



## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification <sup>6</sup> : <b>G11B 5/588</b>	<b>A2</b>	(11) International Publication Number: <b>WO 96/19799</b>
		(43) International Publication Date: 27 June 1996 (27.06.96)
<p>(21) International Application Number: PCT/US95/16499</p> <p>(22) International Filing Date: 19 December 1995 (19.12.95)</p> <p>(30) Priority Data: 08/361,773                      22 December 1994 (22.12.94)      US</p> <p>(71) Applicant: CONNER PERIPHERALS, INC. [US/US]; 3081 Zanker Road, San Jose, CA 95134-2128 (US).</p> <p>(72) Inventors: MOORE, John; 21172 Foxtail, Mission Viejo, CA 92692 (US). LARSEN, Keith; 4 Sequoia Drive, Aliso Viejo, CA 92656 (US).</p> <p>(74) Agents: HELLER, Paul, H. et al.; Kenyon &amp; Kenyon, One Broadway, New York, NY 10004 (US).</p>		<p>(81) Designated States: CA, CN, JP, KR, MX, SG, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).</p> <p><b>Published</b> <i>Without international search report and to be republished upon receipt of that report.</i></p>
<p>(54) Title: RECORDING HEAD FOR RECORDING TRACK-CENTERING SERVO SIGNALS ON A MULTI-TRACK RECORDING MEDIUM</p>		
<p>(57) Abstract</p> <p>A system to write a servo signal pattern onto a recording medium incorporating a transducer with a full-width write head, and one or more slotted erase head(s). The full-width write head is used to record signals across the full width of the recording medium; the erase head(s) is used to erase "nulls" in the servo signal pattern. The resulting servo pattern has an extremely good match of signal characteristics between the different portions of the resulting signal pattern, since the recorded patterns were all written in the same pass by the same write head. The use of precisely fabricated and aligned erase head(s) results in a very accurate signal pattern.</p>		

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria	GB	United Kingdom	MR	Mauritania
AU	Australia	GE	Georgia	MW	Malawi
BB	Barbados	GN	Guinea	NE	Niger
BE	Belgium	GR	Greece	NL	Netherlands
BF	Burkina Faso	HU	Hungary	NO	Norway
BG	Bulgaria	IE	Ireland	NZ	New Zealand
BJ	Benin	IT	Italy	PL	Poland
BR	Brazil	JP	Japan	PT	Portugal
BY	Belarus	KE	Kenya	RO	Romania
CA	Canada	KG	Kyrgystan	RU	Russian Federation
CF	Central African Republic	KP	Democratic People's Republic of Korea	SD	Sudan
CG	Congo	KR	Republic of Korea	SE	Sweden
CH	Switzerland	KZ	Kazakhstan	SI	Slovenia
CI	Côte d'Ivoire	LI	Liechtenstein	SK	Slovakia
CM	Cameroon	LK	Sri Lanka	SN	Senegal
CN	China	LU	Luxembourg	TD	Chad
CS	Czechoslovakia	LV	Latvia	TG	Togo
CZ	Czech Republic	MC	Monaco	TJ	Tajikistan
DE	Germany	MD	Republic of Moldova	TT	Trinidad and Tobago
DK	Denmark	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	US	United States of America
FI	Finland	MN	Mongolia	UZ	Uzbekistan
FR	France			VN	Viet Nam
GA	Gabon				

RECORDING HEAD FOR RECORDING TRACK-CENTERING  
SERVO SIGNALS ON A MULTI-TRACK RECORDING MEDIUM

Field of the Invention

5           This invention relates generally to magnetic storage devices, and more particularly to a recording head for recording servo signals on a tape with high mechanical precision, providing an accurate reference for use in placing recorded tracks on recording media.

10                           BACKGROUND OF THE INVENTION

          Increasing the amount of data recorded on a given surface area of a recording medium, i.e., a tape, is a continuing endeavor of manufacturers. It is essential to the goal of increased data densities to store each  
15       magnetic data signal on the smallest possible surface area of the recording medium while retaining the capability of reliably recovering the data stored on the recording medium.

          An impediment to accurate recording and recovery of  
20       the data stored on narrow, closely spaced, tracks is lateral wander of the recording medium as it moves longitudinally over the recording head. As data tracks are narrowed and placed closer together, the spacing between the tracks cannot accommodate the lateral wander  
25       of the recording medium, and consequently a transducer initially aligned to one track may become misaligned as the recording medium is transported past the transducer. Tape wander may take the form of excursions of comparatively large magnitude, both longitudinally to and  
30       laterally with respect to the transducer, especially during stopping and starting conditions, but also during steady state transport. These large excursions make accurate alignment of the recording head relative to the recording medium particularly difficult. Because of the

above mentioned excursions and the non-uniformity of tape movement, accurate alignment of the recording head relative to the recording medium becomes increasingly important as track density increases and the tracks are arranged closer together.

To compensate for lateral tape wander and in an effort to maintain recording head position relative to the recording medium, servo systems have been developed which physically manipulate the recording head position in response to that of the recording medium as it is transported past the head. These servo systems use servo tracking centering signals prerecorded on a recording medium as a reference for the recording head and continuously adjust the position of the recording head relative to any selected one of several long tracks of servo signals prerecorded on the tape.

Although these servo tracking systems allow for significant reduction in the track width and the space between the tracks on the recording medium, the ability of manufacturers of magnetic storage systems to make further reductions in the track width, and the space in between the tracks on the record member, is limited by the ability of transducers to accurately record servo-tracking signals which are narrower and spaced closer together.

Some transducers for writing servo tracking centering signals on a recording medium use a write core which sequentially writes the servo tracking signals for each track by embedding the sensing signals on the recording medium one track at a time. Consequently, the servo system is required to accurately, and with high precision, position the transducer on each track as the write core records the tracking signal for that track. Due to the excursions of the recording medium relative to the transducer head, both laterally and longitudinally, which occur during stopping and starting as well as steady state transport of the recording medium, since the tape is under a tension as it is transported lengthwise,

it is difficult and impractical for a system using a single track write core to accurately align servo tracking centering signals longitudinally and laterally as the number of tracks on the recording medium  
5 increases.

In addition to the difficulties encountered in accurately positioning the single track transducer for recording the servo tracking centering signals due to lateral excursions of the recording medium, and  
10 longitudinal offset due to repeated transport of the storage media past the transducer, expended writing centering signals increases as the number of tracks increase. This increase occurs because the entire length of the recording medium must be transported past the  
15 transducer as the centering signals for each individual track of the recording medium is recorded. For storage media having a large number of tracks, the time required to repeatedly transport the storage media past the transducer and record the centering signals becomes  
20 excessively large.

Multi-gap transducers are known which are capable of reading or writing signals from a plurality of different data tracks simultaneously. However, these transducers have a number of characteristics which prevent them from  
25 being truly effective or desirable for recording multiple-track servo-tracking signals for high density data storage. For example, stacked-core transducers have multiple cores which are magnetically isolated from one another and have gaps which are spaced apart by a  
30 distance of at least one track width. These transducers are relatively complex in construction and thus are costly to manufacture due to the number of cores and windings which make up the transducer. Additionally, the physical dimensions of each of the cores which form the  
35 respective gaps of each stacked-core transducer limit the number of cores which can be stacked for a particular width of tape due to the thickness of material required to give the legs of the core structural strength and a

geometry for generating flux in the recording medium. The width of the respective cores added to the thickness of the magnetic insulator between each core essentially prevents the use of stacked-core transducers to record adjacent, closely spaced tracks.

5 In an improved process, a special recording head is used which has "slots" cut into the write head corresponding to the spacing between the bursts in the recorded servo signal pattern. Since no signal is written underneath the region corresponding to the slots, the "above" center line burst patterns for all written tracks can be written in a single pass across the media, then the "below" center line burst patterns for all written tracks can be written in a subsequent pass. The match between the signal characteristics, which is a critical part of the subsequent usage of the signals for positioning, is fair between the "above" and "below" burst patterns, since they are written by the same write head, but some differences can be observed due to the fact that they were written in two separate passes across the media, and possibly the use of write operations in different directions across the recording medium.

10  
15  
20  
25  
30 In an alternative process, two separate slotted write heads can be implemented, again with the slot size corresponding to the desired space in between the bursts in the recorded pattern. However, signal characteristics of bursts written by two separate write heads will not always match well, so that an error in decoding position information will result. Most of the aforementioned systems require multiple passes over the media in order to write the desired servo pattern. In addition to the signal mismatch due to multiple passes, the processing time required to write the pattern also increases.

#### SUMMARY OF THE INVENTION

35 The present invention solves the aforementioned and related problems of accurately writing track centering servo signals on a recording medium. The present

invention discloses a transducer having a full-width write head which records signals across the full width of the recording medium, then uses precisely fabricated and aligned slotted erase head(s) to erase out the "nulls" in the desired pattern. This results in extremely well matched signals, since they are all written in the same pass by the same write head.

An advantage of the present invention is the ability to record precisely aligned servo signals on a recording medium to eliminate the error in the calculation of the servo position signal.

Another advantage of the present invention is the ability to achieve much higher efficiency in the creation of the recorded signals on the recording medium by recording all required signals in a single pass over the recording medium.

A feature of the present invention is that the slotted erase head(s) are precisely fabricated and aligned so that the resulting pattern is extremely accurate.

Another feature of the present invention is that the mechanical relationship between the write head and the erase head(s) are controlled so that the head can be used to produce the desired signal pattern in a single pass of the recording medium across the head.

#### BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects, advantages and features of the present invention will become apparent from the following description, taken in conjunction with the accompanying drawings, in which:

Fig. 1 is an isometric view of a recording head according to the present invention, illustrating the two slotted erase heads and the full-width write head.

Fig. 2 is an enlarged view of the slots of the erase heads.

Fig. 3 is an overhead plan view of the device shown in Fig. 1, shown with a recording medium contacting the

recording head.

Fig. 4 is a system block diagram showing the nature of the storage apparatus (recording head and recording medium) used with the invention.

5 Fig. 5 is an enlarged, fragmentary schematic view of the recording medium after being written to by the recording head according to the present invention.

10 Fig. 6 is an enlarged, fragmentary schematic view of the recording medium after having the servo burst pattern erased out by the recording head according to the present invention.

#### DESCRIPTION OF THE PREFERRED EMBODIMENT

The recording head 10 in the most preferred embodiment of the present invention, for providing the servo signal pattern shown in Figure 6, will now be described with reference to Figs. 1-2. The recording head 10 has a core made from a Hot Isostatic Process (HIP'ed) nickel-zinc ferrite material and has a transducer with a full-width write head 12 and two full width servo erase heads 14 and 16, having multiple slotted regions 21 and 22 formed therein. The recording head 10 also contains a read head 18 preferably having a width over a range of at least .0080 inch to .0120 inch, and optimally .0100 inch.

25 The servo erase heads 14 and 16 are positioned on the transducer so that their magnetic erase gaps 24 and 25, respectively, are spaced apart from each other by at least 0.365 inch to .0385 inch, and optimally .0375 inch. The write head 12 is positioned relative to the nearest erase head 16 such that the magnetic write gap 23 of the write head 12 is separated by a distance of at least .0590 inch to .0610 inch, and optimally .0600 inch from the magnetic erase gap 24 of the nearest servo erase head 16. The magnetic write gap 23 of the write head 12 extends across the entire width of the recording head 10.

35 As shown in greater detail in Figure 2, the multiple slotted regions 21 and 22 formed on servo erase heads 16



and 14, respectively, extend substantially in parallel to one another along the width of the recording head 10. The slotted regions 21 and 22 preferably have a width over a range of 0.0038 inch to .0040 inch, and optimally .0039 inch, and a pitch along the width of the recording head 10 over a range of .0077 inch to .0079 inch, and optimally .0078 inch. Servo erase heads 14 and 16 are substantially identical, and accordingly, only erase head 14 will be described in greater detail hereinafter. It is to be understood that the description of the servo erase head 14 applies equally to the other servo erase head 16 aside from the differences pointed out below.

The slotted portion 22 of erase head 14 is formed by machining slots 28 into the erase head 14, then back-filling the slots 28 with glass or other suitable substances. The slots 28 of slotted region 22 preferably have a total width over a range of at least .0038 inch to .0040 inch, and optimally .0039 inch, and the pattern of the slotted region 22 along the servo erase head 14 is laid out so that the slots 28 have a pitch along the width of the servo erase head 14 of at least .0077 inch to .0079 inch, and optimally .0078 inch. As further seen in Figure 2, the slotted region 21 on the servo erase head 16 is aligned relative to the slotted region 22 on the servo erase head 14 such that these regions are offset over a range of at least .0038 inch to .0040 inch, and optimally .0039 inch, so that the width, pitch and alignment will determine the track pitch and alignment of the final desired servo burst pattern. The slotted region 21 of servo erase head 16 is also formed by machining slots 28a into servo erase head 16, then back-filling the machined slot 28a with glass or other suitable substances.

The micro-controller 30 which controls the operation of the write head 12, the servo erase heads 14 and 16, and the read head 18 is shown in schematic form in Fig. 4. The micro-controller 30 sends control signals to a plurality of state machines located in programmable array

logic (PAL) circuit 32 via signal lines 40a-c. The output of one state machine contained within the PAL 32 is sent to the write driver 34 via line 42, whose output is sent to the write head 12 on the recording head 10 via line 46. The output of the other two state machines contained within the PAL 32 are sent to the A- erase driver 35 and the B- erase driver 36 via lines 43 and 44, respectively. The outputs from the A- erase driver 35 and the B- erase driver 36 are sent to servo erase heads 14 and 16 via lines 47 and 48, respectively, for controlling the erasing of the bursts on the recording medium. A cycle count signal from the PAL 32, which informs the micro-controller 30 of how many servo burst patterns have been formed on the recording medium, is fed back to the micro-controller 30 via line 41. The micro-controller 30 also reads back calibration signal information from the read head 18 which transmits the information signal from the recording head 10 via line 49 to the Read Preamp/filter circuit 37, which transmits the information to the micro-controller 30 via line 45. The operation of the data recorder mechanism 38 is also controlled by the micro-controller 30 via line 60. The control of the data recorder 38 is understood by those of ordinary skill in the art and shall not be discussed further herein.

The operation of how the recording head 10 writes the servo burst pattern as seen in Fig. 6 will now be described with references to Figs. 3-6. When the recording medium 50 propagates across the recording head in direction P, the data recorder mechanism 38 detects the end of tape (EOT) hole of the recording medium 50. The EOT detection signal is then transmitted to the micro-controller 30 which transmits a signal on line 42 to the write driver 34, which then sends an activation signal to the write head 12 via line 46. When the write head 12 is activated, the magnetic write gap 23 is energized and writes a magnetic stripe 48 preferably having a length over a range of at least .017 inch to

.023 inch, and optimally .020 inch on the storage surface 51 of the recording medium 50. The write head 12 is then deactivated long enough to leave a .0070 inch to .0130 inch, and optimally a .010 inch long gap 60 on the storage surface 51 of the recording medium 50. Once the write head 12 has been deactivated long enough to leave the gap 60 on the storage surface 51 of the recording medium 50, the write head 12 is then reactivated and the magnetic write gap 23 is energized to write another magnetic stripe 49 preferably having a length over a range of at least .0570 inch to .0630 inch, and optimally .06 inch onto the storage surface 51 of the recording medium 50. The write head 12 is then deactivated long enough to leave another gap 60 preferably having a length over a range of at least .0070 inch to .0130 inch, and optimally .010 inch on the storage surface 51 of the recording medium 50. This pattern of approximately .02 inch stripe, approximately .01 inch gap, approximately .06 inch stripe, and approximately .01 inch gap is repeated until there are a total of 575 such patterns written on the storage surface 51 of the recording medium 50.

At approximately the same period that the write head 12 is deactivated after writing the approximately .02 inch long gap 60 on the storage surface 51 of the recording medium 50, the micro-controller 30 transmits control signals to the PAL 32 via lines 40 which activate the A-erase driver 35 and B-erase driver 36, via lines 43 and 44, respectively, which further activate the servo erase heads 14 and 16, respectively. When the servo erase head 16 is activated, the magnetic erase gap 24 is energized and proceeds to erase out a void pattern preferably having a length over a range of at least .0270 inch to .0330 inch, and optimally .030 inch on the storage surface 51 of the recording medium 50 which represented by the area "A" in Fig. 6. At approximately the same period, the magnetic erase gap 24 of the servo erase head 14 is energized, and proceeds to erase out a

void pattern preferably having a length over a range of .0270 inch to .0330 inch, and optimally .030 inch on the storage surface 51 of the recording medium 50 which further represented by the area "B" in Fig. 6. The PAL 32 is programmable with adjustments to the exact timing between the write head 12 and the servo erase heads 14 and 16, so that mechanical tolerances on the recording head 10 and the data recorder mechanism 38 may be compensated for, thereby resulting in the accurate generation of the servo burst pattern 70 shown in Fig. 6. The above described procedure of the having the micro-controller 30 and PAL 32 activate and deactivate the write head 12 and the servo erase heads 14 and 16, respectively is repeated until the servo pattern 70 has been placed on the entire recording medium 50 for a total of 575 servo burst patterns.

The foregoing description of a preferred embodiment of the invention has been presented for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise form disclosed, and obviously many modifications and variations are possible in light of the above teaching. The head for writing servo signals onto a tape was chosen and described in order to best explain the principles of the invention and its practical application to thereby enable others skilled in the art to best utilize the invention in various embodiments and with various modifications as are suited to the particular use contemplated. It is intended that the scope of the invention be defined by the claims appended hereto.

CLAIMS

What is claimed is:

1. A recording head for recording servo tracking signals on a multi-track recording medium, comprising:  
a transducer, said transducer including a write head operative to write a full width magnetic stripe; and  
a plurality of erase heads coupled to said write head which erase a servo burst pattern on said magnetic stripe, wherein a servo signal pattern is recorded in one pass.
2. The recording head of claim 1, further including a read head operative to read said servo signal pattern.
3. The recording head of claim 1, wherein said erase head comprises a first erase head having first slots machined therein and a second erase head having second slots machined therein, said first erase head and said second erase head separated by a distance of about .0375 inch.
4. The recording head of claim 3, wherein said slots have a width of about .0039 inch.
5. The recording head of claim 3, wherein said first slots and said second slots are substantially parallel.
6. The recording head of claim 1, wherein said write head has a width of about .4 inch.
7. The recording head of claim 1, further including circuitry operative to control said write head and said plurality of erase heads.
8. A recording head for recording servo tracking signals on a multi-track recording medium, comprising:

a transducer having a write head;  
a first erase head coupled to said write head, said first erase head having slots machined therein;  
a read head coupled to said erase head; and  
a controller operative to control said write head, said first erase head and said read head.

9. The recording head of claim 8, further including a second erase head, said second erase head being coupled to said first erase head and having slots machined therein, said first erase head and said second erase head being disposed generally parallel to one another on said transducer.

10. The recording head of claim 8, wherein said controller includes circuitry operative to generate control signals and circuitry responsive to said control signals for controlling the operation of said write head and said first erase head and said second erase head.

11. The recording head of claim 8, wherein said slots are back-filled with glass.

12. The recording head of claim 8, wherein said first erase head includes an erase gap, said erase gap being filled with copper.

13. The recording head of claim 8, wherein said slots have a width of about .0039 inches.

14. The recording head of claim 9, wherein said second erase includes an erase gap, said erase gap being filled with copper.

15. A recording head as claimed in claim 8, wherein said write head has a width of about .4 inch.

16. A recording head for recording servo tracking signals on a multi-track recording medium, comprising:  
a transducer including a write head, said write head having a width of about .4 inch operative to write a servo signal on recording medium;  
a plurality of erase heads coupled to said transducer; and  
a controller coupled to said transducer operative to control the relationship between said write head and said erase heads.

17. The recording head of claim 15, wherein said erase heads include a first slotted portion for erasing a first servo burst pattern and a second slotted portion for erasing a second servo burst pattern.

18. The recording head of claim 17, further including a read head operative to read said servo signal, said first servo burst pattern and said second servo burst pattern, said read head operate to allow automatic calibration of electrical settings for recording head operation.

19. The recording head as claimed in claim 17, wherein said first slotted portion is generally parallel to said second slotted portion.

20. The recording head of claim 17, wherein said first slotted portion and said second slotted portion are separated by approximately .0375 inch.

21. A recording head for recording servo tracking signals on a multi-track recording medium, comprising:  
a transducer having a write head, said write head operative to write a servo signal on a recording medium;  
a first erase head coupled to said write head, said first erase head having slots machined therein to

erase out a first burst pattern on said servo signal;  
a second erase head coupled to said write head,  
said second erase head having slots machined therein to  
erase out a second burst pattern on said servo signal;  
and

a read head operative to read said servo  
signal, said first burst pattern, and said second burst  
pattern to allow automatic calibration of electrical  
settings for recording head operation, wherein a servo  
signal pattern is written in one pass.

22. The recording head of claim 21, further  
including circuitry operative to control said write head,  
said first erase head, said second erase head and said  
read head.

23. The recording head of claim 21, wherein said  
write head has a width of about .4 inch.

24. The recording head of claim 21, wherein said  
first erase head and said second erase head are separated  
by a distance of about .0375 inch.

25. The recording head of claim 21, wherein said  
first erase head and said second erase head being  
disposed generally parallel to one another.

26. The recording head of claim 21, wherein said  
slots have a width of about .0039 inch.

27. The recording head of claim 21, wherein said  
slots are backfilled with glass.

28. A recording head for recording servo tracking  
signals on a multi-track recording medium, comprising:  
a transducer, said transducer including a full  
width write head which writes a servo signal on said  
recording medium;



a first erase head operative to erase out a first burst pattern on said servo signal;

a second erase head operative to erase out a second burst pattern on said servo signal;

a read head, operative to read said servo signal, said first burst pattern and said second burst pattern to allow automatic calibration of electrical settings for recording head operation;

a controller coupled to said transducer which generates control signals; and

a programmable array logic circuit responsive to said control signals which controls the operation of said write head and said erase heads so that a servo signal pattern is recorded by said transducer in one pass over said recording medium.

29. The recording head of claim 28, wherein said first erase head includes a first slotted portion for erasing a first burst pattern and said second erase head includes a second slotted portion for erasing a second burst pattern.

30. The recording head of claim 29, wherein said first slotted portion is disposed generally parallel to said second slotted portion.

31. The recording head of claim 28, wherein said first erase head and said second erase head are separated by approximately .0375 inch.

32. The recording head of claim 29, wherein said first slotted portion and said second slotted portion are backfilled with glass.

33. A method for recording servo tracking signals on a multi-track recording medium which comprises steps of:

(a) writing a full width magnetic stripe on a

recording medium; and

(b) selectively erasing a servo burst pattern on said recording medium.

34. The method of claim 33 wherein step (b) further comprises:

(c) activating a first erase head to erase a first servo pattern on said recording medium;

(d) pausing said erasing of said first erase head;

(e) activating a second erase head to erase a second servo pattern on said recording medium; and

(f) pausing said erasing of said second erase head.

35. A method for writing servo burst patterns on a recording medium which comprises the steps of:

(a) activating a write head;

(b) writing a magnetic stripe of predetermined length across a recording medium;

(c) pausing the writing of said magnetic stripe;

(d) activating a first erase head; and

(e) erasing a servo burst from said magnetic stripe.

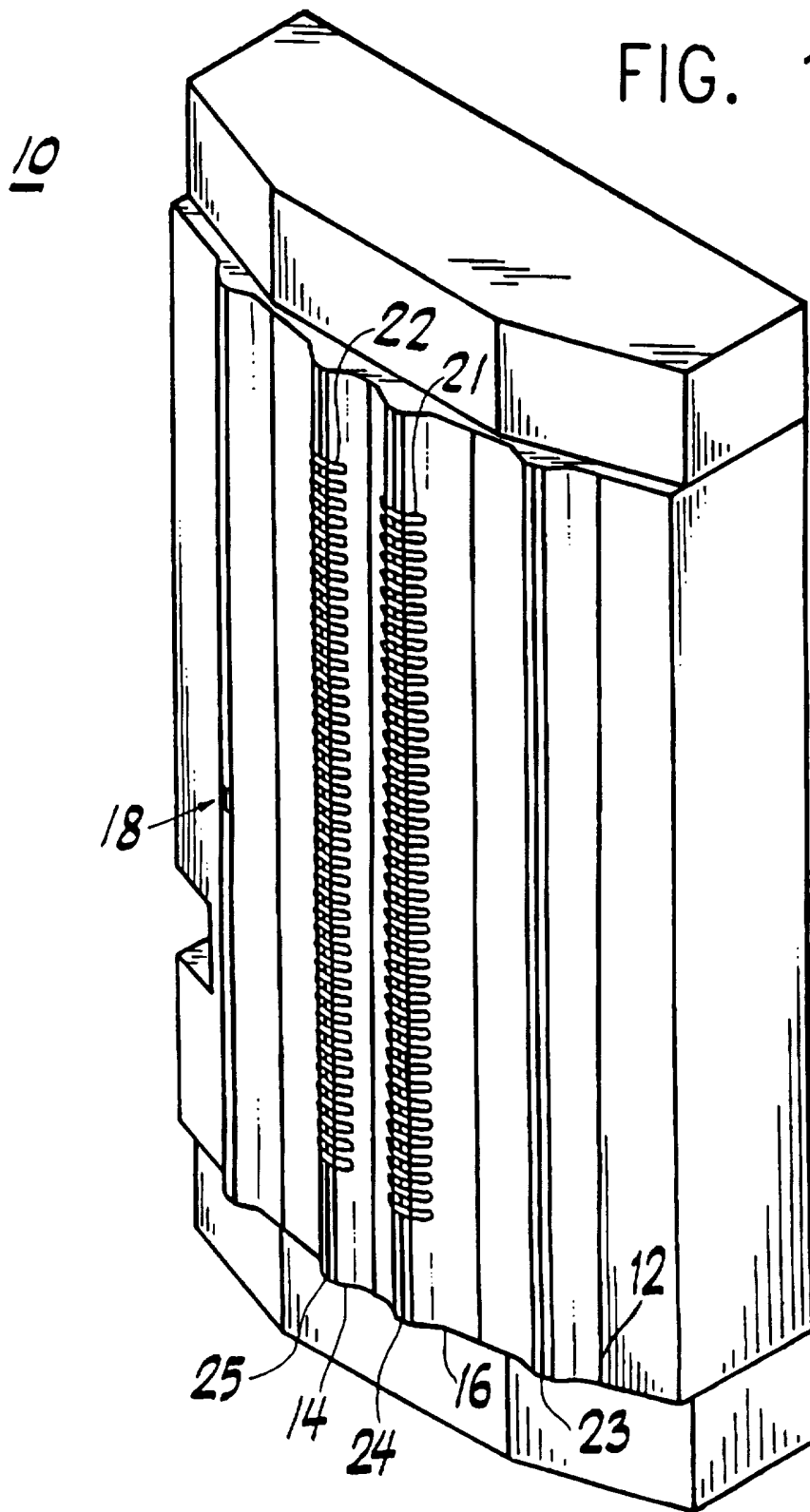
36. The method of claim 35 wherein step (e) further comprises the steps of:

(f) activating a second erase head; and

(g) erasing a servo burst from said magnetic stripe.

1/5

FIG. 1



**SUBSTITUTE SHEET (RULE 26)**

2/5

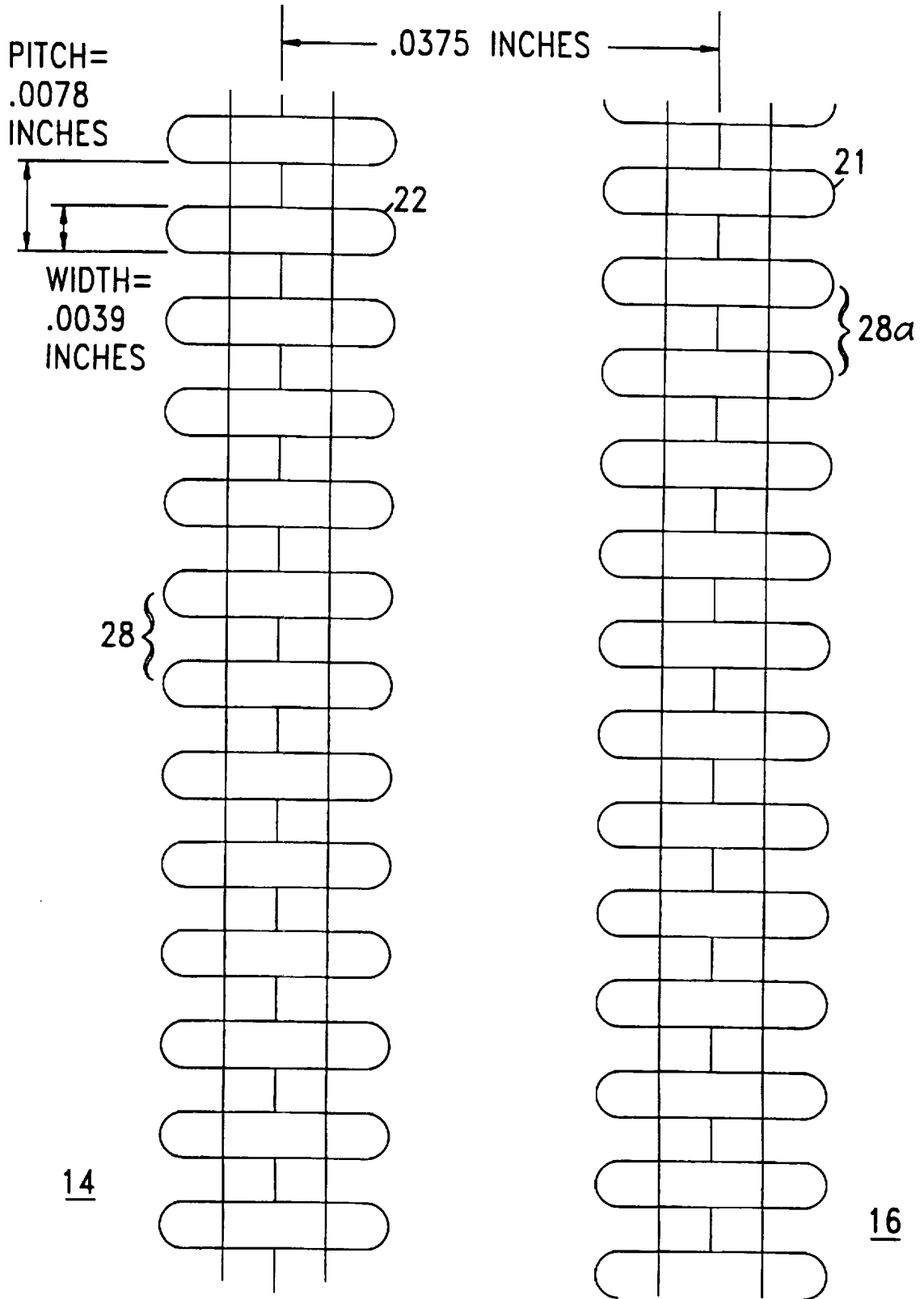


FIG. 2

SUBSTITUTE SHEET (RULE 26)

3/5

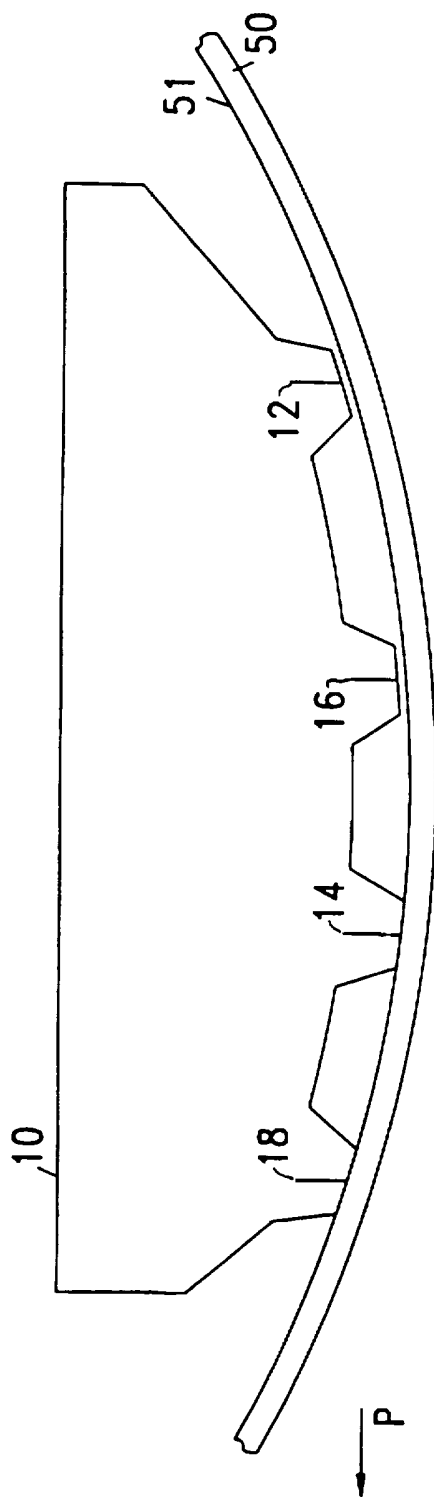


FIG. 3

4/5

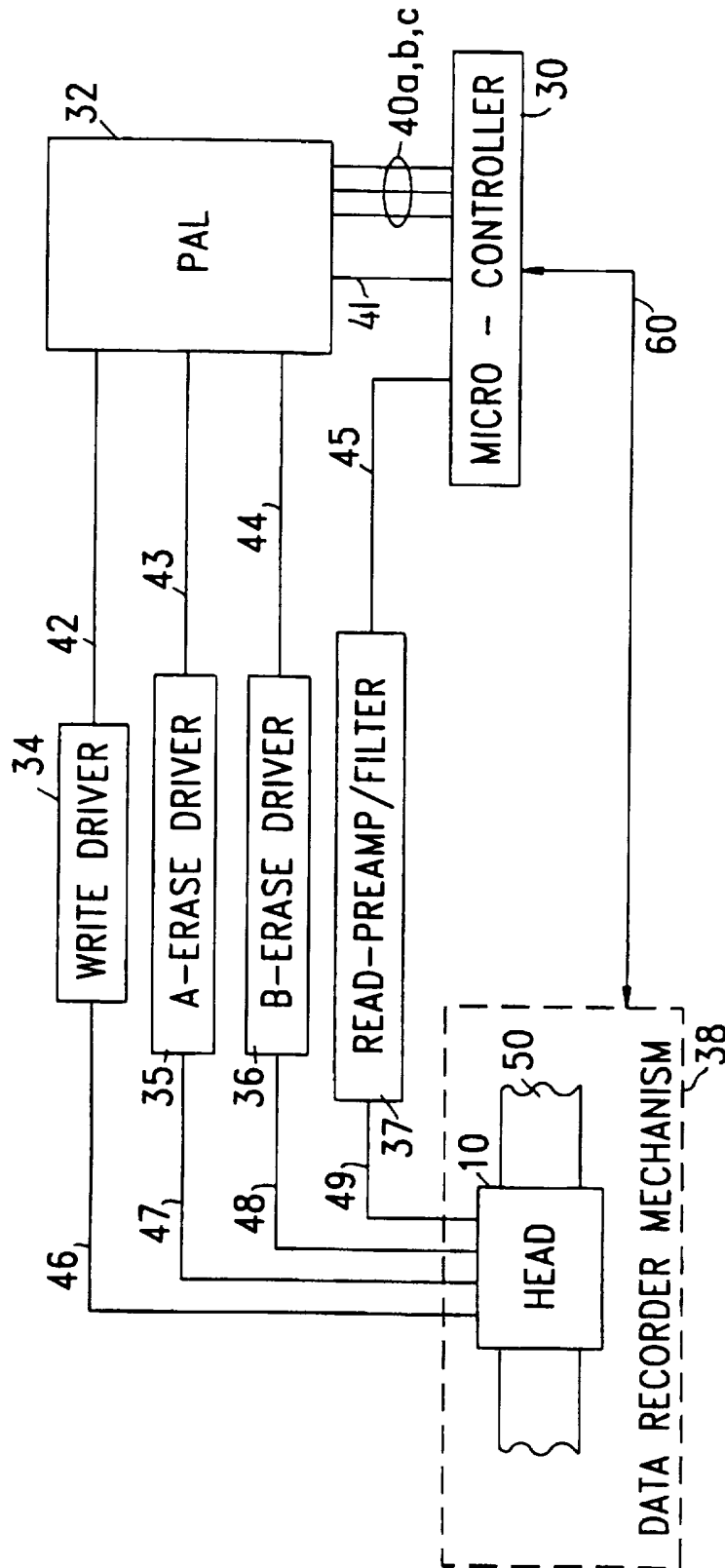


FIG. 4

5/5

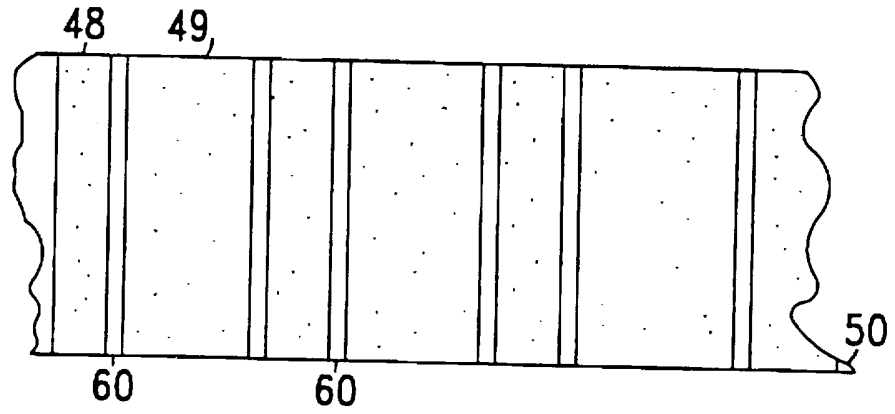


FIG. 5

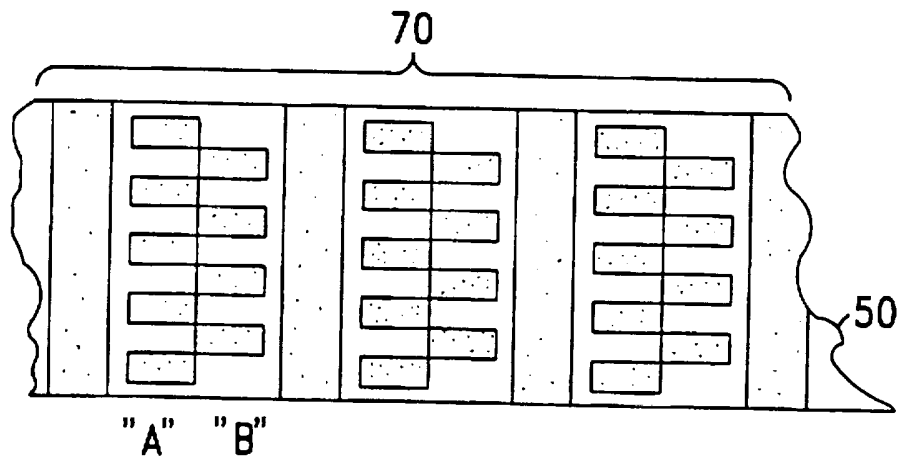


FIG. 6

SUBSTITUTE SHEET (RULE 26)