

Sept. 2, 1969

J. A. WEIDENHAMMER ET AL

3,465,320

CONVEX-SURFACED VACUUM CONTROLLED AIR FILM

Filed Jan. 10, 1966

3 Sheets-Sheet 1

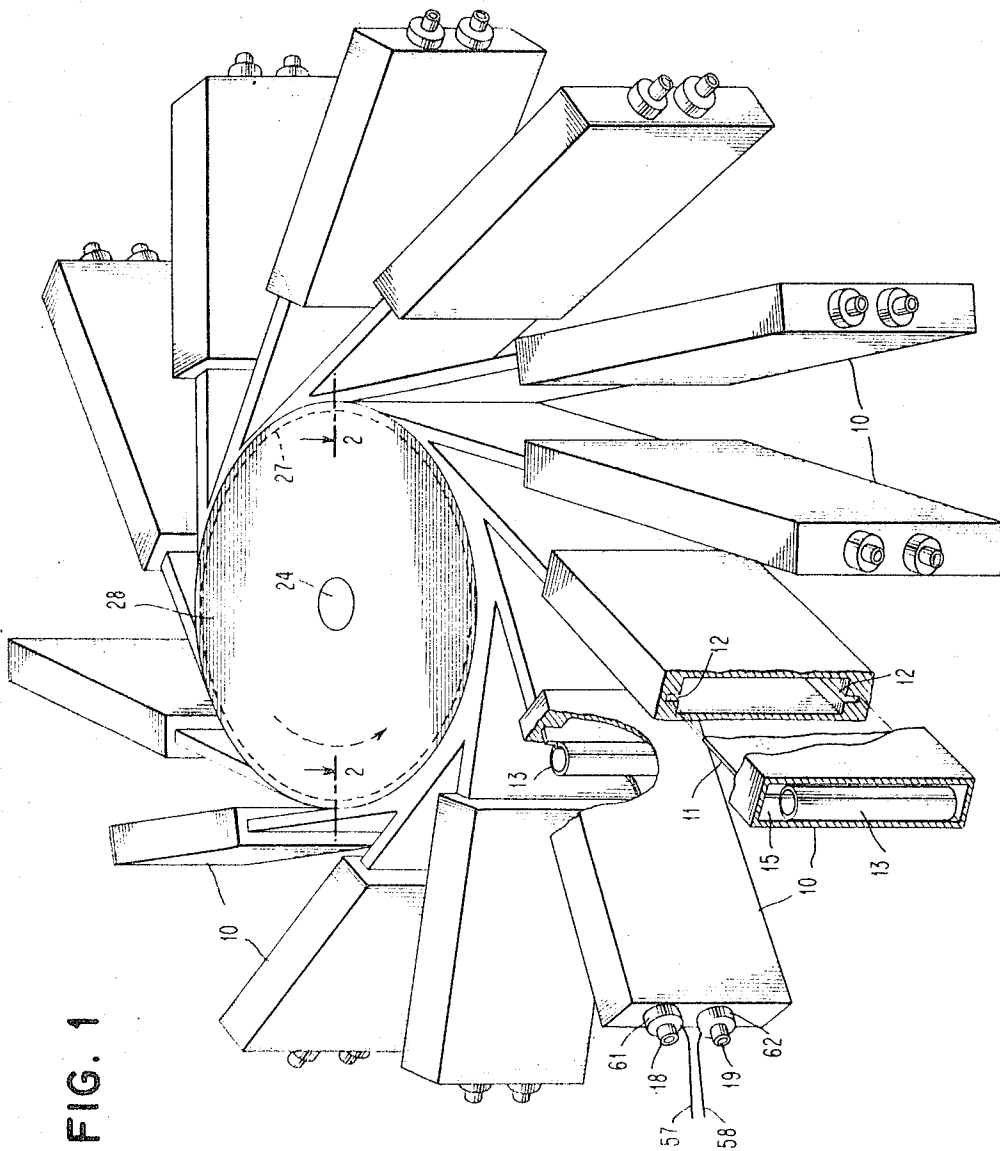


FIG. 1

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FIG. 2

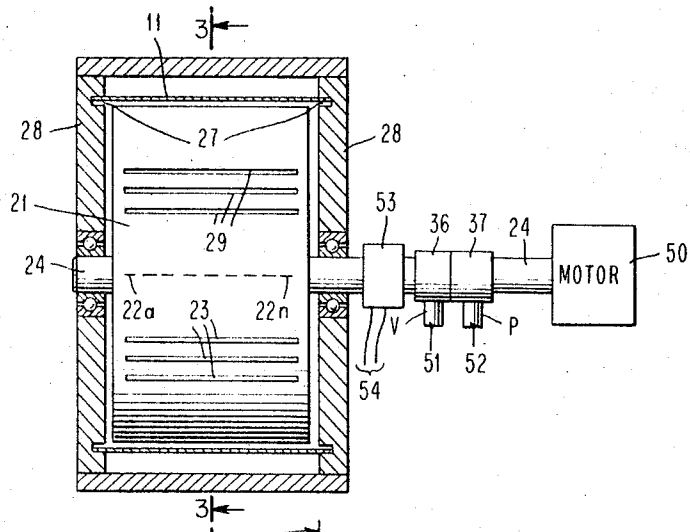


FIG. 3

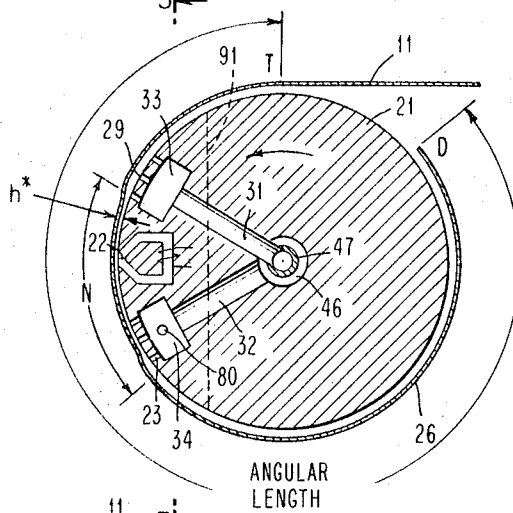
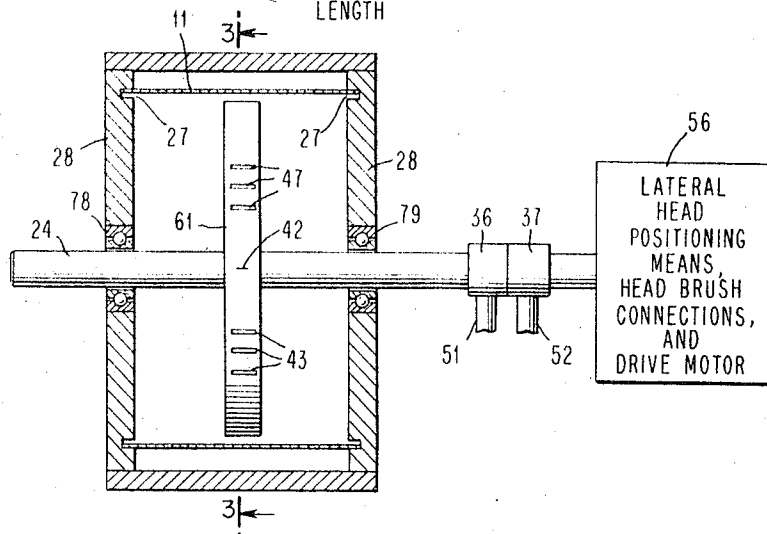


FIG. 4



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FIG. 5

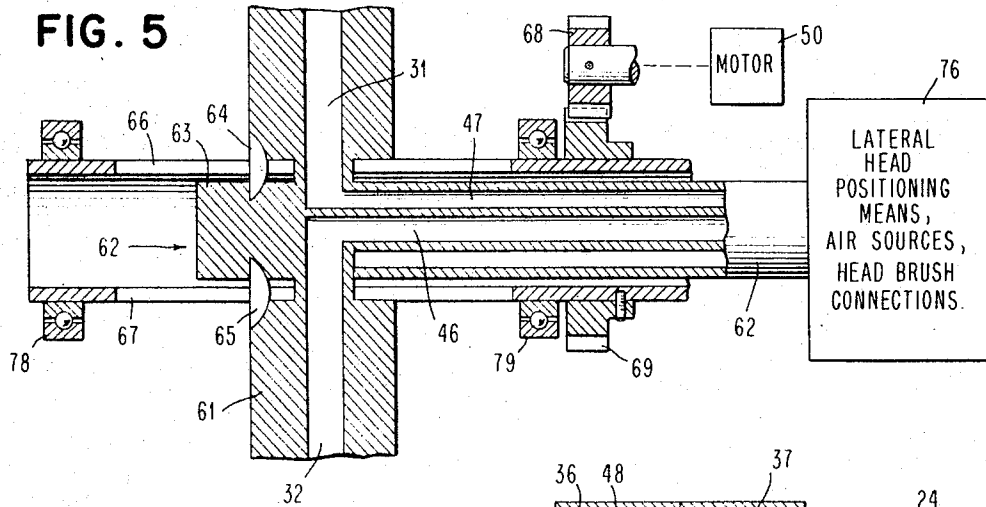


FIG. 6

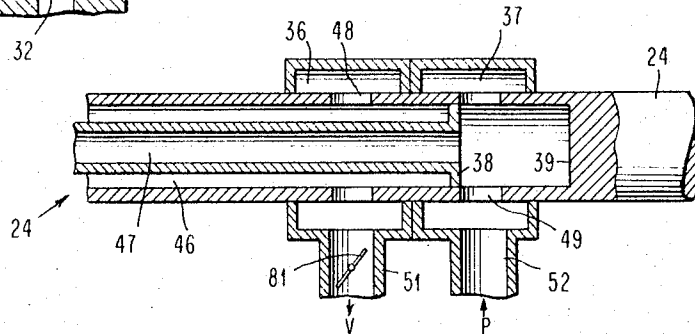


FIG. 7

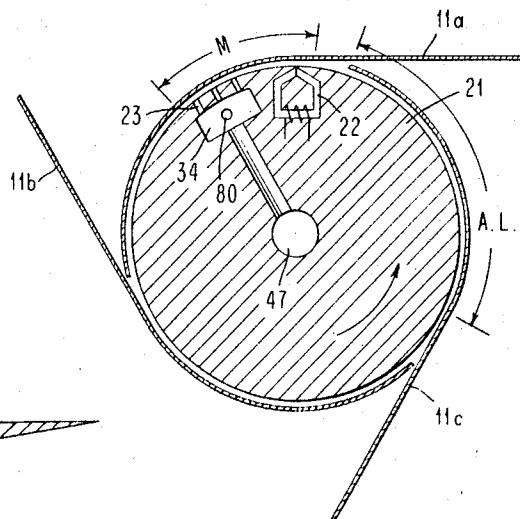
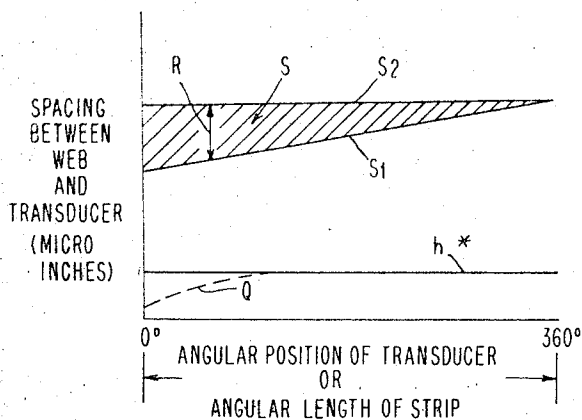


FIG. 8



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CONVEX-SURFACED VACUUM CONTROLLED AIR FILM

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U.S. Cl. 340—174.1

8 Claims

ABSTRACT OF THE DISCLOSURE

A convex "controlled-spaced area" over which a web is moved with only a thin air film lubricating separation.

The convex "controlled-spaced area" has a magnetic transducer smoothly embedded therein and is bounded on a leading side by one or more vacuum ports and is optionally bounded on its lagging side by one or more blowing air ports. Vacuum ports may be provided on opposite sides of the "area" for bidirectional relative movement; or blowing air and vacuum may be reversed for bidirectional relative motion, since only the leading ports are required to have vacuum. With long angular length webs (having more than about 100° angle-of-wrap about the convex surface), lagging blowing air ports prevent excessive tension and wear on the initial angular portion of the web. The convex "controlled-spaced area" requires a smoothness factor that is inter-related with the spacing (h^*) between the "area" and the web.

This invention relates generally to the spacing control between a continuously-smooth convex-surfaced area and a flexible web having relative motion. In particular, the convex surface can be moved relative to the web with a separation in the order of tens of microinches. Such close spacing enhances recording communications between them when the web has a recording surface in electrostatic or electromagnetic relationship with a transducer smoothly embedded in the convex-surfaced area.

Prior devices involving magnetic heads in relation to magnetic tape have utilized a hydrodynamic laminar air boundary to lubricate the frictional engagement between surfaces with a spacing in the order of hundreds of microinches. The relatively moving surfaces carry air molecules between them causing them to be spaced by a distance dependent upon a number of variables such as the relative velocity between the surfaces, the tension between them, the coefficient of friction of the surfaces, and other factors. Blowing air between the surfaces has also been used to control this spacing relationship. In neither the hydrodynamic nor the blowing air techniques is the spacing between a web and a relatively moving surface made sufficiently small and controllable for the high density recording and sensing techniques found in today's magnetic recording apparatus involving bit densities in excess of three thousands bits per inch.

This invention relates generally to a discovered species within the technique described and claimed in IBM owned Patent No. 3,327,916 with the title "Vacuum Controlled Air Film" by inventors R. A. Barbeau, D. K. Close, K. B. Day, Jr., E. J. Wroblewski and J. A. Weidenhammer.

It is therefore the primary object of this invention to provide gas lubrication control between a relatively moving web and convex surface to maintain a precisely-controlled stable spacing (such as within plus or minus ten millionths of an inch of a required spacing) between them over a selected area of the convex element during relative movement.

It is another object of this invention to provide an air lubrication arrangement between a relatively moving web and a portion of a cylindrical surface to obtain precise spacing control between the web and the portion of the surface to enable very high density recording or reading operations between them.

It is a further object of this invention to provide a rotating surface having a flexible strip wrapped around a portion of it, wherein a precise spacing is maintained between a selected area on the rotating surface and the web, with the spacing being independent of either the angular position of the selected area, or the angular length of the strip about the rotating surface.

It is still another object of this invention to provide a rotating surface in relation to a web wrapped partly about it using a vacuum technique to control a precise spacing between the rotating surface and the web over an area following the vacuum ports and to prevent severe tension on initial web portions.

It is another object of this invention to provide means for obtaining a constant spacing between a recording strip and a controlled-spaced area on a rotating drum by providing vacuum control prior to said controlled spaced area and by providing blowing air after said area.

It is another object of this invention to provide means for preventing significant varying tension on a strip having a substantial angular length about a rotating surface and a very close non-touching relationship.

It is another object of this invention to magnetically write and/or read a high density digital signal between a rotating surface and a web wrapped in excess of 100° about said rotating surface by using pneumatic vacuum control prior to and pneumatic pressure control following a controlled-spaced area having a transducer to obtain constant spacing and to avoid any possibility of rubbing contact.

It is a further object of this invention to provide a cyclically operating rotating surface containing a transducer enabling the transducer to have high density flux communication with a web for any angular length of said web up to 360° about the rotating surface and for every angular position of said transducer within said angular length without any rubbing contact between them.

In order to accomplish the objects of this invention a convex "controlled-spaced area" is provided having a smooth continuously convex surface with vacuum ports formed through a leading part of the smooth-convex surface prior to the "controlled-spaced area" over which said web is to be precisely spaced. A flux transducer may be mounted in said "controlled-spaced area"; but it must not interrupt the smooth convex contour. For bidirectional relative movement between the web and convex "controlled-spaced area," vacuum ports are provided on opposite sides of the "area," since each opposite side is a leading port of the "area" for one direction of movement. This invention also may provide blowing air to the lagging ports (following the "controlled-spaced area" in a particular direction of relative movement), since only the leading ports are required to have vacuum for operating the "controlled-spaced area." The lagging blowing air ports obtain increased spacing between the surfaces outside the "controlled-spaced area" to prevent rubbing of the web on a possible non-smooth surface outside the "controlled-spaced area." With long angular length webs (having more than about 100° angle-of-wrap about the convex surface), the lagging blowing air ports also prevent excessive tension and wear over the initial angular portion of the web. The convex "controlled-spaced area" requires a surface with a smoothness factor

that is inter-related with the smoothness factor of the facing surface of the web and spacing (h^*) between them. The sum of the two smoothness factors is approximately equal to one-half of h^* .

The foregoing and other objects, features and advantages of the invention will be apparent from the following more particular description of the preferred embodiments of the invention, as illustrated in the accompanying drawings.

FIG. 1 is a perspective view of a strip-file embodying the invention.

FIG. 2 shows a partial cross-section through section 2—2 in FIG. 1 with an elevational view of a drum member therein.

FIG. 3 represents a schematic view of section 3—3 found in FIG. 2.

FIG. 4 represents another embodiment having the invention.

FIG. 5 illustrates a sliding connection between a rotating member and a supporting shaft related to the embodiments in FIGS. 2 and 4.

FIG. 6 shows pneumatic vacuum and pressure communication from non-rotatable tubes to headers within a rotatable shaft.

FIG. 7 illustrates another embodiment of the subject invention.

FIG. 8 shows diagrams used in explaining certain operating characteristics of the invention.

The subject invention involves the discovery that the principles of the flat vacuum surface for obtaining a controlled spacing h^* , which is described and claimed in patent application Ser. No. 463,727, is also applicable to a convex continuously-smooth surface operating with a relatively moving web. The convex species of the controlled-vacuum surface is described and claimed herein. It has also been discovered that certain additional problems exist with operation of this invention species when it is incorporated in a rotating drum or otherwise involves a long angular length; and means has been discovered for solving these problems which is described and claimed herein.

FIG. 1 shows an embodiment of a strip-file arrangement in which a plurality of strip-file cartridges 10 (which may be removable and interchangeable) are tangentially arranged about a processing chamber 28 through which the end of a rotating shaft 24 is visible. Each cartridge 10 includes a web or strip 11. The edges of strip 11 are supported on opposite sides by slots 12 within cartridge 11. The web comprising strip 11 may be made from Mylar Polyester Film (Du Pont trademark) or some comparable flexible plastic or metal structure. One of both sides may have a recording surface applied thereon, such as iron oxide or other magnetic particles supported in binder, or cobalt nickel or other magnetic materials plated thereon, either electrolessly or electrically.

A piston 13 is provided at the outer end of strip 11, and it may be made of the same material from which the strip is made. Piston 13 substantially fills the entire cross-sectional opening in cartridge 10 engaged by it.

A minimum-size plenum chamber 15 is provided at the outer end of each carriage 10. Air conveyance tubes 18 and 19 connect to each plenum 15. Tube 18 connects to a vacuum source and tube 19 connects a pressure source of air. Electromagnetically-actuated valves 61 and 62 communicate with plenum 15 and connect to the respective tubes 18 and 19. Each valve may be constructed as the "High Speed Valve" disclosed on page 40 of the October 1963 issue of the IBM Technical Disclosure Bulletin. Valve 61 controls the vacuum V (below-atmospheric pressure) to plenum 15 from tube 18 and is operated by an electrical cable 57; a similar valve 62 controls the application of pressure P (above-atmospheric pressure) to plenum 15 and is controlled by electrical cable 58. Thus, electrical energization of cable 58 opens valve 62 to connect pressure from tube 19 to plenum 15

which drives piston 13 away from the plenum to move the end of strip 11 out of the cartridge into the processing chamber 28. Cable 58 can be de-energized immediately after the end of the strip is received by chamber 28, since the normal operation of processing chamber 28 causes the strip to be maintained in this outward position. After processing, the strip can be retrieved within the cartridge 10 by energizing cable 57 which opens valve 61 at the end of tube 18 and connects plenum 15 to the vacuum source, which lowers the pressure on piston 13 forcing it to move back to its original position at the outer end of the cartridge, pulling strip 11 out of the processing chamber simultaneously. When the strip is moved back to its normal storage position in cartridge 10, the energization of cable 57 can be discontinued so that valve 18 may be closed. Thus, both valves may be normally closed and in a normally deenergized condition when its strip 11 is not being moved in or out of the cartridge.

A "controlled-spaced area" on a rotating drum 21 in processing chamber 28 is revealed in FIG. 2 including the two sets of slots 23 and 29. A drum 21 is supported by a shaft 24 that extends through the side walls of chamber 28 and is supported rotationally therein by ball bearings. The "controlled-spaced area" on the surface of drum 26 has smoothly embedded within it a plurality of electromagnetic recording or reading head gaps 22a . . . n, useful for writing or reading magnetically recorded data on plural tracks of any strip 10. Such head gaps are conventional in the art, and any of the well-known narrow-gap types may be used for recording or reading high-density digital information. Such gaps are filled with non-magnetic material.

A plurality of slots 23 are formed through the leading portion of the "controlled-spaced area," and these slots are connected to a vacuum source. Another plurality of slots 29 are formed through the lagging portion of the "controlled-spaced area," and these slots are connected to a pressurized air source.

The "controlled-spaced area" in this invention only includes the part of the convex surface required for obtaining the precisely controlled surface-to-web spacing operation. The "controlled-spaced area" generally extends only for a fraction of 360° over the convex surface, and it is represented for example by the angles M and N in FIGS. 3 and 7, respectively. The limits of the "controlled-spaced area" need extend only for a short distance for example, about one-half inch) before the first vacuum slot 23 (away from the controlled-spaced area) to the opposite side of the "controlled-spaced area" that may be extended as far as required about the drum (up to 360°). This smooth convex surface for the "controlled-spaced area" is smooth to approximately 20 millionths of an inch or less, which distinguishes it from the remainder of the drum surface which need not be smooth to within this tolerance. The precise amount of smoothness tolerance required for the surface of the "controlled-spaced area" is inter-related with the smoothness on the web surface facing it. The actual smoothness limits on the web and the "controlled-spaced area" is inter-related as follows: the sum of the actual smoothness limits on both the "controlled-spaced area" and its facing web surface is equal to approximately one-half of the spacing (h^*) between them, which is controlled by the vacuum ports.

When blowing jets 29 are used, the first jet 29 adjacent to the "controlled-spaced area" may be considered to terminate the "controlled-spaced area."

In FIG. 3, shaft 24 is constructed to have separate internal coaxially-arranged air headers 46 and 47. Header 47 may convey pressurized air while header 46 conveys vacuumized air (below atmospheric pressure). A channel 31 through drum 21 connects header 47 to a plenum distribution chamber 33 connecting to slots 29. Similarly, channel 32 connects header 46 to plenum 34 to convey vacuumized air to slots 23. An opening 80 is provided

through the wall of plenum 34 to atmospheric pressure. Opening 80 reduces any variations in vacuum pressure at slots 23 caused by fluctuation in the vacuum pressure of the source (not shown).

FIG. 6 shows a technique for conveying pressurized and vacuumized air to the respective coaxial headers within shaft 24. A tube 51 is connected between a chamber 36 and a conventional vacuum source (not shown) supplying for example a pressure of 10 inches of water below atmospheric pressure. Similarly a tube 52 is connected between a separate chamber 37 and a conventional pressurized source (not shown). Cylindrical non-rotatable chambers 36 surround a part of rotatable shaft 24; and they are isolated from each other. Chamber 36 pneumatically communicates with a plurality of openings 48 through the wall of hollow shaft 24. Openings 48 are aligned circumferentially about shaft 24, and they enable the vacuumized air within chamber 36 to communicate with the vacuum coaxial header 46. In a similar manner, a plurality of circumferentially-aligned openings 49 are cut through another portion of shaft 24 in a circular pattern for communicating the pressurized air from chamber 37 to the inner coaxial header 47. To do this, the inner coaxial header 47 terminates by flaring out to the outer edge of shaft 24 with a barricade 38 which terminates the outer coaxial header 46. A wall 39 similarly terminates header 47 on the right in FIG. 6. A butterfly valve 81 is placed within tube 51 to add serial resistance to the pneumatic vacuum path to further isolate source fluctuations in the vacuum pressure from vacuum pressure at slots 23.

As shown in FIG. 2, a motor 50 drives shaft 24 to rotate drum 21 at a constant rotational velocity in the counterclockwise direction of the arrow shown in FIGS. 3 or 7.

Strip 11, shown in FIG. 3, may be obtained from any of the cartridges 10, shown in FIG. 1, by energizing electrically cable 58 to open the valve connecting the pressure source from tube 19 to plenum 15.

As soon as the end of the strip 11 is moved into slight frictional-pneumatic engagement with rotating drum 21, the air movement tangentially from the drum in the direction of the arrow exerts a force on the end of the strip tending to pull it from the cartridge and decreasing the access time of strip over and above the actuation solely provided by piston 13 being actuated by the pressure source. Strip 11 may have any angular length (A.L.) of wrap about the drum between 0° and 360°. FIG. 3 shows a single strip with about a 300° angular length. FIG. 7 shows a plurality of strips 11a, 11b, 11c each with an angular length (A.L.) of about 100° and being simultaneously processed. When plural strips are processed, each strip can have an angular length (A.L.) up to 360°/K where K is the number of strips being simultaneously processed.

FIG. 3 shows the position of strip 11 about drum 21 after piston 13 has moved to a bottom extreme position in cartridge 10. In principle, the angular length (A.L.) of strip 11 can be controlled by piston 13 to have a shorter A.L. or even a variable A.L. up to the full extension of the strip. In fact, any strip 11 can be processed while it is moving toward its fully extended position. In extended position shown, the inner side of the strip contains a magnetic recording surface which may be recorded upon or read from by means of any or all magnetic write/read head gaps 22a . . . n which may be the type used for writing or reading upon a conventional magnetic surface, such as tape, drum or disk. Hence, any strip 11 can be processed while head gaps 22 are sweeping along all or part of its angular length.

The moving surface of drum 21 frictionally engages air molecules and carries them along to create a laminar air boundary between the convex cylindrical surface and the angular length of strip 11. No portion of strip 11 makes actual rubbing contact with the surface of drum 21.

Without the vacuum pressure on the drum surface, the laminar air film about the drum surface would cause excessive spacing of strip 11 from the drum surface making high density writing or reading of digital data on the strip impossible.

In the absence of any vacuum pressure at slots 23, any strip 11 of whatever length being moved toward the rotating drum would not be drawn toward the drum surface. This is because the normal movement of air about the drum surface causes centrifugal outward air movement tending to blow the strip away from the drum. Thus, circumferential and tangential grooves 27 are provided to guide each strip 11 about the drum. Grooves 27 loosely support each strip 11, and they tangentially connect to grooves 12 in cartridges 10. The outward guidance of a strip 11 along opposite grooves 27 is aided by the circumferential air flow about the drum in its direction of rotation. This air movement creates an outward tension on the strip which causes the strip to move outwardly along opposite grooves 27 without any required assistance from vacuum ports 23 at a speed less than the drum surface velocity. The vacuum ports obtain a closer pneumatic-frictional engagement between the rotating drum surface and a web being extended to further aid the speed of the extending operation.

With only vacuum applied to slots 23, and no pressure applied to slots 29, the close spacing h^* (shown in FIG. 8) precisely exists between strip 11 and the "controlled-spaced area," as long as the angular length of strip "does not exceed about 120° in the embodiment." In this case, h^* is substantially constant for all angular positions of the transducer within any angular length. The "controlled-spaced area" extends behind the vacuum slots until an interruption occurs in the smooth-convex surface comprising the "controlled-spaced area."

The force on strip 11 increases as the air film thickness h^* is made smaller, and/or the size of the "controlled-spaced area" is made larger. Thus, the force increase as the length of the h^* spaced area is made longer, or by increasing the vacuum pressure at slots 23 to decrease h^* .

The force on strip 11 is maximum at the initial point T (in FIG. 3) of the angular length; and the force decreases to zero at the final point D of the angular length. The maximum tension within the angular length of an operating strip 11 thus exists along its initial portion at and near the initial point T. The tension on this initial portion of the strip increases as its angular length about drum 21 is increased, other parameters remaining unchanged. Accordingly, the more the angle of wrap, the greater becomes the total molecular drag; and thus the greater becomes the pull at the point of entry T, and tension on the strip decreases along the strip as the end of strip D is approached. When the angular length exceeds about 120° with no blowing air slots 29, but with vacuum slots 23 operating, the tension forces along the initial portion of the angular length may increase to the point where air spacing h^* there may decrease undesirably as represented by curve Q in FIG. 8. In other words, an increase in angular length beyond about 120° increases the varying tension about the initial angular length to the degree that the increased force squeezes the air film so that spacing h^* at the "controlled-spaced area" reduces up to the beginning T of the strip as shown by curve Q in FIG. 8.

This initial spacing variation can have very detrimental effects on the operation of a long strip 11 by causing premature wear failure on its initial angular length portion, where the spacing Q in FIG. 8 is so small that roughness on the drum surface or small moving particles in the air can catch abrasively between the surfaces to destroy this initial web surface. Even for short strips (between 0° and 120° angular length), premature wear may be caused over an entire strip surface by undesired rubbing of rough surfaces on the drum outside an area being designated as the "controlled-spaced area," which may be

the only area on the drum machined to the smoothness needed for reliable operation with a narrow air spacing h^* . If the remainder of the drum surface is not machined to the same order of microninch smoothness, peak roughness points may penetrate the h^* spacing to wear quickly along the entire angular length of strip 11.

In addition to obtaining a precisely small strip spacing h^* , this invention also alleviates all of the abovementioned problems resulting from (1) having h^* too small at initial portions of a long angular length, or (2) obtaining h^* along rough surfaces of drum 21 outside of a uniquely defined "controlled-spaced area." This invention alleviates these problems by providing blowing air ports 29 following the vacuum "controlled-spaced area" for increasing the air film thickness to much greater than h^* for drum areas outside of the "controlled-spaced area" to extend the useful life of a strip of any angular length and to prevent undue initial tension on any strip of large angular length (120° or more).

The evacuating operation at the leading ports 23 causes a substantially constant spacing h^* to exist between the web and the "controlled-spaced area" following ports 23. The amount of spacing h^* is a function of the number of ports their size, spacing, and the amount of vacuum applied at the ports. Spacing h^* can be regulated easily by controlling the vacuum pressure to ports 23.

Although ports 23 are shown as slots, they may be openings of any shape, such as a series of small holes, as long as the openings are generally positioned in the locations of slots 23 and 29, so that they respectively lead and lag in the "controlled-spaced area." Such openings cannot exist either through or laterally along either or both sides of the "controlled-spaced area," which would destroy the uniformity of spacing h^* .

Slots 29 in FIG. 3 eject blowing air to increase the spacing S following the "controlled-spaced area." The spacing S before the "controlled-spaced area" is also large due to the cyclic operation of slots 29. After slots 29 have left a strip, it is left with the relatively large spacing S between it and the drum surface compared to the smaller spacing h^* .

This large spacing S does not significantly change by the time the vacuum slots 23 begin their next sweep of the angular length, since air leakage along the edges of the strip is not significant within the short cyclic period involved with, for example, 1800 revolutions per minute of the drum. Hence, the spacing S existing ahead of the "controlled-spaced area" is a result of the cyclic operation of this embodiment.

In more detail, with both vacuumized slots 23 and pressurized slots 29 operating, a dynamic pneumatic operation occurs in the spacing between the angular length of strip 11 and rotating drum 21, with respect to the cycled evacuation and ejection of air by slots 23 and 29. Spacing h^* over the "controlled-spaced area" remains constant as shown in FIG. 8. However, at the trailing edge of the "controlled-spaced area," the blowing air from jets 29 creates the much larger and somewhat variable spacing S which is a point falling in the cross-hatched area in FIG. 8. Spacing S varies somewhat with the angular length of the strip 11 and with the angular position of the "controlled-spaced area." For any particular angular length for a strip 11, spacing S varies within a range R shown in FIG. 8, which is a vertical line at the abscissa value representing the angular length of the strip. Range R is bounded by lines S_1 and S_2 in FIG. 8. Curve S_1 represents the limit of the spacing S at the beginning T of the angular length; and curve S_2 represents the opposite limit of spacing S at the end D of strip 11. The reason for the variation of curve S_1 with angular length is because tension at the beginning of the angular length increases with the size of the angular length, which correspondingly decreases the spacing S_1 along the initial portions for longer angular length strips. Surprisingly, this tension variation does not appear to effect the controlled spacing h^* . On

the other hand, a lack of tension at the end of the angular length prevents this factor from affecting the spacing S_2 , which may even increase very slightly with an increase in angular length.

Thus slots 29 restore a thick film of air after the "controlled-spaced area" to eliminate any windless squeezing of the strip about the drum, particularly about the highest tensioned initial angular length. Accordingly, this invention permits reliable reading and writing on substantially the entire angular length of the strip about drum 21 at very high data density, because spacing h^* can be precisely controlled to a very small amount, without resulting in any detrimental effects on strip 11 due to roughness on the drum outside the "controlled-spaced area" or due to large angular lengths.

If relative movement between the web and drum is stopped in FIG. 3, spacing control would be lost, since the h^* spacing would collapse with the web drawn to the vacuumized slots. Hence, control of spacing h^* depends on maintaining relative movement. If the speed in movement is changed, a compensating change is needed in the vacuum pressure at slots 23 to equalize h^* .

As previously mentioned, a plurality of strips can be processed simultaneously. For example, the three strips shown in FIG. 7 are simultaneously handled by drum 21, that is all strips can have information written or read during a single rotational cycle of the drum. In FIG. 7, each of the strips 11a, 11b, 11c has an angular length which is sufficiently small (less than 120°) that it does not have a substantial force affecting h^* at the beginning of its angular length when there are no blowing air ports 29 following the "controlled-spaced area." Hence, in the case of small angular length strips, the trailing blowing air slots 29 may be eliminated leaving only the vacuum slots 23 to obtain the required controlled small spacing h^* . Thus, in the case of FIG. 7, curve Q in FIG. 8 does not exist even without blowing air ports 29. The lack of blowing air ports in FIG. 7 extends the "controlled-spaced area" to the first discontinuity following the vacuum ports 23, which is the initial point T of the angular length for each strip. The spacing h^* is obtained therefore throughout the angular length of each strip. This results in requiring the entire surface of the drum to have the smoothness requirements of the "controlled-spaced area," in order to obtain long life for the strips. This situation with the embodiment in FIG. 7 is contrasted with the embodiment in FIG. 3 where only the drum surface between and including slots 23 and 29 need have the precise smoothness tolerances needed for the "controlled-spaced area," regardless of whether it is used with only the single strip shown in FIG. 3 or with plural strips as shown in FIG. 7.

In the embodiments thus far discussed with respect to FIGS. 2, 3 and 7, it is presumed that there are a plurality of heads positioned across the drum so that any of plural lateral recording tracks on a strip can be written or read by electronically switching among the different laterally displaced heads 22a . . . n. However, in some circumstances, it may be desirable to have only a single head which is laterally positionable among plural tracks on a strip (or strips). This situation is represented by the embodiment shown in FIG. 4 having a single head gap 42 (or a few head gaps) supported on a drum 61 of the same type as drum 21 in FIG. 2, except that drum 61 is thinner and is laterally movable for aligning the head with different tracks on a strip. Either drum cross-section represented by FIG. 3 or 7 can represent a cross-section of FIG. 2 to provide vacuum ports (like 23) only or in combination with blowing air ports (like 29).

Likewise in FIG. 4, vacuum slots 43 precede the "controlled-spaced area" which includes head gap 42. Slots 47 emit pressurized air following the "controlled-spaced area." Thus a precise spacing h^* is obtained at head gap 42 in the same manner as explained for obtaining the

precise spacing h^* at the head gaps $22a \dots n$ in FIG. 2.

In FIG. 4, a box 56 represents a lateral head positioning means, head brush connections, and the drive motor. The drive motor may be identical to motor 50, and the brush connections may be identical to the brush connections 53 provided in FIG. 2. Pneumatic chambers 36 and 37 likewise communicate with ports 43 and 47. The lateral positioning of drum 21 in FIG. 4 may be accomplished in any of several ways. The lateral head positioning means may be similar to the head positioning means conventionally provided on disc drives, such as the IBM 1311 disc drive for positioning a head inwardly or outwardly upon computer command for accessing a selected track. Head positioning means also is being commercially used on drum files and on strip files, for example, in the IBM 2321 data cell drive.

It is also possible to have the strip laterally positioned instead of the drum in order to obtain lateral track accessing, and this is a matter of expediency in the particular design of the system.

In FIG. 4, shaft 24 is laterally slideable within bearings 78 and 79 supporting the shaft in processing chamber 28. Another arrangement is shown in FIG. 5, which allows shaft 24 to be laterally fixed in bearings 78 and 79, in the manner shown in FIG. 2. Thus, in FIG. 5, shaft 24 is hollow and receives within it a laterally slideable shaft 62 to which is attached drum 61. Hence, drum 61 is laterally slideable on shaft 24. Drum 61 is fastened to shaft 62 by keys 64 and 65 received in keyways formed in drum 61 and in a solid portion 63 of shaft 62. Keys 64 and 65 pass through and slideably engage slots 66 and 67 formed through diametrically opposite sides of hollow shaft 24. The amount of lateral movement for shaft 62 is determined by the length slots 66 and 67 in shaft 24.

In FIG. 5 motor 50 drives shaft 24 by means of gears 68 and 69, wherein gear 69 is fixed directly to shaft 24; and they are independent of the head positioning means. In this case, the head positioning means, pressure and vacuum air sources, and brush connections are represented by box 76, and they are connected directly to shaft 62. The air source connection shown in FIG. 6 may be used in FIG. 5. The brush connections and lead arrangements to the head are not shown but are well known in the art, such as those commercially used on video tape recorders having rotating heads.

The strip file shown in FIG. 1 may include as many cartridges as can feasibly be placed at respective tangential positions about the rotating drum. The cartridges may be made removable, replaceable and interchangeable, so that the strip file device can have a library of interchangeable cartridges.

The vacuumized convex-surfaced spacing-control feature of this invention is usable wherever there is relative movement between the web and the vacuumized convex surface. Thus, the embodiment previously described may be used in the reverse sense. That is, the drum 21 may be held stationary while the strip is moved past head gap 22 under actuation of piston 13. For bidirectional control of spacing h^* , slots 23 and 29 have their air sources reversed, so that the vacuum pressure is always applied to the leading ports for any direction of movement. Alternatively, vacuum can be applied to both sets of slots 23 and 29 for bidirectional relative motion between the web and the "controlled-spaced area." A further practical extension of this same situation is to use an elongated web, such as conventional magnetic tape passing from reel-to-reel, instead of strip 11 in FIG. 3. In the latter case, vacuum is applied to both sets of ports 23 and 29; and the angular length of the web need only be sufficient to encompass both sets of slots. In this case, the remainder of the drum surface can be eliminated to the right of dashed line 91 in FIG. 3.

The ports 23, 43, 29 and 47 in FIGS. 2 and 4 may also be represented by a plurality of small round holes having a diameter substantially equivalent to the width of slots 23 and 29 or 43 and 47 and located in the leading or lagging positions represented by ports 23, 43 or 29, 47, respectively in order to obtain substantially the same type of performance. Slots appear to give optimum performance, but other shaped holes may give satisfactory performance, and round holes are easier to make and hence may be more economic.

In either FIG. 3 or 7, it has been found that a plurality of slots in each group 23 and 29, or 43 and 47 operate better than having a single slot representing each group. It has been found that with a plurality of longitudinally-displaced slots in each group, variation in the vacuum-source pressure does not affect the controlled spacing h^* to the degree affected by a single slot in each group.

Multiple "controlled-spaced areas," each with its head gaps, its vacuum ports 23 and pressure slots 29 may be provided at different angular locations about a single drum used with either a single strip as in FIG. 3, or with simultaneous strips as in FIG. 7, in order to shorten the access time to different parts of the same strip or to different simultaneous strips, without increasing the rotational velocity of the drum. Of course, the rotational velocity alone can be increased to shorten the access time.

This application is related to patent application having U.S. Ser. No. 519,570, filed on Jan. 10, 1966 now Patent No. 3,420,424 by R. A. Barbeau, K. B. Day, Jr. and J. A. Weidenhammer.

What is claimed is:

1. Spacing control means between a flexible web and a transducer including
 - a convex surface having formed thereon a smooth controlled-spaced area surrounding said transducer, at least one vacuum port being formed through a leading side of said controlled-spaced area,
 - means for providing relative movement between said web and said controlled-spaced area,
 - an air film bearing with a thickness of the order of tens of microinches being the only separation between said relatively moving web and said convex surface,
 - said controlled-spaced area extending from said vacuum port to a first interruption in smoothness continuity for said area,
 - the smoothness factor of said convex controlled-spaced area being to an order of microinches,
 - and at least one blowing air port following said controlled-spaced area in the direction of relative movement,
 - whereby said transducer can communicate flux between said non-contacting convex controlled-spaced area and said web with only said air film bearing intervening.
2. Spacing control means between a flexible web and a transducer including
 - a convex surface having formed thereon a smooth controlled-spaced area surrounding said transducer, at least one vacuum port being formed through a leading side of said controlled-spaced area,
 - means for providing relative movement between said web and said controlled-spaced area,
 - an air film bearing with a thickness of the order of tens of microinches being the only separation between said relatively moving web and said convex surface,
 - said controlled-spaced area extending from said vacuum port to a first interruption in smoothness continuity for said area,
 - the smoothness factor of said convex controlled-spaced area being to an order of microinches,
 - and said convex controlled-spaced area being a part of a surface of a rotatable cylinder.

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3. Convex air-bearing means as defined in claim 2 in which web supporting means comprises opposite grooved members having a spaced circumferential relationship around at least a portion of said cylinder for supporting said web about its angular length for relative rotation by said controlled-spaced area.

4. Convex air-bearing means as defined in claim 3 which further includes means for moving said web into said opposite grooved members to provide an angular length about the surface of said drum.

5. Convex air-bearing means including a convex surface having formed thereon a smooth controlled-spaced area, at least one vacuum port being formed through a leading side of said controlled-spaced area, said controlled-spaced area extending to a first interruption in smoothness continuity for said area following said vacuum port, a drum for supporting rotatably said controlled-spaced area, means for providing relative motion between said convex surface and a web, the direction of said relative motion being to carry any point on said web over said surface from said ports to said controlled-spaced area, whereby said web moves over said controlled-spaced area behind said vacuum ports with a stable and precisely controllable spacing therefrom, means for supporting the web with an angular length about said rotatable means, means for supporting a plurality of webs about said drum in positions having no angular length about said rotatable means, and means for selecting at least one web at a time for movement to a position of angular length about said drum.

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6. Convex air-bearing means as defined in claim 5 further including means for operating said air-bearing means with a plurality of said web being selected.

7. A strip file device comprising a storage pocket containing a strip having a magnetic surface, with a piston formed at an outer end of said strip, means located at the outer end of said pocket for communicating high and low pressure air for moving said strip in and out of said pocket, a rotating drum having its surface tangentially arranged with respect to said strip, at least one head located in said drum with a recording gap flush with at least a smoothly-defined portion of the surface of said drum, and means for applying a vacuum pressure through the smoothly-defined portion of the surface of said drum prior to said head gap.

8. A strip file device as defined in claim 7 further including means for applying above-atmospheric pressure through the surface of said drum after said recording gap.

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