While the prior art describes how various slider configurations can be designed to cope with the problems of skew, it generally does not address the question of minimizing speed and skew dependence, individually. Typically, prior art sliders have taper angles of 10 milliradians or larger. At such large taper angles, a slider's aerodynamic lift decreases with increasing taper angle (i.e. in aeronautical parlance, a "stall" regime). The tapers of most prior art sliders operate in the stall regime in that they employ a large taper angle. The primary reason is for manufacturing ease in that it is easier to assure that the intersection formed by the juncture of slider's taper and flat regions ends up at the correct location when the taper angle is large. However, a cost of such a high taper angle is that in the stall regime, lift becomes highly speed dependent, even at normal operating speeds.

A further problem with a large taper angle is that at medium and high disk speeds, air is regurgitated from the taper region. As a result, a sliders' taper regions are exposed to relatively large amounts of contaminated air which never enter the flat rail sections of the slider. This may cause debris accretion in the taper area that contributes to head crashes since it modifies the shape of the air bearing in the crucial entry region.

SUMMARY OF THE INVENTION

It is an object of the present invention to ameliorate one or more disadvantages of the prior art.

According to one aspect of the present invention there is provided an air bearing slider for supporting a transducer over a moving recording surface, said air-bearing slider comprising: a slider body having a major surface opposed to said recording surface, said slider body also having leading and trailing edges oriented along a direction of motion of said recording surface; front pad means depending from said major surface and substantially adjacent said leading edge of said slider body and having a leading edge substantially transverse to said direction of motion of said recording surface, said front pad means exhibiting a contact face opposed to said recording surface; rear pad means depending from said major surface and substantially adjacent said trailing edge of said

slider body and having a leading edge, said rear pad means exhibiting a contact face opposed to said recording surface, said leading edge of said rear pad means separated from a trailing edge of said front pad means by a distance that is substantially greater than a fly height of said air bearing slider, both contact faces of said front pad means and rear pad means, when positioned on a plane of said recording surface, exhibiting effective taper angles which cause each said front pad means and rear pad means to exhibit stagnation lines that are substantially co-located with leading edges of said contact faces when said moving recording surface is at operating speed, a stagnation line defining a boundary below which air is substantially entrained beneath a contact face, whereby an inlet throttling effect occurs at both said pad means.

According to another aspect of the present invention there is provided an air bearing slider comprising: front pad means and rear pad means, both extending from a generally planar body and having faces opposed to a recording medium and separated by a gap that is substantially larger than a fly height of said air bearing slider, said faces being disposed in parallel orientation but not co-planar so that when positioned on a plane of a recording medium, said front pad means and rear pad means both exhibit effective taper angles at inlets which cause each said front pad means and rear pad means to exhibit stagnation lines that are substantially co-located with leading edges of said faces when said recording medium moves at operating speed, a stagnation line defining a boundary below which air is substantially entrained beneath a face, whereby an inlet throttling effect occurs at both said pad means.

According to another aspect of the present invention there is provided an air bearing slider comprising: front pad means and rear pad means, both extending from a generally planar body, having leading edges and having faces opposed to a recording medium and separated by a gap that is substantially larger than a fly height of said air bearing slider, said faces being disposed in parallel orientation but not co-planar, said faces of said front pad means and said rear pad means each exhibiting a taper angle α_p at a leading edge when said air bearing slider is positioned on a plane of said

recording medium, said taper angle α_p no greater than α_p* to enable an inlet throttle action, wherein:

$$\alpha_p^* \leq \frac{2\mu U}{P_a h_i}$$

μ = dynamic gas viscosity

U = disk speed

p_a = ambient pressure

h_i = inlet gap

each said taper angle α_p causing each said front pad means and rear pad means to exhibit stagnation lines that are substantially co-located with leading edges of said faces when said recording medium moves at operating speed, a stagnation line defining a boundary below which air is substantially entrained beneath a contact face, whereby an inlet throttling effect occurs at both said pad means.

According to still another aspect of the present invention there is provided apparatus comprising: a rotatable magnetic disk recording surface; a slider body having a major surface opposed to said magnetic recording surface, said slider body also having leading and trailing edges oriented along a direction of motion of said magnetic recording surface; a transducer attached to said slider body adjacent said trailing edge; front pad means depending from said major surface of said slider body and substantially adjacent said leading edge of said slider body and having a leading edge substantially transverse to said direction of motion of said recording surface, said front pad means exhibiting a contact face opposed to said recording surface; rear pad means depending from said major surface of said slider body and substantially adjacent said trailing edge of said slider body and having a leading edge, said rear pad means exhibiting a contact face opposed to said recording surface, said leading edge of said rear pad means separated from a trailing edge of said front pad means by a distance that is substantially greater than a fly height of said air bearing slider, said contact faces of said front pad

means and rear pad means, when positioned on a plane of said recording surface, exhibiting effective taper angles which cause each said front pad means and rear pad means to exhibit stagnation lines that are substantially co-located with leading edges of both said contact faces when said moving recording surface is at operating speed, a stagnation line defining a boundary below which air is substantially entrained beneath a contact face, whereby an inlet throttling effect occurs at both said pad means.

DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side sectional view of an air bearing slider pad that is tilted in relation to a disk surface.

Fig. 2 is the view of Fig. 1 with an air flow pattern charted thereon showing the effect of a large taper angle.

Fig. 3 is the view of Fig. 1 when the taper angle causes a pad to be "inlet-throttled".

Fig. 4 is a plan view of a bearing slide of an inlet-throttled air bearing slider constructed in accordance with the invention.

CLAIMS

1. An air bearing slider for supporting a transducer over a moving recording surface, said air-bearing slider comprising:

a slider body having a major surface opposed to said recording surface, said slider body also having leading and trailing edges oriented along a direction of motion of said recording surface;

front pad means depending from said major surface and substantially adjacent said leading edge of said slider body and having a leading edge substantially transverse to said direction of motion of said recording surface, said front pad means exhibiting a contact face opposed to said recording surface;

rear pad means depending from said major surface and substantially adjacent said trailing edge of said slider body and having a leading edge, said rear pad means exhibiting a contact face opposed to said recording surface, said leading edge of said rear pad means separated from a trailing edge of said front pad means by a distance that is substantially greater than a fly height of said air bearing slider, both contact faces of said front pad means and rear pad means, when positioned on a plane of said recording surface, exhibiting effective taper angles which cause each said front pad means and rear pad means to exhibit stagnation lines that are substantially co-located with leading edges of said contact faces when said moving recording surface is at operating speed, a stagnation line defining a boundary below which air is substantially entrained beneath a contact face, whereby an inlet throttling effect occurs at both said pad means.

2. The air bearing slider as recited in claim 1, wherein said taper angles of said front pad means and rear pad means do not exceed approximately one milliradian.

3. The air bearing slider as recited in claim 2, wherein said taper angles of said front pad means and rear pad means are in a range of approximately 100 to 500 microradians.

4. The air bearing slider as recited in claim 1, wherein said faces of said front pad means and rear pad means have different surface areas.

5. The air bearing slider as recited in claim 4, wherein said face of said rear pad means has a surface area that is less than the surface area of said face of said front pad means.

6. The air bearing slider as recited in claim 5, wherein said surface area of said face of said rear pad means has a surface area that is approximately 75% of the surface area of said face of said front pad means.

7. The air bearing slider as recited in claim 1, wherein said faces of said front pad means and rear pad means are parallel, said front pad means further having a layer of bearing material resident thereon, said front pad means thus being non-coplanar with said rear pad means.

8. The air bearing slider as recited in claim 7 wherein said front pad means and rear pad means each have bearing material layers resident on their respected faces, said bearing material resident on said front pad means exhibiting a greater thickness than said bearing material resident on said rear pad means, thereby rendering said front pad means and rear pad means non-co-planar.

9. The air bearing slider as recited in claim 7 wherein both said front pad means and rear pad means have bearing material layers resident on said faces thereof, said bearing material resident only on lagging portions of said faces.

10. The air bearing slider as recited in claim 7, wherein said layer of bearing material resident on said front pad means only covers a frontal portion of said face of said front pad means, a terminating edge of said layer in combination with an exposed portion of said face of said front pad means providing an area for development of a sub-ambient pressure to load said air bearing slider when in flight over a moving recording surface.

11. The air bearing slider as recited in claim 1 wherein said distance between said leading edge of said rear pad means and said-trailing edge of said front pad means is approximately one half of a longitudinal length of said slider body along said direction of motion of said recording surface.

12. The air bearing slider as recited in claim 1, which is symmetrical about a center line, and wherein at least said front pad means or rear pad means exhibits a convex curvature of its leading and trailing edges, said convex curvature being symmetrical with respect to said center line and oriented in a direction of movement of said recording surface in relation to said air bearing slider.

13. The air bearing slider as recited in claim 12 wherein both said front pad means and rear pad means exhibit said convex curvature of leading arid trailing edges.

14. The air bearing slider as recited in claim 1 wherein at least a portion of said front pad means or rear pad means exhibits a convex curvature of its leading and trailing edges, said convex curvature oriented in a direction of movement of said recording surface in relation to said air bearing slider.

15. The air bearing slider as recited in claim 1 wherein said taper angles α_p of said faces of said front pad means and rear pad means are both less than α_p*, where:

$$\alpha_p^* < \frac{2\mu U}{P_a h_i}$$

μ = dynamic gas viscosity

U = disk speed

p_a = ambient pressure

h_i = inlet gap

16. The air bearing slider as recited in claim 15 wherein a channel is formed in said front pad means to provide added roll stability for said air bearing slider.

17. The air bearing slider as recited in claim 1 further comprising:

side pad means disposed between said front pad means and said rear pad means for increasing roll stiffness of said slider.

18. The air bearing slider as recited in claim 1, wherein said front pad means includes a first front pad and a second front pad, said first front pad and said second front pad

being shaped and positioned so as to define a channel between said first front pad and said second front pad.

19. The air bearing slider as recited in claim 18, wherein said rear pad means includes a single rear pad, said rear pad having a surface which tapers to a point in a direction toward the leading edge of said slider.

20. The air bearing slider as recited in claim 19, wherein said rear pad has a width less than that of said slider.

21. The air bearing slider as recited in claim 20, wherein said face of said rear pad is hexagonal in shape.

22. The air bearing slider as recited in claim 18 further comprising:

side pad means disposed between said front pad means and said rear pad means for increasing roll stiffness of said slider.

23. The air bearing slider recited in claim 22, wherein said side pad means comprises a first side pad and a second side pad, said first side pad and said second side pad being shaped and positioned so as to define a channel between said first side pad and said second side pad.

24. The air bearing slider as recited in claim 23, wherein said first side pad and said second side pad have faces which taper to a point in a direction towards the leading edge of said slider.

25. The air bearing slider as recited in claim 24 wherein said face of said rear pad is pentagonal in shape.

26. The air bearing slider as recited in claim 24 wherein said side pads are disposed so as to be closer to said rear pads than said front pads.

27. The air bearing slider as recited in claim 26 wherein said side pads have a face which is hexagonal in shape.

28. The air bearing slider as recited in claim 1, wherein:

said front pad means includes two front pads separated by a first channel extending along the length of said slider; and

said rear pad means includes two rear pads separated by a second channel extending along the length of said slider.

29. The air bearing slider as recited in claim 28 wherein said channels are positioned so that a first of said front pads is wider than a second of said front pads; and a first of said rear pads is wider than a second of said rear pads.

30. The air bearing slider as recited in claim 1, wherein:

said rear pad means includes a single rear pad;

said front pad means includes two front pads sized, shaped and positioned to define a channel in the longitudinal direction of said slider between said front pads, each of said pads having a step disposed at a rear portion of the pad extending outwardly from the face of the pad.

31. The air bearing slider as recited in claim 30, wherein said step has a leading edge swept backward towards side edges of said slider.

32. An air bearing slider comprising:

front pad means and rear pad means, both extending from a generally planar body and having faces opposed to a recording medium and separated by a gap that is substantially larger than a fly height of said air bearing slider, said faces being disposed in parallel orientation but not co-planar so that when positioned on a plane of a recording medium, said front pad means and rear pad means both exhibit effective taper angles at inlets which cause each said front pad means and rear pad means to exhibit stagnation lines that are substantially co-located with leading edges of said faces when said recording medium moves at operating speed, a stagnation line defining a boundary below which air is substantially entrained beneath a face, whereby an inlet throttling effect occurs at both said pad means.

33. An air bearing slider comprising:

front pad means and rear pad means, both extending from a generally planar body, having leading edges and having faces opposed to a recording medium and separated by a gap that is substantially larger than a fly height of said air bearing slider, said faces

being disposed in parallel orientation but not co-planar, said faces of said front pad means and said rear pad means each exhibiting a taper angle α_p at a leading edge when said air bearing slider is positioned on a plane of said recording medium, said taper angle α_p no greater than α_p* to enable an inlet throttle action, wherein:

$$\alpha_p^* < \frac{2\mu U}{P_a h_i}$$

μ = dynamic gas viscosity

U = disk speed

p_a = ambient pressure

h_i = inlet gap

each said taper angle α_p causing each said front pad means and rear pad means to exhibit stagnation lines that are substantially co-located with leading edges of said faces when said recording medium moves at operating speed, a stagnation line defining a boundary below which air is substantially entrained beneath a contact face, whereby an inlet throttling effect occurs at both said pad means.

34. The air bearing slider as recited in claim 33, which is symmetrical about a center line, and wherein at least said front pad means or rear pad means exhibits a convex curvature of its leading and trailing edges, said convex curvature being symmetrical with respect to said center line and oriented in a direction of movement of a recording surface in relation to said air bearing slider.

35. The air bearing slider as recited in claim 34 wherein both said front pad means and rear pad means exhibit said convex curvature of leading and trailing edges.

36. Apparatus comprising:

a rotatable magnetic disk recording surface;

a slider body having a major surface opposed to said magnetic recording surface, said slider body also having leading and trailing edges oriented along a direction of motion of said magnetic recording surface;

a transducer attached to said slider body adjacent said trailing edge;

front pad means depending from said major surface of said slider body and substantially adjacent said leading edge of said slider body and having a leading edge substantially transverse to said direction of motion of said recording surface, said front pad means exhibiting a contact face opposed to said recording surface;

rear pad means depending from said major surface of said slider body and substantially adjacent said trailing edge of said slider body and having a leading edge, said rear pad means exhibiting a contact face opposed to said recording surface, said leading edge of said rear pad means separated from a trailing edge of said front pad means by a distance that is substantially greater than a fly height of said air bearing slider, said contact faces of said front pad means and rear pad means, when positioned on a plane of said recording surface, exhibiting effective taper angles which cause each said front pad means and rear pad means to exhibit stagnation lines that are substantially co-located with leading edges of both said contact faces when said moving recording surface is at operating speed, a stagnation line defining a boundary below which air is substantially entrained beneath a contact face, whereby an inlet throttling effect occurs at both said pad means.