Description

This invention relates to a head/suspension assembly for a magnetic record disk store.

The requirement for progressively higher magnetic disk drive storage capacities is met through the use of increased linear bit densities, increased track densities and by increasing the number of recording surfaces. The single constraint that remains unaltered is the overall size of the drive. The overall dimensions of the drive unit or the form factor is the standard that must be accommodated to make the drive a commercially acceptable product.

When two, three or four disks are used within the existing form factors, the existing head and suspension designs are adequate. As increased numbers of disks are used to achieve more disk surfaces within the same dimensions or form factor, the space between adjacent disks is reduced, making more difficult both the assembly and operation of the device. Two major problems arise, one is the height limitation and the other is the less than adequate dynamic response of existing suspension designs in the closely spaced disk environment. One way to accommodate close spacing between disk surfaces is to offset head assemblies rather than use back to back mounting so that in the side by side arrangement each head and associated suspension can utilize the full height separating adjacent disks. However, since when using a rotary actuator the object is to cause the arcuate path followed by the transducer to closely approach a chord positioned on a radius and also have the transducer axis through the transducer gap tangent to each track accessed, the use of a side by side mounting technique causes the actual paths of the transducers to deviate further from the realized path. In addition, the use of a side by side configuration will result in a loss of storage capacity. Normally all the data surface is utilized from the outermost track at which the head will fly properly to the innermost track at which an acceptable signal can be generated at the reduced linear speed. In a side by side environment one head will not use tracks at the innermost diameter, while the other will sacrifice tracks at the outer diameter (which are the most valuable tracks). If the back to back head orientation is avoided by having the heads mounted at different radial distances from the actuator axis of rotation, a loss of storage capacity occurs since one head must operate at a much higher track density.

US patent 4,167,765 discloses one type of magnetic head/arm assembly in which air bearing head slider assembly is attached to a flexure which allows pitch and roll movement of the slider. The flexure is secured at one end of a combined load beam spring element which is attached at its other end to a rigid arm.

JP-A-62-12917 (Koshikawa) shows a slider assembly with a reduced height slider portion to which is attached a second block in which is embedded a thin film transducer. This design is employed to reduce the length of the lead wire connecting to the thin film lead terminals thereby reducing inductance.

The invention provides a head/suspension assembly for a magnetic record disk store, comprising: a magnetic transducer assembly comprising: a slider including a body presenting an air bearing surface for supporting it in closely confronting relation to a record disk, and a magnetic core forming a transducing gap adjacent the trailing edge of the body, the head/suspension assembly further comprising a gimbal spring attached to the slider and a load beam that engages the gimbal spring to permit pitch and roll movement of the slider, characterised in that the slider body has a full height portion disposed to the rear of the vertical axis through the centre of area of the air bearing surface and a reduced height portion extending from the full height portion to the leading edge of the slider body, the gimbal spring having an upper surface portion which is secured to the upper surface of the reduced height portion, wherein the gimbal spring and load beam portion overlying the magnetic slider do not project above the full height portion of the slider.

Thus, the full height portion of the slider provides the maximum height for the coil and core portions of the transducer and the reduced height forward portion accommodates the gimbal spring-load beam structure of the associated suspension without exceeding the vertical dimension of the full height portion. The window size in the core can thus receive 25 turns of 45 gauge bifilar wire and still achieve a slider height of less than 1.5 millimeters. The slider or head disclosed herein, in combination with a suspension contained within the height of the head, allows the head-suspension assembly to obtain an overall height in an inline configuration of less than 1.5 millimeters. In an actual embodiment of the invention, the full height rear portion has a maximum height which does not exceed 1.4 millimeters and the reduced height forward portion has a height of 0.65 millimeters. This is a reduction of about 35% from the current state of the art designs. The reduced height portion also lowers the mass of the slider which raises the resonant frequencies of the head suspension system and moves such frequencies away from the lower frequencies generated by the mechanical elements of the file. The lower mass also improves access time, the reduced amount of ferrite reduces magnetic noise pickup and the head center of

mass and the load point of the suspension are lowered, both of which contribute to increasing the dynamic stability of the head suspension assembly. Other magnetic properties of the head are not compromised by the reduced mass design and the heads can be manufactured using current processes and equipment.

The load beam, with a flexible gram form and a load carrying portion, is formed as a single part with the stiffened substantially rigid load carrying portion attached to the gimbal spring. The gimbal spring is connected to both the load beam and the slider to provide the support for the magnetic transducer as a part of the actuator assembly. The load carrying portion is afforded rigidity by turning the tapered margins to not only provide rigidity, but also create a lead channel to receive and support the snare through which passes the conductors from the transducer coil. The lead channels not only provide a convenient route to contain the head leads within a minimum height, but further protect the head leads against mechanical damage during manufacture and afford protection against electrical noise interference by providing a grounded three quarter enclosure along much of the lead length.

At the rear of the load beam, flexure is afforded by a flat portion of increasing width that has stiffness controlled by the material, thickness, length and the size of a central aperture which enhances lateral stiffness. The reduced length of this suspension design offers better space utilization in compact files. The high lateral stiffness allows high access rates without suspension windup or suspension roll of the slider. This attribute enables maximum acceleration during seek operations and minimizes settle time after reaching the desired track, both of which functions contribute to improved access time. File storage capacity is increased using the suspension since the lack of resonance of the suspension requires less disk area be used for crash stopping.

While the suspension design is shown in the environment of an inline transducer head suspension and optimized to a particular set of parameters, the performance advantages could also be used in an orthogonal head-suspension assembly. The technique could be extended by further shortening overall suspension length to increase resonant frequencies for optimum performance in a particular environment and the length and width of the formed area can be changed to tailor the stiffness to the required value. Constrained layer damping can be added to portions of the formed area and/or load beam to further enhance the dynamics of the design beyond what is possible with the all metal design shown. A viscoelastic material such as RTV silicone rubber can be applied to the load dimple for applications where extremely high accelerations without hysteresis are needed.

How the invention can be carried out will now be described by way of example, with reference to the accompanying drawings, in which:-

FIG. 1 is an exploded view of a head-suspension assembly embodying the invention;

FIGS. 2 and 3 are respectively elevation and bottom views of the slider assembly in FIG. 1;

FIGS. 4 and 5 are respectively bottom and side elevation views of a known head-suspension assembly in an inline configuration;

FIG. 6 is a graph showing resonance gain of the head-suspension of FIGS. 4 and 5 due to lateral input.

FIGS. 7 and 8 are respectively plan and side elevation views of the head-suspension assembly of FIG. 1, when assembled;

FIG. 9 is a graph, similar to that of FIG. 6, showing the resonance gain of the head-suspension assembly of FIGS. 7 and 8; and

FIG. 10 is an isometric view of a disk drive with the cover removed and using the present head-suspension assemblies in conjunction with a rotary actuator and an eight disk spindle assembly.

A head-suspension assembly (FIG. 1) includes a halfback slider 12 (also shown in FIGS. 2 and 3) which has a full height rear portion 13 and a reduced height forward portion 14 that presents a planar shelf 15 to which the gimbal spring 17 is bonded. The full height portion 13 of the slider includes the magnetic core portions including the C-core 19 that creates the window 20 through which the windings 21 are received about the bobbin 22. The C-core 19 is intimately bonded to the slider body at the upper side of the window 20 and is bonded by the glass filled gap 23 in the conventional manner to create a minimum length transducer gap immediately adjacent the magnetic media recording surface. The head is of the three rail type with the outer rails 25 presenting the principal air bearing surfaces that in the operative assembled condition support the head above the adjacent media. The read-write transducer gap is formed at the rear of the central rail 26.

The reduced height portion 14 extends well to the rear of the location axially overlying the center of the air bearing surface and the center of mass of the slider. The full height portion 13 accommodates the coil windings 21 and the reduced height portion enables the gimballed suspension to be connected without exceeding the full height dimension. With these constraints it is possible to design and manufacture a transducer head assembly less than 1.5 millimeters in height. The reduced height portion 14 is less than half the height of the full height portion 13 to create a low mass head. The reduced mass of the head raises the resonant frequencies

of the head-suspension assembly and also improves the access time. The smaller quantity of ferrite in the head reduces the magnetic core noise pickup. The resonances of this reduced size and mass head-suspension system are at a frequency above the file resonances thus enabling superior dynamic performance in a fast access magnetic disk storage system.

The gram form and load carrying elements of the load beam are formed as a single part 30 from resilient metal sheet material. Along the tapered forward portion the margins 31 are debossed and turned upward to form channels 32,33 and channel crimp tabs 34 with the distal end terminating in an outboard crimp tab 35. Thus the forward portion is not only stiffened by the formed channels 32,33 and the working of the metal, but in addition receives the snare 37 which encloses the leads 38 from the transducer coil windings 21. The snare 37 is retained by the crimp tabs 34,35. The channel 32 or 33, in addition to providing mechanical protection, affords a grounded electrical shield which approximately three quarters surrounds the snare 37 throughout a substantial portion of its length. The symmetrical channel structures 32,33 at each side permit a common part to be used for both upwardly and downwardly facing transducer head assemblies.

The gram form portion of the suspension is in the form of two legs 40 separated by a window opening 41 and with a longitudinal extent from the rear of the channels 32,33 to the laser weld locations 43 which attach the flexure to the mounting plate 45. The permanent set applied by bending the gram form legs 40 determines the gram load force which urges the slider toward the confronting media surface A total of seven laser welds 43,44 secure the load beam 30 to mounting plate 45. Additional crimp tabs 46 are used to position and secure the snare 37 as it reaches the actuator arm beyond the flexure portion of the suspension.

The rearward opening 48 in the load beam 30 and the tooling slot 49 in the mount plate 45 serve to correctly align the parts during fabrication of the suspension assembly. Mount plate 45 is also provided with an orientation feature 50 for use when automatically attaching the load beam to the mount plate 45. The weld pockets 51 are of reduced material thickness to provide the welding sites for attachment of the head-suspension assembly to the actuator arm.

A gimbal spring 17 serves to connect the transducer head 11 to the load beam 30 and is designed to accommodate pitch and roll movements of the transducer head 11. Gimbal spring 17 is formed of a single piece of resilient sheet metal and is planar except for the raised tab portion 53 that is bonded to the shelf surface or upper surface 15 of the slider 12 reduced height portion 14. A load dome 55 is a substantially spherical debossment that extends to the lower surface of the planar portion. The gimbal spring 17 is laser welded at four locations 57, 58 to the load beam portion of the load beam member 30. Tooling holes 56,59 assist in aligning the load beam-flexure 30 and gimbal spring 17 during the welding of the parts to one another. During operation of the drive, load dome 55 maintains essentially point contact with the load beam surface while the curved flexure portions 68 of gimbal spring 17 permit the pitch and roll motions of the head 11.

FIGS. 4 and 5 illustrate a known head-suspension assembly 63 in an inline configuration with a single load path that is advantageous in minimizing the number of resonances in the servo bandwidths to allow faster access times and more stringent servo control. The load beam-flexure 64 is welded at locations 65 to a mounting plate 66. The load beam portion is stiffened by marginal flanges 67 and a flat back slider 68 is bonded to gimbal spring 69 which is welded to the load beam portion at locations 70. The magnetic transducer gap 71 is formed using a C-core 72 at the trailing edge of the central rail 73. The transducer coil leads 74 pass through a snare 75 that is retained along the center of the lower surface of the load beam portion (as seen in FIG. 4) and is retained by crimp tabs 76 and pickle forks 77.

The graph of FIG. 6 shows a typical mechanical gain of the head-suspension assembly of FIGS. 4 and 5 that has been experimentally determined. In particular there are resonance conditions at about the 2 to 2.5 KHZ frequencies that exceed acceptable values. It would be necessary to suppress these resonance conditions by the use of added damping material or other damping techniques. Such alternatives would not only add cost, but would introduce an additional source of particulate material into the ultraclean environment of the head-disk enclosure.

FIGS. 7 and 8 show the head-suspension assembly of FIG. 1 in assembled form. The plan view of FIG. 7 shows the load beam-flexure 30 welded to mount block 45 and the gimbal spring 17 which is welded to the load beam portion and bonded to the halfback slider 12. The coil leads 38 pass through the tubular snare 37, with the snare being retained by the terminal crimp tab 35, the channel crimp tabs which are not visible and the crimp tabs 46 formed in the load beam and adjoining mount block 45.

As compared with the design of FIGS. 4 and 5, this head-suspension has a shorter length and lower mass elements which in conjunction with the head and flexure configurations increase the resonance frequencies. FIG. 9 illustrates a transfer

function that has been achieved using the design of FIGS. 7 and 8. The mechanical gain is constrained within allowed limits such that the transfer function shows no severe resonance conditions at the lower frequencies that would require additional damping materials. The frequency increase of the conditions of resonance allows more servo bandwidth and increased file storage capacity. The head-suspension of FIGS. 7 and 8, using the flexure legs 40 and intervening window 41 maintains a higher lateral stiffness to enable higher access rates by tolerating maximum initial acceleration and having a shorter settle time at the addressed track location.

Fig.10 shows a disk file with the head-disk assembly cover removed and a rotary actuator 81 that supports and moves transducer heads 82 from one concentric data track to another using inline suspensions 83. The spindle assembly 84 includes eight magnetic storage disks 85.

The head-suspension design disclosed hereinbefore provides a maximum overall height that does not exceed the full height portion of the transducer head by using a halfback slider design that enables the suspension to attach to the upper surface or shelf of the reduced height portion of the halfback slider. This overcomes the space constraints dictated by closely spaced disks. In addition the design enhances the lateral stiffness of the suspension, both factors improving the dynamic response of the system.

The head-suspension assembly design as shown and described makes possible a profile height of less than 1.5 millimeters while increasing resonance frequencies above file resonance frequencies and achieving superior dynamic performance in a fast access device. Further, these benefits have been achieved without impairing or compromising other magnetic or mechanical properties of the head or suspension. Although shown and described in the environment of an inline suspension where the suspension extends generally tangentially with respect to the data track of interest, the invention could also be applied to obtain the advantages in an orthogonal suspension.

Claims

1. A head/suspension assembly for a magnetic record disk store, comprising:

   a magnetic transducer assembly comprising:

   a slider (11) including a body presenting an air bearing surface for supporting it in closely confronting relation to a record disk, and

   a magnetic core (19) forming a transducing gap (23) adjacent the trailing edge of the body,

   the head/suspension assembly further comprising a gimbal spring (17) attached to the slider and a load beam (30) that engages the gimbal spring to permit pitch and roll movement of the slider,

   characterised in that the slider body has a full height portion (13) disposed to the rear of the vertical axis through the centre of area of the air bearing surface and a reduced height portion (14) extending from the full height portion to the leading edge of the slider body, the gimbal spring having an upper surface portion which is secured to the upper surface of the reduced height portion, wherein the gimbal spring and load beam portion overlying the magnetic slider do not project above the full height portion of the slider.

2. An assembly as claimed in claim 1, wherein the lower portion of the slider body is provided with three parallel rails (25,26) with the outer rails (25) presenting the principal air bearing surfaces and the transducer gap being substantially coplanar with the bottom surface of the central rail (26).

3. An assembly as claimed in claim 1 or claim 2, wherein the height of the reduced height portion of the slider does not exceed one half the height of the full height portion of the slider.

4. An assembly as claimed in any preceding claim, wherein the height of the full height portion of the slider does not exceed 1.5 millimeters.

5. An assembly as claimed in any preceding claim, wherein the load beam is a combined flexure and load beam member with a forward stiffened load beam portion and a rearward flexure portion which permits movement of the slider towards and away from the surface of the record disk.

6. An assembly as claimed in claim 5, wherein the load beam is formed from a single piece of resilient metal which is stiffened by flanged margins (31) extending along the load beam portion.

7. An assembly as claimed in claim 6, wherein the flanged margins form channels (32,33) in which leads from a transducer coil associated with the transducer gap may be received.

8. An assembly as claimed in any of claims 5 to 7, wherein the flexure portion comprises a pair

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function that has been achieved using the design of FIGS. 7 and 8. The mechanical gain is constrained within allowed limits such that the transfer function shows no severe resonance conditions at the lower frequencies that would require additional damping materials. The frequency increase of the conditions of resonance allows more servo bandwidth and increased file storage capacity. The head-suspension of FIGS. 7 and 8, using the flexure legs 40 and intervening window 41 maintains a higher lateral stiffness to enable higher access rates by tolerating maximum initial acceleration and having a shorter settle time at the addressed track location.

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The head-suspension assembly design as shown and described makes possible a profile height of less than 1.5 millimeters while increasing resonance frequencies above file resonance frequencies and achieving superior dynamic performance in a fast access device. Further, these benefits have been achieved without impairing or compromising other magnetic or mechanical properties of the head or suspension. Although shown and described in the environment of an inline suspension where the suspension extends generally tangentially with respect to the data track of interest, the invention could also be applied to obtain the advantages in an orthogonal suspension.

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2. An assembly as claimed in claim 1, wherein the lower portion of the slider body is provided with three parallel rails (25,26) with the outer rails (25) presenting the principal air bearing surfaces and the transducer gap being substantially coplanar with the bottom surface of the central rail (26).

3. An assembly as claimed in claim 1 or claim 2, wherein the height of the reduced height portion of the slider does not exceed one half the height of the full height portion of the slider.

4. An assembly as claimed in any preceding claim, wherein the height of the full height portion of the slider does not exceed 1.5 millimeters.

5. An assembly as claimed in any preceding claim, wherein the load beam is a combined flexure and load beam member with a forward stiffened load beam portion and a rearward flexure portion which permits movement of the slider towards and away from the surface of the record disk.

6. An assembly as claimed in claim 5, wherein the load beam is formed from a single piece of resilient metal which is stiffened by flanged margins (31) extending along the load beam portion.

7. An assembly as claimed in claim 6, wherein the flanged margins form channels (32,33) in which leads from a transducer coil associated with the transducer gap may be received.

8. An assembly as claimed in any of claims 5 to 7, wherein the flexure portion comprises a pair

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of legs that extend from the load beam portion and are separated by an aperture (41) having a transverse dimension which exceeds the width of the slider.

Patentansprüche

1. Kopf/Aufhängung-Baugruppe für einen Plattenspeicher mittels magnetischer Aufzeichnung, die aufweist:
eine Magnetwandler-Baugruppe mit:
einem Läufer (11) einschließlich eines Körpers, der eine Luftlageroberfläche aufweist, um ihn in einem nahe gegenüberliegenden Verhältnis zu einer Aufzeichnungsplatte zu tragen und
einem Magnetkern (19), der einen zu der Hinterkante des Körpers benachbarten Wandlerspalt (23) bildet,
wobei die Kopf/Aufhängung-Baugruppe ferner eine kardanische Feder (17) aufweist, die an dem Läufer und einem Lastträger (30) befestigt ist, der sich mit der Kardanfeder in Eingriff befindet, um einen Kipp- und Rollbewegung des Läufers zu ermöglichen,
dadurch gekennzeichnet, daß der Läuferkörper einen Abschnitt (13) in voller Höhe, der an dem hinteren Teil der durch das Zentrum liegenden vertikalen Achse eines Bereichs der Luftlageroberfläche angeordnet ist und einen Abschnitt (14) in verringerter Höhe aufweist, der sich von dem Abschnitt in voller Höhe zu der Vorderkante des Läuferkörpers erstreckt, wobei die kardanische Feder einen oberen Oberflächenabschnitt aufweist, der an der oberen Oberfläche des Abschnitts in verringerter Höhe befestigt ist, wobei die kardanische Feder und der Lastträgerabschnitt, welcher den Magnetläufer überdeckt, nicht über den Abschnitt in voller Höhe für den Läufer vorspringen.

2. Baugruppe nach Anspruch 1, bei welcher der untere Abschnitt des Läuferkörpers mit drei parallelen Schienen (25, 26) versehen ist, wobei die äußeren Schienen (25) die Grundoberflächen für eine Luftlagerung darstellen und der Wandlerspalt im wesentlichen koplanar mit der Bodenoberfläche der zentralen Schiene (26) liegt.

3. Baugruppe nach Anspruch 1 oder Anspruch 2, bei welcher die Höhe des Abschnitts in verringerter Höhe für den Läufer die Hälfte der Höhe des Abschnitts in voller Höhe für den Läufer nicht übersteigt.

4. Baugruppe nach irgend einem vorgehenden Anspruch, bei welcher die Höhe des Abschnitts in voller Höhe für den Läufer 1,5 Millimeter nicht übersteigt.

5. Baugruppe nach irgend einem vorgehenden Anspruch, bei welcher der Lastträger ein kombinierter Biegungs- und Lastträgerteil mit einem vorne versteiften Lastträgerabschnitt und einem hinteren Biegungsabschnitt ist, der eine Bewegung des Läufers in Richtung zu der Oberfläche der Aufzeichnungsplatte und von ihr fort ermöglicht.

6. Baugruppe nach Anspruch 5, bei welcher der Lastträger aus einem einzigen Stück aus federndem Metall ausgbildet ist, das durch geflanschte Ränder (31) versteift ist, die sich entlang des Lastträgerabschnitts erstrecken.

7. Baugruppe nach Anspruch 6, bei welcher die geflanschten Ränder Kanäle (32, 33) bilden, in welchen Leitungen aus einer dem Wandlerspalt zugeordneten Wandlerspule aufgenommen werden können.

8. Baugruppe nach irgend einem der Ansprüche 5 bis 7, bei welcher der Biegungsabschnitt ein Paar von Schenkel aufweist, die sich aus dem Lastträgerabschnitt erstrecken und durch eine Öffnung (41) mit einer Querabmessung getrennt sind, welche die Breite des Läufers übersteigt.

Revendications

1. Ensemble tête/suspension pour une mémoire à disques d'enregistrement magnétiques, comprenant :
un ensemble formant transducteur magnétique comportant :
un curseur (11) comprenant un corps possédant une surface formant palier pneumatique destiné à le supporter dans une relation de vis-à-vis intime avec un disque d'enregistrement, et
un noyau magnétique (19) formant un entrefer de transduction (23) au voisinage du bord arrière du corps, l'ensemble suspension/tête comprenant en outre un ressort de suspension à la cardan (17) fixé au curseur et un barreau de charge (30) qui s'applique contre le ressort de suspension à la cardan pour permettre des déplacements de tangage et de roulis du curseur,
caractérisé en ce que le corps du curseur possède une partie (13) qui s'étend sur la hauteur totale et est disposée en arrière de l'axe vertical passant par le centre de la surface du palier pneumatique, et une partie de

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hauteur réduite (14), qui s'étend depuis la partie, qui s'étend sur la hauteur totale, jusqu'au bord avant du corps du curseur, le ressort de suspension à la cardan possédant un élément de surface supérieur qui est fixé à la surface supérieure de la partie de hauteur réduite, le ressort de suspension à la cardan et la partie du barreau de charge, qui recouvre le curseur magnétique, ne faisant pas saillie au-dessus de la partie, qui s'étend sur toute la hauteur, du curseur.

2. Ensemble selon la revendication 1, dans lequel la partie inférieure du corps du curseur comporte trois rails parallèles (25,26), dont les rails extérieurs (25) représentent les surfaces principales du palier à air, tandis que l'entrefer de transduction est sensiblement coplanaire à la surface inférieure du rail central (26).

3. Ensemble selon la revendication 1 ou 2, dans lequel la hauteur de la partie de hauteur réduite du curseur ne dépasse pas la moitié de la hauteur de la partie, qui s'étend sur la hauteur totale, du curseur.

4. Ensemble selon l'une quelconque des revendications précédentes, dans lequel la hauteur de la partie, qui s'étend au-dessous de la hauteur, du curseur, ne dépasse pas 1,5 millimètre.

5. Ensemble selon l'une quelconque des revendications précédentes, dans lequel le barreau de charge est un élément formant barreau de flexion et de charge combiné possédant une partie avant rigidifiée formant barreau de charge et une partie arrière de flexion permettant au curseur de se rapprocher et de s'écarter de la surface du disque d'enregistrement.

6. Ensemble selon la revendication 5, dans lequel le barreau de charge est formé d'une seule pièce d'un métal élastique, qui est rigidifiée par des bords (31) à brides, qui s'étendent le long de la partie formant barreau de charge.

7. Ensemble selon la revendication 6, dans lequel les bords équipés de brides forment des profilés en U (32,33), dans lesquels peuvent être logés des conducteurs raccordant une bobine du transducteur associée à l'entrefer du transducteur.

8. Ensemble selon l'une quelconque des revendications 5 à 7, dans lequel la partie de flexion comprend un couple de bras qui partent de la partie formant barreau de charge et sont séparés par une ouverture (41) possédant une dimension transversale supérieure à la largeur du curseur.