against the front surface of the leaf 32 such that the axis of rotation of the rollers 44 coincides with that surface, further simplifying the design considerations. These factors are also helpful in minimizing any tendency toward harmonic vibration.

Some of the most important considerations in the design of this mechanism concern the trajectory of the picker knife 18 and the placement of the cards C in relation thereto. The first requirement, illustrated by FIG. 1, is that the rearward limit of the picker knife trajectory be far enough back so that the blade 18a moves behind the rear edge of the card C₁ and will then be in position to catch such edge as the cams 48 rotate past the position of FIG. 1 and the spring action of the leaf 32 drives the picker knife 18 forwardly to the position of FIG. 3. As this forward stroke continues to the position illustrated by FIG. 4, it is necessary that the blade 18a remain in engagement with the rear edge of the card C₁ in order to prevent misfeed. It has been found that an effective way to maintain such engagement between blade and card is to provide a picker knife trajectory which rises slightly at this stage of the card-moving stroke, thus pressing the picker knife 18 more firmly upward against the lowermost card C₁. This, in cooperation with the downward pressure of the rest of the cards C and the weight 24, provides positive mating of the blade 18a and the rear edge of the card C₁. A further feature of the picker knife trajectory is illustrated in FIG. 5, which depicts the moment when the card C₁ has just been moved into contact with the feed rollers 20. From this moment on, the feed rollers will take over the job of moving the card C₁; therefore it is highly desirable that at such time the picker knife 18 drop below the level of the card C₁ in order to disengage the blade 18a from the rear edge thereof. If this were not done, then in the event that the card C₁ for any reason were not immediately drawn into the grip of the feed rollers 20 (for example, because of an obstruction, or because the card had a damaged front edge), then the continued forward motion of the picker knife (to the forward limit position illustrated in FIG. 6) might tear or otherwise utilize the card, impairing its usefulness for data-processing purposes and creating a risk that such a mutilated card would then jam this or some other card-handling machine.

The diagram of FIG. 7 illustrates these design require-

ments geometrically. The straight line 60 represents the plane of the clamping surface 30; note that it is slanted at an angle 62 to the vertical line 64. Point 66 represents the point at which the leaf 32 emerges from between the clamping surface 30 and the clamping bar 34 and begins to curve. The curved lines L_1 and L_{3-6} represent the curvatures of the leaf at the key operating positions of the respective correspondingly numbered FIGS. 1 and 3-6. Thus line L_1 represents the rearward limit position of FIG. 1, lines L_{3-5} represents the intermediate positions of FIGS. 3 to 5 respectively, and line L_6 represents the forward limit position of FIG. 6. Note that even at this latter position, the least flexed of all, the upper end of the leaf is still bent at an angle 68 from the line 60 representing its orientation at the clamping surface 30, so that it is always subjected to a static pre-load for continuous cam-following action.

The curve 70 represents the trajectory of the blade 18a, and the points P_1 and P_{3-6} therealong represent the location of the blade at the phases of operation illustrated by the respective correspondingly numbered FIGS. 1 and 3 to 6. The straight line 72 represents the orientation of the lowermost card C_1 . This line intersects the blade trajectory curve 70 at point P_3 where the blade first engages the rear card edge (the position of FIG. 3). Between that point P_3 and the point P_1 (the initial position of FIG. 1) the blade trajectory curve 70 rises up to meet the card line 72. The blade trajectory curve 70 then continues to rise after passing the initial engagement point P_3 , and thus goes above the card line 72 to achieve the slight lift which improves the firmness of card-engagement and thus the reliability of the feed. At point P_5 (the position of FIG. 5) the blade trajectory curve 70 again intersects the card line 72, heading downward, and the blade thus desirably disengages from the card edge to prevent card damage, subsequently continuing forward to point P_6 (the position of FIG. 6). At some intermediate point P_4 (the position of FIG. 4) a line 74 which is tangent to the blade trajectory curve 70 is also parallel to the card line 72. Thus, the orientation of the card C_1 is such that it is aligned with the path of the blade 18a somewhere between the endpoints P_3 and P_5 of the card-engaging portion of its trajectory 70, so as to be best aligned with that trajectory over the whole of its card-engaging portion. As a result of the picker knife stroke described, the card C_1 is fed along the line 72 until it meets the feed rollers 20 at point 76. Note that so far as the card C_1 is concerned, the described requirements are best met by a card orientation 72 which is tilted down toward the feed rollers 20 at an angle 78 to the horizontal 80. Such a card orientation is achieved by mounting the throat plate 16 an appropriate distance below the level of the front upper surface 18b of the picker knife 18.

Prior picker knife mechanisms were generally designed so that the various linkages, pivots, rails, and other guides thereof imparted a linear trajectory to the picker knife. The present flexure spring suspension structure, in contrast, inherently involves a curved picker knife trajectory 70 because of the vertical displacement which the free upper end of the leaf 32 undergoes when the leaf flexes during the horizontal reciprocation of the picker knife 18. This fact presents an opportunity to select the curved path 70 which will provide the superior trajectory described above, including the advantageous rise and fall features discussed. As may be seen from a standard engineering text on small deflection theory, such as "Elements of Strength of Materials," by Timoshenko and Young, 4th edition, 1962, D. Van Nostrand Company, Inc., pp. 111 et seq., when the free end of a prismatic cantilever beam undergoes "pure bending" and the total transverse deflection is relatively small in relation to the length of the beam and also is within the elastic limit of the material so that no permanent deformation takes place, then the shape assumed by the bent beam itself is

approximately a circular arc. In this case, something occurs which is similar to pure bending, with the result that here too the curve of the bent beam (its "elastic line") is nearly circular. To show this, we note that the curvature of a beam at any point P along its length is equal to M/EI . (In this expression: M is the "bending moment" experienced by the beam at the point P; E is the "modulus of elasticity" of the beam material; and I is the "moment of inertia" of the beam at point P. The expression is Equation 5.4, Timoshenko and Young, p. 114, which is there derived from a general definition of moment of inertia that is true for all cases, whether or not there is pure bending.) The next step is to show that the curvature M/EI is constant. E, the modulus of elasticity, is constant for a given material. M and I are both variable, depending on the location of the point P. But it can be shown that, owing to the construction of the beam or leaf 32 in this case, their ratio M/I is constant over the length of the leaf. M, the bending moment, increases in proportion to the distance of the point P from the place (near the triangle apex 50) where the bending force is applied to the leaf 32 by the cams 46. I, the moment of inertia, increases in proportion to the cross-sectional area of the leaf 32. Because of its tapering, approximately triangular shape, the cross-sectional area of the leaf 32 increases approximately in proportion to the distance from the triangle apex 50; and the moment of inertia I therefore does the same. Thus the quantity M/I varies over the length of the leaf 32 in nearly the same way as the quantity M does. Therefore the ratio M/I remains nearly constant over the length of the leaf 32. It then follows that the leaf curvature M/EI is nearly constant over the length of the leaf; i.e. the curve assumed by the bent leaf 32 approximates a circular arc. Further, in order to avoid consideration of any minute variations in the length of the leaf 32 during bending, we may make the simplifying assumption, (true for pure bending and approximately so in other cases; see Timoshenko and Young, p. 112) that the length of the central portion of the beam, the neutral fiber, remains approximately constant and equal to the length of the beam before bending. Using this information, a way has been devised to calculate the approximate trajectory 70 of the free end of the beam or leaf 32 and thus of the picker knife 18 mounted thereon.

FIG. 8 represents a rectangular coordinate graph in which the origin O represents the point (66 in FIG. 7) at which the fixed end of the curved leaf 32 is anchored against the support 30, the remainder of the leaf below that point being clamped and therefore unable to bend. Thus, point O is the lower end of the curved leaf 32. The upper end of the curved leaf is at point P, having the coordinates x, y. The circular arc L drawn between points O and P represents the approximately circular curve of the leaf 32. This circular arc is drawn tangent to the y axis at the origin O; therefore the x axis coincides with a radius of the circular arc. A second radius R drawn from the point P intersects the x axis at point S, the center of the circular arc L. This second radius makes an angle of θ radians with the x axis. If R represents the length of this radius, it is seen that the coordinates of point P are given by:

$$x = R - R \cos (\pi - \theta) = R(1 + \cos \theta)$$

$$y = R \sin (\pi - \theta) = R \sin \theta$$

These relations are true in general for any curvature to which the leaf 32 may be bent, and therefore for the entire path 70 of point P. L, representing the length of the circular arc, is given by:

$L = R(\pi - \theta) = \text{a constant} = \text{the length of the leaf 32}$
Therefore the equations:

$$x = \frac{L(1 + \cos \theta)}{\pi - \theta} \text{ and } y = \frac{L \sin \theta}{\pi - \theta}$$

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give the locus of point P for all values of the variable θ . The blade 18a of the picker knife 18 is at point B, which is spaced from point P (the outer tip of the leaf 32) along a straight line D tangent to the circular arc at point P. If D represents the length of that straight line, the equation of the blade trajectory 70 is given by:

$$x = \frac{L(1 + \cos \theta)}{\pi - \theta} + D \cos(\theta - \pi/2)$$

and

$$y = \frac{L \sin \theta}{\pi - \theta} + D \sin(\theta - \pi/2)$$

Once the trajectory 70 is selected, these equations determine what dimensions L and D will provide the desired results.

The leaf length L then sets certain limitations on the minimum thickness of the leaf 32. In choosing this thickness it is first necessary to select a shape for the cams 46 which, if followed by the rollers 44, would give the desired card-acceleration. Then the leaf 32 should be chosen of sufficient thickness, in view of its length, to meet certain operating requirements.

First, as to the required card-acceleration, the motion of the picker knife 18 is necessarily rapid in both directions over its entire stroke, so as to be compatible with high-speed card-handling and other data-processing procedures. However, the cams 46 are shaped so as to vary the picker knife velocity according to the phase of the card-feeding cycle in a manner to provide superior results. Specifically, the cams 46 are designed so that the velocity of the picker knife 18 is comparatively low as it initially engages the card C₁ (FIG. 3), so as to avoid violent hammering of the card and to provide for a more even engagement of the card edge by the blade 18a. After this initial engagement the cams 46 accelerate the picker knife 18 and card C₁ rapidly through the phase of the cycle represented by FIG. 4; by the time the position of FIG. 5 is reached the card C₁ is accelerated to a velocity equal to the tangential speed of rotation of the circumference of the feed rollers 20, so that it passes on through the positions of FIGS. 5 and 6 without any abrupt change in velocity. In this way the card C₁, at the beginning and end of its engagement with the picker knife 18, is spared any sudden jolt which might crumple or otherwise damage the card and/or disrupt its contact with the blade 18a to cause a misfeed. The result is more reliable card feeding and the prevention of jams or misreadings caused by damaged cards.

Next, as to the thickness of the leaf 32, that must be great enough in view of the required length L thereof to provide the degree of stiffness necessary for uninterrupted cam-following action. First the picker knife acceleration is calculated for the various phases of the operating cycle thereof. Then, from the basic equation relating force, mass, and acceleration, it is possible to calculate the force necessary to impart the required acceleration at each phase of the operating cycle to the known combined mass of the card C₁ and the driven assembly of the picker knife 18, shaft 40, rollers 44, and fasteners 38 and 42, plus the effective mass of the leaf 32 itself. The accelerating force exerted by the deflected leaf 32 at each such phase of the cycle depends upon the extent of the leaf deflection at that phase, which is a known quantity determined by the geometry of the structure, and by the ratio of the leaf's thickness to its length L. Since the length L is determined by the required picker knife trajectory, the only remaining variable to be chosen is the thickness of the leaf 32. This dimension is then made large enough so that the degree of leaf deflection occurring along each part of the operating stroke produces the cam-following force necessary to cause the required acceleration and keep the cam-follower rollers 44 pressed into engagement with the drive cams 46. In particular, this driving engagement is maintained in the least de-

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flected position of FIG. 6 because of the fact that even in this position the leaf 32 is deflected owing to the static pre-load, as indicated by the curved line L6 in FIG. 7.

Returning for a moment to the matter of picker knife acceleration, a further requirement is that the cams 46 be shaped so that on the backstroke they drive the picker knife assembly rapidly rearwardly from the position of FIG. 6 to that of FIG. 1. The cam-following force developed by the leaf 32 at this rearward limit position of FIG. 1 must then be great enough so that at the end of the backstroke the driven assembly does not whip backwardly to bring the cam-follower rollers 44 momentarily out of contact with the drive cams 46. Stated differently, the thickness and thus the stiffness of the leaf 32 must be sufficient to provide a force great enough to produce the powerful deceleration required by the shape of the cams 46 when the driven assembly reaches the end of its backstroke. If this precaution were not taken, the whipping of the driven assembly would cause bouncing and harmonic vibration of the picker knife 18 so as to impair the positive control over its trajectory, thus adversely affecting the operation of the mechanism, and it would further cause a hammering of the cam-follower rollers 44 against the drive cams 46 which would adversely affect the life of the structure.

Another consideration is that the stiffness of the leaf 32 must be sufficient to keep the natural frequency of flexural oscillation of the leaf 32, with its attached masses, well above the cycling rate encountered at the maximum operating speed for which the card-handling machine is designed, so as to discourage harmonic vibrations which would similarly affect both operation and longevity.

Finally, the leaf thickness should be chosen large enough so that the static and dynamic loads to which the leaf 32 is subjected are well within the static and dynamic stress and fatigue limits of the material used, which, in view of the rapid and prolonged flexing to which the leaf 32 is subjected, should be an elastic and resilient metal such as high quality heat-treated spring steel, beryllium copper, or Phosphor bronze. The dynamic loads imposed on the leaf 32 are determined by the maximum forward and backward deflections to which it is driven by the cams 46. In order to avoid concentration of these bending stresses at the place where the leaf 32 emerges from between the clamping surface 30 and clamping bar 34, locations 30a and 34a are provided with the gentle curvatures seen in FIG. 1. The static forces include the flexural static pre-load to which the leaf is subjected by virtue of its being maintained in a flexed condition to act as a cam-following return spring. In addition, the static stresses include the downward buckling or compressive force, which is determined by the force of the combined weight of the leaf 32 itself, picker knife 18, shaft 40, rollers 44, and bolts 38 and 42, plus whatever portion of the weight of the cards C and weight 24 is borne by the picker knife 18. Thus the thickness of the leaf 32 must also be great enough so that its stiffness is sufficient to support the buckling load associated with the maximum card stack size, and to do so without suffering, at any of the flexed positions to which it is driven, a buckling deflection great enough to significantly alter the picker knife trajectory 70 or to disrupt the driving contact between the cams 46 and their follower rollers 44.

Because the picker knife upper surfaces 18b, 18c remains in contact with, and supports, the rear portion of the cards C as the picker knife 18 reciprocates between the positions of FIGS. 1 and 6, the forward and rearward surfaces 18b and 18c are curved downwardly forwardly and rearwardly of the blade 18a respectively. In this way the level at which the rear portion of the cards C is supported is not altered solely due to the forward and backward tilting of the picker knife 18 (compare FIGS. 1 and 6) induced by the flexing of the leaf 32, since the described curvatures provide clearance for the cards C even at the rearward (FIG. 1) and forward

(FIG. 6) limits of the picker knife travel. The proper curvatures may be calculated from the picker knife trajectory and the degree of flexing to which the leaf 32 is subjected at these limit positions, since the latter determines the degree of tilting of the picker knife 18.

In addition, the forward and rearward curved surfaces 18b and 18c respectively are displaced from each other in such a manner that, if we imagine the curvature of the forward surface 18b to be extended rearwardly past the "step" 18a, the curve of the rearward surface 18c would be substantially parallel to, but not congruent with, such extension curve. Instead, the curve of 18c is spaced upwardly from the extension of the curve of 18b (as measured along any common radius of the curves) by substantially the thickness of a conventional data card. This has the advantage that as the lowermost card C₁ leaves the stack of cards C, the remaining cards do not drop suddenly down upon the picker knife 18 but instead, as seen in FIG. 1, they are supported at a constant level by the rear surface 18c. As a result, there is no downward jarring of the picker knife 18 during the forward card-feeding stroke, which would risk disrupting the engagement of the blade 18a against the rear edge of card C at a critical moment in the feeding thereof. The dropping down of the remaining cards C upon the picker knife 18 is postponed until the backstroke, at which time it does not have a critical effect on card-feeding.

It will now be appreciated that a card-feeder and picker knife mechanism so constructed not only avoids the manifold disadvantages of other suspensions and spring return mechanisms, but also affords reliable and non-damaging card feed over a long operating life.

The foregoing, illustrating a preferred embodiment of this invention, suggests other variations which will be apparent to those ordinarily skilled in the art. Therefore, it is desired that the scope of protection be defined as set forth in the claims.

What is claimed is:

1. In a card-handling machine including a card container; a card-feeding mechanism comprising:

- (a) a support spaced from the container in a selected direction;
- (b) a flexible member secured at one end to the support with the other end thereof projecting generally along the selected direction toward the container;
- (c) a picker knife movable in a direction transverse to the selected direction for extracting cards from the container, carried on the said other end of the flexible member;
- (d) the flexible member being sufficiently bendable to permit such transverse movement of the picker knife;
- (e) and means for flexing the flexible member and driving the picker knife through such transverse movement in one direction;
- (f) the flexible member being sufficiently resilient to thereafter return the picker knife in the opposite direction to complete such transverse movement.

2. In a card-handling machine including a card container; a card-feeding mechanism comprising:

- (a) a support spaced from the container in a selected direction;
- (b) a flexible member secured at one end to the support with the other end thereof projecting generally along the selected direction toward the container;
- (c) a picker knife movable in a direction transverse to the selected direction for extracting cards from the container, carried on the said other end of the flexible member;
- (d) the flexible member being sufficiently bendable to permit such transverse movement of the picker knife;
- (e) and means for operatively positioning the picker knife in relation to the container and for flexing the flexible member and driving the picker knife through such transverse movement in one direction;

(f) the flexible member being sufficiently resilient to thereafter return the picker knife in the opposite direction to complete such transverse movement;

(g) the support and the drive means being arranged to maintain the flexible member in a flexed condition whereby to exert a static pre-load on the picker knife.

3. In a card-handling machine including a card container, a card-feeding mechanism comprising:

- (a) a support spaced from the container in a selected direction;
- (b) a flexible member secured at one end to the support, with the other end thereof projecting generally along the selected direction toward the container;
- (c) and a picker knife movable in a direction transverse to the selected direction for extracting cards from the container, carried on the said other end of the flexible member;
- (d) the flexible member being in the form of a leaf arranged with the plane thereof substantially perpendicular to the direction of movement of the picker knife and being sufficiently bendable to permit such movement thereof.

4. A mechanism in accordance with claim 3 wherein the shape of the flexible member is tapered in the plane of the leaf from a part thereof near the support to a part thereof near the picker knife.

5. In a card-handling machine including a card container, a card-feeding mechanism comprising:

- (a) a support spaced from the container in a selected direction and formed with a clamping surface;
- (b) a flexible member in the form of a leaf secured at one end flat against the clamping surface, with the other end projecting generally along the selected direction toward the container;
- (c) and a picker knife movable in a direction transverse to the selected direction for extracting cards from the container, carried on the said other end of the flexible member;
- (d) the flexible member being sufficiently bendable to permit such transverse movement of the picker knife;
- (e) and means for operatively positioning the picker knife relative to the container and driving the picker knife through its card-extracting movement;
- (f) the clamping surface being so angled in relation to the picker knife positioning means as to maintain the flexible member in a flexed condition for exerting a static pre-load on the picker knife.

6. Card-handling machinery comprising:

- (a) a container adapted to hold a stack of cards, and arranged to permit extraction of the endmost card at one end of the container, and for feeding the stack toward the said end of the container when the said endmost card is removed therefrom;
- (b) means adjacent the said end of the container and arranged to feed the said endmost card from the stack to another location when such card is moved theretoward;
- (c) a support spaced in a selected direction from the said end of the container;
- (d) a flexible member secured to the support and projecting generally in the selected direction;
- (e) a card-moving device mounted on the projecting part of the flexible member in position to be moved transversely to the selected direction into operative engagement with such endmost card;
- (f) the flexible member being sufficiently bendable to permit the card-moving device to perform such movement;
- (g) a cam-follower carried by the flexible member;
- (h) and a cam drive operable against the cam-follower to cycle the card-moving device repeatedly through the said movement;
- (i) the flexible member being sufficiently resilient to provide a restoring force normally maintaining oper-

ative engagement between the cam drive and cam-follower.

7. Machinery in accordance with claim 6, wherein the flexible member is so arranged in relation to the cam drive that throughout the operating cycle of the cam drive the engagement thereof against the cam-follower holds the flexible member in a flexed condition for providing a static pre-load to increase the force exerted thereby.

8. Card-handling machinery comprising:

- (a) a gravity feed hopper, adapted to contain a substantially vertical stack of substantially horizontal cards, and arranged to permit removal of and to at least partly expose the lower surface of the lowermost card to provide access thereto;
- (b) means adjacent the lower end of the hopper and arranged to feed the said lowermost card from the stack to another location when such card is initially moved theretoward;
- (c) a support spaced below the lower end of the hopper;
- (d) a flexure spring having a lower end secured to the support and an upper portion rising generally toward the hopper;
- (e) and a device for performing such initial card-movement mounted on the upper portion of the flexure spring in position to exert an upward force on the exposed part of such lowermost card for at least partially supporting the weight of the stack, and constructed to make card-moving engagement with such lowermost card when moved in a substantially horizontal direction;
- (f) the flexure spring being sufficiently bendable to permit the card-moving device to perform such movement.

9. Machinery in accordance with claim 8 wherein the card-moving device is formed with a forward upper surface, a forwardly directed card-edge-engaging blade behind the forward upper surface, and a rearward upper surface behind the card-edge-engaging blade elevated by substantially one card-thickness above the forward upper surface whereby to prevent dropping down of the remaining cards upon the card-moving device as the forward stroke thereof moves the lowermost card.

10. Card-handling machinery comprising:

- (a) a gravity feed hopper, adapted to contain a substantially vertical stack of up to a selected maximum number of substantially horizontal cards, and arranged to permit removal of and to at least partly expose the lower surface of the lowermost card to provide access thereto;
- (b) means adjacent the lower end of the hopper and arranged to feed the said lowermost card from the stack to another location when such card is initially moved theretoward;
- (c) a support spaced below the lower end of the hopper;
- (d) a flexure spring having a lower end secured to the support and an upper portion rising generally toward the hopper;
- (e) a device for performing such initial card-movement mounted on the upper portion of the flexure spring in position to exert an upward force on the exposed part of such lowermost card for at least partially supporting the weight of the stack, and constructed to make card-moving engagement with such lowermost card when moved in a substantially horizontal direction;
- (f) the flexure spring being sufficiently bendable to permit the card-moving device to perform such movement;
- (g) a cam-follower assembly carried by the upper portion of the flexure spring;
- (h) and a cam drive operable against the cam-follower assembly to cycle the card-moving device repeatedly through such movement;

(i) the flexure spring being sufficiently stiff to support the weight of the card-moving device and cam-follower assembly plus the required portion of the weight of the selected maximum number of cards, without undergoing a sufficiently large buckling deflection to disrupt operative engagement between the cam drive and cam-follower or disrupt operative engagement between the lowermost card and the card-moving device.

11. Card-handling machinery comprising:

- (a) a gravity feed hopper, adapted to contain a substantially vertical stack of substantially horizontal cards, and arranged to permit removal of the lowermost therefrom;
- (b) means adjacent the lower end of the hopper and arranged to feed the said lowermost card from the stack to another location when such card is initially moved theretoward;
- (c) a support below the lower end of the hopper;
- (d) a flexure spring having a lower end secured to the support and an upper portion rising generally toward the hopper;
- (e) a device for performing such initial card-movement mounted on the upper portion of the flexure spring in position to be moved substantially horizontally into operative engagement with such lowermost card;
- (f) the flexure spring being sufficiently bendable to permit the card-moving device to perform such movement, and tilting and guiding such device along a curved trajectory;
- (g) the card-moving device having card-edge-engaging means thereon and being formed with a top surface adjacent the card-edge-engaging means curved downwardly away from the card-edge-engaging means whereby to provide clearance for the tilting of the card-moving device relative to the card stack.

12. Card-handling machinery comprising:

- (a) means for supporting a stack of cards and for moving an endmost card thereof in a selected direction from the stack, such means including—
 - (1) a device movable substantially parallel to such cards and having card-edge-engaging means for accomplishing such card-movement;
 - (2) and means guiding the card-moving device such that the card-edge-engaging means describes a curved card-moving trajectory including a card-engaging portion;
- (b) the stack-supporting means being arranged to orient such endmost card substantially parallel to a line which is tangent to the curved card-moving trajectory at a point between the end points of the card-engaging portion of such trajectory.

13. Card-handling machinery comprising:

- (a) means for supporting a stack of cards and for moving an endmost card thereof in a selected direction from the stack, such means including—
 - (1) a device movable substantially parallel to such cards and having card-edge-engaging means for accomplishing such card-movement;
 - (2) and means guiding the card-moving device such that the card-edge-engaging means describes a curved card-moving trajectory including a card-engaging portion;
- (b) the stack-supporting means being arranged to orient such endmost card substantially parallel to a line which is tangent to the curved card-moving trajectory at a point between the end points of the card-engaging portion of such trajectory, wherein the line of orientation of such endmost card is aligned with a chord of the curved trajectory, whereby in traversing the card-engaging portion of such trajectory the card-engaging means extends beyond such line of card orientation in the direction toward the

stack, to exert an increased force against the said endmost card.

14. Card-handling machinery comprising:

(a) means for supporting a stack of cards and for moving an endmost card thereof in a selected direction from the stack; such means including— 5

(1) a device movable substantially parallel to such cards and having card-edge-engaging means for accomplishing such card-movement;

(2) and means guiding the card-moving device such that the card-edge-engaging means describes a curved card-moving trajectory; 10

(b) the stack-supporting means being arranged to orient such endmost card along a line so selected that the curved card-moving trajectory extends beyond such line in the direction away from the stack to disengage the card-edge-engaging means from the endmost card near the terminal end of the card-moving stroke thereof. 15

15. Card-handling machinery comprising: 20

(a) a hopper adapted to contain a substantially vertical stack of substantially horizontal cards and to orient the lowermost of such cards along a selected line;

(b) a support spaced below the hopper; 25

(c) a flexure spring having a lower end secured to the support and an upper portion rising generally toward the hopper;

(d) and a picker knife having a blade and being mounted on the upper portion of the flexure spring adjacent the lowermost card; 30

(e) the flexure spring being bendable to guide the picker knife through a card-moving stroke such that the blade describes a curved trajectory wherein it is effective to move the lowermost card from the stack; 35

(f) such card-handling machinery being so arranged that the blade trajectory includes an initial card-

engagement point, followed by a rise above the selected card-orientation line, thereafter followed by a drop below such card-orientation line for disengagement of the blade from the lowermost card near the terminal end of the card-moving stroke.

16. Card-handling machinery comprising:

(a) a gravity feed hopper adapted to contain a substantially vertical stack of substantially horizontal cards;

(b) the hopper being substantially open at the bottom, but including a throat plate at the forward end thereof positioned for the forward part of the stack to rest thereon;

(c) a support below the hopper;

(d) a flexure spring having a lower end secured to the support and an upper portion rising generally toward the hopper;

(e) and a picker knife having a blade and being mounted on the upper portion of the flexure spring in position for the rear part of the stack to rest thereon;

(f) the flexure spring being bendable to guide the picker knife through a card-moving stroke such that the blade describes a curved trajectory wherein it is effective to move the lowermost card from the stack;

(g) the throat plate being so positioned in relation to the picker knife to orient the lowermost card along a line which tilts downwardly from the picker knife to the throat plate and is aligned with a chord of the curved blade trajectory;

(h) such card-handling machinery being arranged so that the terminal portion of the card-moving stroke carries the blade below the card-orientation line.

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