

- [54] TRACKING CONTROL FOR
RECORDER-REPRODUCER SYSTEMS
WITH THE CONTROL TRANSDUCER
LOCATED AT THE NEUTRAL POINT OF
THE TAPE STRETCH

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[21] Appl. No.: **196,271**

- [52] U.S. Cl..... 179/100.2 T, 178/6.6 P
[51] Int. Cl.... G11b 5/48, G11b 15/43, G11b 21/00
[58] Field of Search..... 179/100.2 T, 100.2 S,
179/100.2 MD; 178/6.6 A, 6.6 P; 340/174.1
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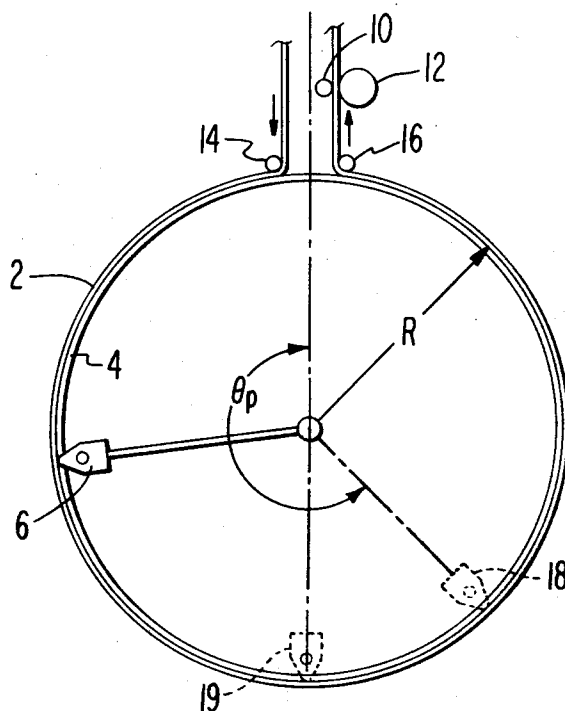
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[57] **ABSTRACT**

An arrangement for a stationary control transducer in a recorder-reproducer system which minimizes mis-tracking of transverse extending information tracks by rotatable information transducers. The control transducer is located at the neutral point of stretch of the tensioned web which is transported over a support surface for scanning of the transverse information tracks.



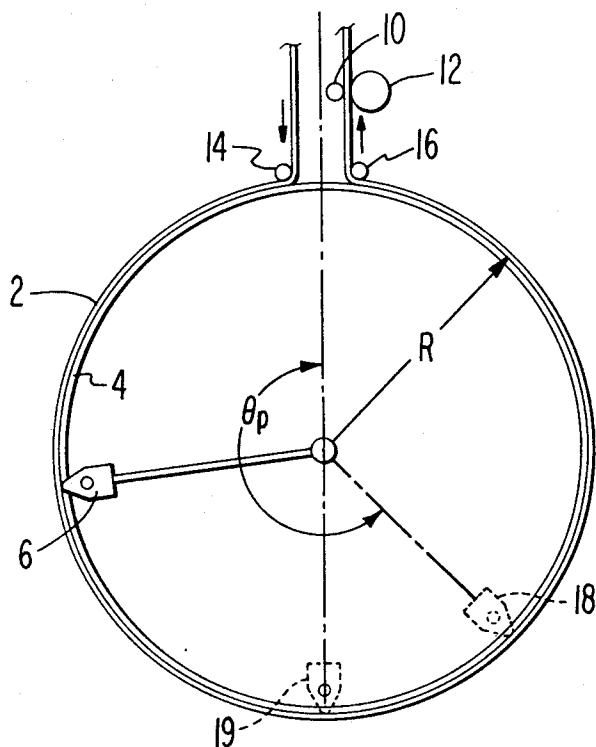


Fig. 1a.

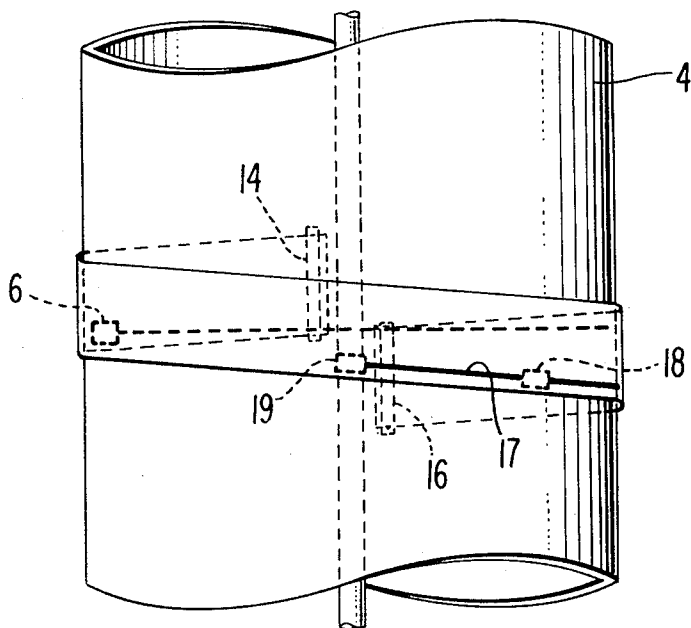


Fig. 1b.

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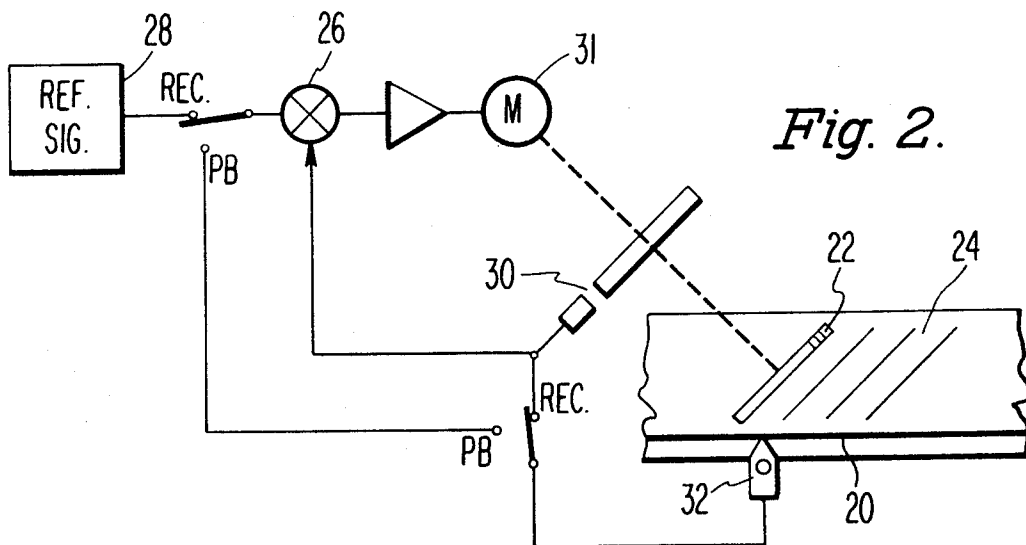


Fig. 3. RECORDED TRACK and TRANSDUCER PATH

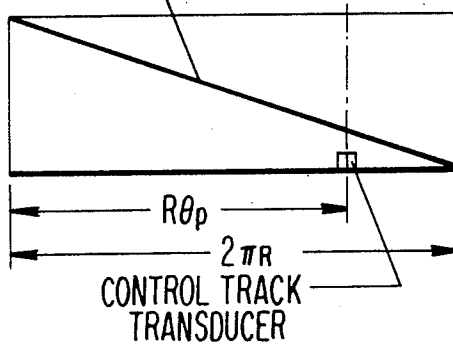


Fig. 4.

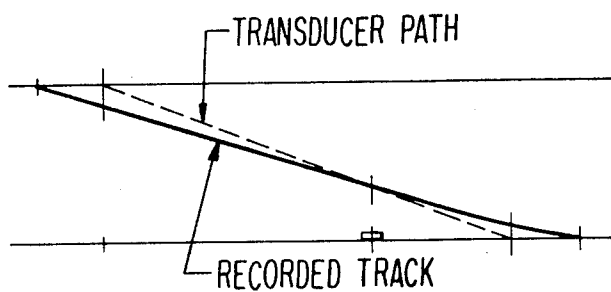
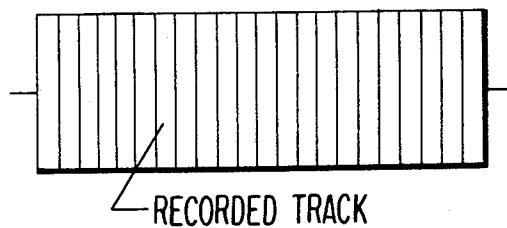


Fig. 5.

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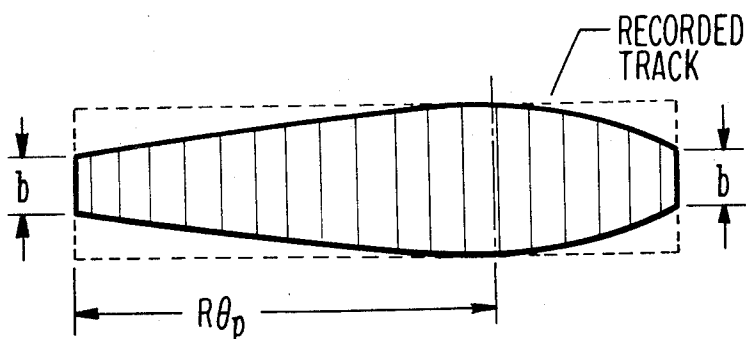


Fig. 6.

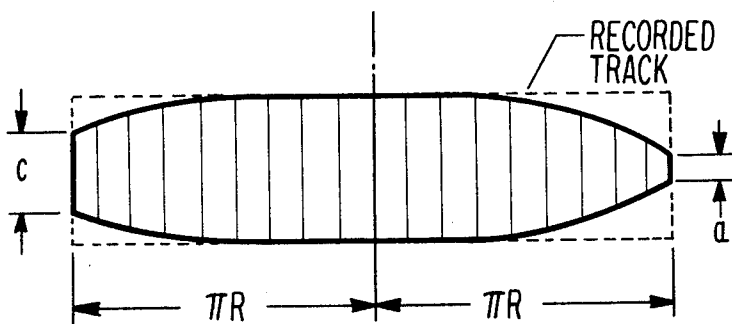


Fig. 7.

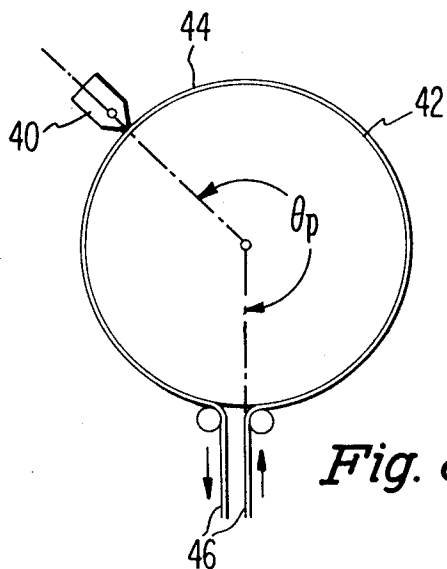


Fig. 8.

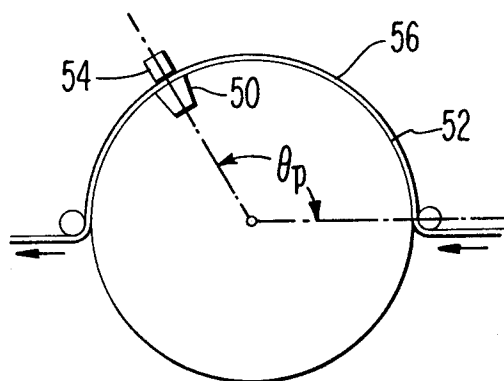


Fig. 9.

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TRACKING CONTROL FOR RECORDER-REPRODUCER SYSTEMS WITH THE CONTROL TRANSDUCER LOCATED AT THE NEUTRAL POINT OF THE TAPE STRETCH

This invention relates to an improved control arrangement in transverse type of recorder-reproducer systems. The disclosed technique compensates for mistracking of the signal information tracks by the scanning transducers which is caused by variation in tension and hence stretch of the record medium over a supporting guide surface.

Various signal recording and reproducing systems are known in which a magnetic tape or other elongated record medium is made to describe a path over the periphery of a drum type structure usually of a cylindrical construction and including one or more signal recording-reproducing devices. Such systems are referred to as helical scan systems and, in certain applications, as slant track systems. The tape may completely encircle the structure so that a tape wrap of 360° or more is developed. Alternatively, an open loop is also used with the tape describing a path around only a portion of the periphery of the structure. By way of example, tape wraps of approximately 270°, 180°, or 90° can be formed in this manner.

The signal recording-reproducing devices, which may be magnetic heads, for example, are made to rotate at a controlled speed and in a fixed plane at an angle to the direction that the tape is driven. Thus a helix angle or angle-of-scan exists between the rotating signal recording-reproducing devices and the direction of tape travel. The angle is governed by the width of the tape and by the diameter of the structure supporting the tape. Each signal recording-reproducing device will scan diagonally across the width of the tape. By a proper choice of such factors as the number and spacing of the recording devices used, the tape helix angle, tape speed, and the rotating speed of the signal recording-reproducing devices, the signal recording-reproducing devices can be made to scan at a desired angle diagonally from one edge of the tape to the other or over only a given portion of the tape, for example, one-half the width of the tape. A signal fed to the recording-reproducing devices is recorded on, and can be reproduced from, a succession of parallel, equal-length tracks each extending at the same angle across the tape width.

In signal recorder-reproducer systems such as described above, a preferred tension exists in the record medium as it moves in a path past the scanning signal recording-reproducing devices. This tension determines the effective position that the tape assumes with respect to the scanning recording-reproducing transducer devices. In order to properly reproduce a signal from the recorded tracks on the tape, it is desirable that the tension and therefore the recorded track length be the same upon reproduction of the signal as it was in recording the signal. Where such condition does not exist upon reproduction, the signal recording-reproducing devices are not properly maintained in alignment with the recorded tracks.

In prior art slant scan systems, a stationary transducer head is provided to produce a further signal track, called a control track, extending longitudinally along the length of the record medium. During recording of the slant information tracks, a signal related to

the velocity of the rotating information signal recording-reproducing devices, is recorded as the control track. On playback, the control track signal is utilized as the reference in controlling the velocity of the rotating information signal recording-reproducing devices, which is usually referred to as the headwheel.

In most existing slant scan systems, the transducer which records and plays back the control track, is located at a portion of the tape path which precedes or follows the drum surface containing the rotating signal transducers which traverse the slant tracks. For such an arrangement of the control track head, if the tape record medium stretches or exhibits a different tension in playback from that during recording, the headwheel, which is referenced to the control track signal, will cause the rotating information signal transducers to mistrack the slant tracks. That is, there will be a mistracking error throughout the complete traverse of the slant track, due to a misalignment of the rotating signal transducers and the slant track which is to be played back.

Further undesirable aspects of the spaced location of the control track transducer, with respect to the area of traverse of the slant tracks by the rotating information signal transducers, have been known. For example, the slight fluctuation of the tape during running of the tape causes a time lag between the information signals obtained by scanning the slant tracks and the signal from the spaced control track transducer. The prior art teaches that, in such an arrangement, the larger the distance between the drum having the rotating information transducers and the stationary control track head, the greater the time lag between the reproduced information signals and the reproduced control track signal.

Because of this time lag phenomenon, some prior art systems are arranged to subject the control track head and information signal transducers to corresponding fluctuations, by locating the control track head to coact with the tape at the geometric center or midpoint of the extent of the portion of the tape which is disposed about the drum for scanning by the information transducers.

While the prior art control track arrangement is useful, in accordance with the present invention an improved control track transducer arrangement is provided, which is more advantageous in dealing with the mistracking problem due to variation in tension and hence stretch of the tape between record and playback.

Briefly therefore in accordance with the invention there is provided, an improved control arrangement in a recorder-reproducer system having a guide surface and means for transporting in tension an elongated record web across the guide surface. The tensioned web is transported through a path on and in frictional engagement with the guide surface, between first and second points on the surface. The transport means includes means for establishing a predetermined tension in the web at the first or entry point, with a further greater tension at the second or exit point being determined by the extent of the path of the web on the guide surface and the frictional relation between the web and the surface, which produces a given amount of stretch of the web. Moveable transducer means are provided for scanning information tracks extending transversely across the web. And a stationary control signal transducer is provided to transduce control signal information longitudinally along the tape. The control signal

transducer is arranged to cooperate with the web at a further point between the first and second points on the guide surface, where the amount of resulting stretch of the portion of the web between the first point and the further point is substantially equal to the amount of stretch of the portion of the web between the second point and the further point.

In the accompanying drawing:

FIG. 1(a) & (b) are a plan view and side view respectively of a recording-reproducing arrangement according to the invention.

FIG. 2 is a diagrammatic view of a system for utilizing the control signal recording-reproducing arrangement of the invention.

FIGS. 3-7 are pictorial diagrams useful in understanding the invention.

FIGS. 8 and 9 are plan views showing alternative arrangements for implementing a control transducer in accordance with the invention.

In FIG. 1, there is shown in elementary form, one arrangement of a slant scan type of recorder-reproducer system. In FIG. 1, a record medium, such as a magnetic tape, 2 is disposed about the peripheral surface of a stationary cylinder or drum 4. In typical fashion, a rotatable transducer 6 is arranged to scan the tape 2 through a slot 8 which is angled with respect to the direction of movement of the tape 2. The tape 2 is drawn about the surface of the drum 4 by means such as a capstan 10 and pinch roller 12 combination. Suitably controlled pay-out and take-up reels, not shown, may be utilized for handling the tape 2. In FIG. 1, the tape 2 extends through substantially a 360° wrap about the surface of the drum 4. However as well known, other degrees of wrap may be used in conjunction with a suitable number of rotatable transducers.

FIG. 2, shows diagrammatically an arrangement in a recorder-reproducer system which inter-relates the control track 20 and movement of the rotatable transducer or headwheel 22 for scanning slant tracks on a tape 24. During recording, the headwheel 22 is servo controlled by a comparator 26 which produces a drive in response to a source of a reference signal 28 and a signal from a pick up 30, which is rotated at the same velocity of the headwheel by the headwheel motor 21. Also during recording, the headwheel 22 velocity indicative signal is recorded on control track 20 by a stationary transducer 32. In playback, the velocity and hence position of the headwheel 22 is controlled with respect to the moving tape 24 in accordance with the signal played back from the control track 20.

When the tape 2 which is disposed in tension, is drawn about the surface of the drum 4, there is a frictional effect therebetween. This frictional effect results in a differential tension between the point of entry and exit of the tape 2 on the surface of the drum 4. The tension of the tape 2 increases in exponential manner from the point of entry to the point of exit of the tape 2. Therefore, the amount the tape is stretched on the surface of the drum 4, will not be a linear but rather also an exponential function. The tension and amount of stretch of the tape 2 is given by the following formulae:

$$\text{Tape Tension: } T_{out} = T_{in} e^{\mu\theta}$$

$$\text{Tape Stretch: } S = (T_{in} R / \mu E A) (e^{\mu\theta} - 1)$$

In the formulae: T_{in} is the tension of the tape 2 at the guide member 14 which is the point of entry of the tape 2 onto the surface of the drum 4, T_{out} is the tape tension

at guide 16 which is the point of exit of the tape 2; μ is the coefficient of friction effective between the tape 2 and the surface of the drum 4 over which the tape passes; θ is the extent of the angle of wrap of the tape 2 about the drum 4; R is the radius of the scanner drum surface; A is the cross sectional area of the tape 2; and E is Young's Modulus for the tape 2.

From the above relationships, it can be shown that there exists a point on the tape about the surface of the drum at which the amount of stretch of the tape is equal to half of the total tape stretch between the entry and exit points. That is, the neutral point of stretch at which the amount of stretch from that point to the point of entry and exit of the tape is the same. The formula for this point can be expressed in terms of an angle θ_p measured from the tape entry point as follows:

$$\theta_p = 1/\mu \ln \left(\frac{e^{\mu\theta} + 1}{2} \right)$$

From the equation it is seen that, this is true independent of the particular value of input and output tensions for a given situation.

To illustrate the significance of this, let it be assumed that as shown in FIG. 1, a stationary control track 18 transducer is located at the neutral point of stretch which is at an angle θ_p about the drum 4 from the point of entry of the tape 2. The transducer 18 produces a longitudinal track 17 along the tape 2. Although the value of θ_p will be a function of the particular value of μ , the location of the neutral point of stretch due to the exponential nature of the functions, is typically as shown in FIG. 1, not at the geometric center or mean between the entry and exit points of the tape 2. Now suppose that some slant track information is recorded on the tape 2 by the transducer 6, under predetermined known tension conditions of the tape 2 at the entry and exit points 14 and 16. If the portion of the tape 2 which is in contact with the drum 4 is examined, the recorded slant track and the path of the moving transducer will appear as superimposed straight lines, as shown in FIG. 3. Now if the same piece of tape is played back with the same known tension conditions as present in recording, and the signal enveloped observed on an oscilloscope, the signal envelope will be substantially a uniform rectangle, such as shown in FIG. 4. Where the tension is the same in both record and playback as hypothesized in the assumed example, the results indicated are substantially independent of the location about the drum of the control track transducer. However, in practical recorder-reproducer systems, the same tension is not present during both record and playback.

Therefore suppose now that the same piece of tape recorded as described above, is played back with a different tension condition than that present during recording. For example, let it be assumed that the playback tension is higher in playback than that present during recording. If we again examine the tape under the new increased tension condition, it will appear as shown in FIG. 5. As shown in FIG. 5, the tape is stretched under the higher playback tension, with deviation or mistracking between the recorded track to be played back which is an exponential shape and the linear path of moving slant track transducer. With the arrangement of FIG. 1 with the control track 17 as shown, during playback the position of the rotating transducer 6 is controlled by the control track servo action such that, the maximum information imparted to the rotating transducer occurs at the point where the

control track transducer head is located. This is so since the location of the control track head is the point about which the tracking control of the rotating transducers is servoed.

Now if an oscilloscope again, is utilized to observe the playback signal envelope under the higher playback tension, the envelope will appear, as in FIG. 6, with a loss of information due to mistracking which is caused by the additional stretching of the tape.

Assume now that the control track transducing head for the system of FIG. 1, is the stationary transducer 19 instead of transducer 18. The transducer 19 is located at the center or midway between the points of entry 14 and exit 16 of the tape 2. Thus the control track transducer 19 is substantially equidistant about the drum 4 from the entry and exit points of the tape 2. If the tape 2 is now recorded for one tension condition and played back a higher tension condition with the control track 19 utilized, the envelope of the playback signal on an oscilloscope will be as shown in FIG. 7. It is noted from FIGS. 6 and 7 that in FIG. 7 utilizing control track 19, mistracking is greater on one end of the track than on the other, as contrasted with the symmetry of FIG. 6. That is, as indicated by the dimensions a , b , and c ; $c > a$ and $c > b > a$.

Thus, it will be noted that there is a point about the periphery of the drum, where the control track transducer head can be located to minimize the effect of mistracking due to tension variation and hence stretch of the tape about the drum. Since from the neutral point of stretch, the tape stretch is equally distributed from the points of entry and exit, it has been found most advantageous that the control track transducer be located such as the head 18 of FIG. 1, at that neutral stretch point.

While the invention has been discussed with regard to a single rotating transducer with a substantially 360° wrap about the drum, as indicated, the principles are applicable to recorder-reproducer systems utilizing other tape wrap angles, number of heads and for various coefficients of friction.

Thus, for example, with a tape having a Young's Modulus "E" in the range of 4.45×10^5 to 5.11×10^5 lb/sq. in.; a tape cross-sectional area "A" of approximately 10^{-3} sq. in. and a drum radius "R" of 2.0624 inches, the following tabulated values are applicable for θ wraps of 360° and 180°, at an input tension T_{in} of 0.5 lb. and for coefficients of friction μ which is typically for example in the range of 0.2 to 0.3.

T_{in} lbs	θ^* degrees	μ	T_{out} lbs	Δs 10^{-3}	θ_p^{**} degrees
0.5	360	0.2	1.75	25	231.94
0.5	360	0.3	3.8	37.3	253.88
0.5	180	0.2	0.94	8.7	102.5
0.5	180	0.3	1.28	10.4	110.2

* Angle of wrap of the tape about drum.

** Angular position of control track head as measured in direction of tape travel from point of entry of the tape on the drum.

It is also to be noted that, while the stationary control track transducer is located about the guide drum as described, the control transducer may be implemented for cooperation with the tape at that point in a number of ways. For example, the control transducer may be mounted in or through the surface of the guide drum as shown. The control transducer in a magnetic recorder reproducer system may for example be a conventional horse shoe shaped magnetic head. The control transducer 40, as shown in FIG. 8, may be posi-

tioned at the desired point about the guide surface 42, on the side 44 of the tape 46 which is facing away from the guide surface 42. For this arrangement, the tape 46 may be arranged to enable recording of the control track on its side 44 or recording of the control track takes place on the side facing the guide surface 42 through the tape 46. Further as shown in FIG. 9, one portion 50 of the control track transducer may be located in the guide surface 52, with a cooperating further portion 54 of the control transducer located on the outside of a record web 56. In this arrangement the control signal may be arranged in or on either side of the web 56.

What is claimed is:

1. The combination with a reproducer system having a guide surface and means for transporting in tension an elongated record web through a path on and in frictional relation with said guide surface between first and second points defining respective entry and exit points of said web on said surface, said transport means including means for establishing a predetermined tension in said web at said first point with a further greater value of tension at said second point being determined by the extent of the path of said web on said surface and the frictional relation between said web and said surface, to thereby produce a given amount of stretch of said web on said surface, and moveable transducer means for scanning information tracks extending transverse of said web, a control arrangement for minimizing the effective mistracking of said information tracks by said moveable transducer means, comprising; stationary transducer means for transducing control information longitudinally of said web said stationary transducer means arranged to cooperate with said web at a further point between said first and second points on said surface, the position of said further point being such that the amount of resulting stretch of the portion of said web between said first and said further point is substantially equal to the amount of stretch of the portion of said web between said second and said further point; said guide surface is arcuate;

the relative differential tension of said web on said surface between said entry and exit points are related by the equation

$$T_{out} = T_{in} e^{\mu\theta};$$

the resulting stretch S of said web on said surface is defined by the equation

$$S = T_{in} R (e^{\mu\theta} - 1) / EA;$$

and the angular position θ_p of said control transducer means, as measured from said entry point is defined by the equation

$$\theta_p = 1/\mu \ln \left(\frac{e^{\mu\theta} + 1}{2} \right)$$

wherein,

θ is the angle of wrap of said tape about said arcuate guide surface,

R is the effective radius of curvature of said arcuate guide surface,

μ is the effective coefficient of friction between said web and said guide surface,

A is the area of the cross-section of the elongated record web, and

E is the value of Young's Modulus for the record web.

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2. The invention according to claim 1, wherein; said control signal transducer is disposed in said guide surface.

3. The invention according to claim 1, wherein; said control signal transducer is disposed on the side of said web which is facing away from said guide surface.

4. The invention according to claim 1, wherein; said

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control signal transducer has first and second portions, one of said first and second portions being disposed to cooperate with the side of said web which is disposed on said guide surface, with the other of said portions cooperating with the side of said web which faces away from said guide surface.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,748,408 Dated July 24, 1973

Inventor(s) Henry Ray Warren

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the title sheet, below the portion reading "[21] Appl. No. 196,271" insert

--[30] Foreign Application Priority Data

March 16, 1971 Great Britain.....6,965/71--.

At column 4, line 49, "contrl" should read --control--. At column 5, line 51, the second line of the table should read
--lbs degrees lbs 10⁻³ inches degrees--.
At column 6, line 51, the equation should read

$$--S = T_{in} R(e^{\mu\theta} - 1) / \mu EA --.$$

Signed and sealed this 20th day of November 1973.

(SEAL)

Attest:

EDWARD M. FLETCHER, JR.,
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents