

Sept. 2, 1947.

H. B. MILLER

2,426,838

ENDLESS TAPE MAGNETIC RECORDING-REPRODUCING DEVICE

Filed April 18, 1945

7 Sheets-Sheet 1

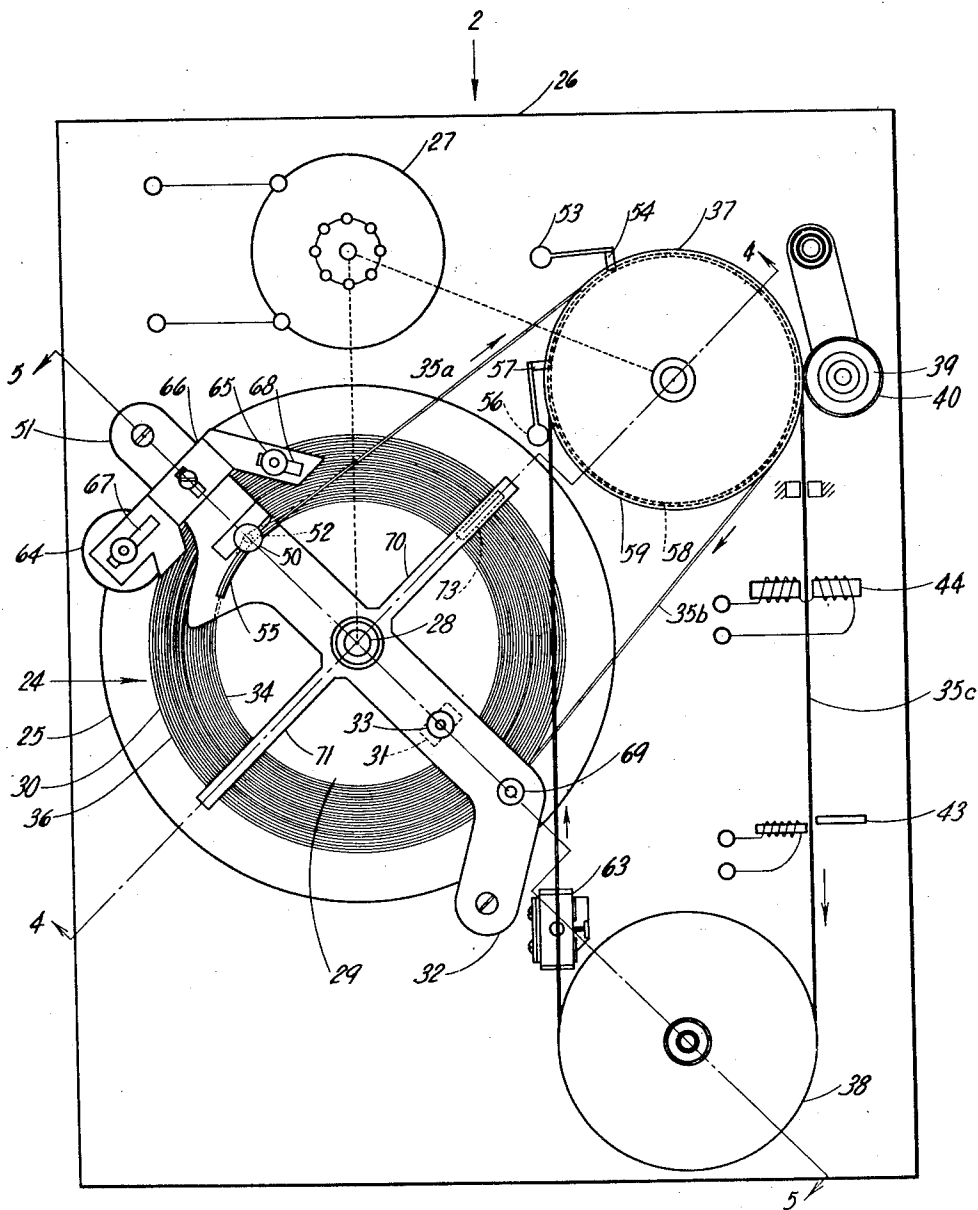


FIG. 1

BY

INVENTOR.  
HARRY B. MILLER  
*Eber J. Hyde*  
ATTORNEY.

Sept. 2, 1947.

H. B. MILLER

2,426,838

ENDLESS TAPE MAGNETIC RECORDING-REPRODUCING DEVICE

Filed April 18, 1945

7 Sheets-Sheet 2

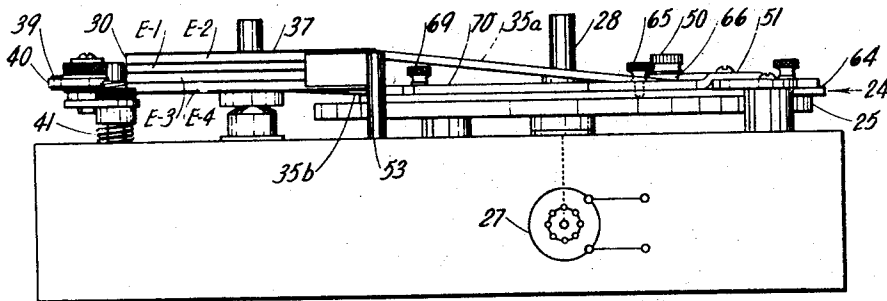


FIG. 2

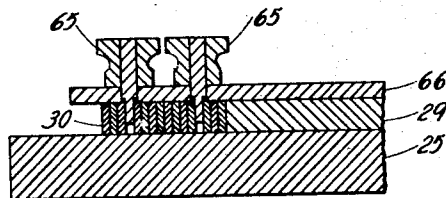


FIG. 3

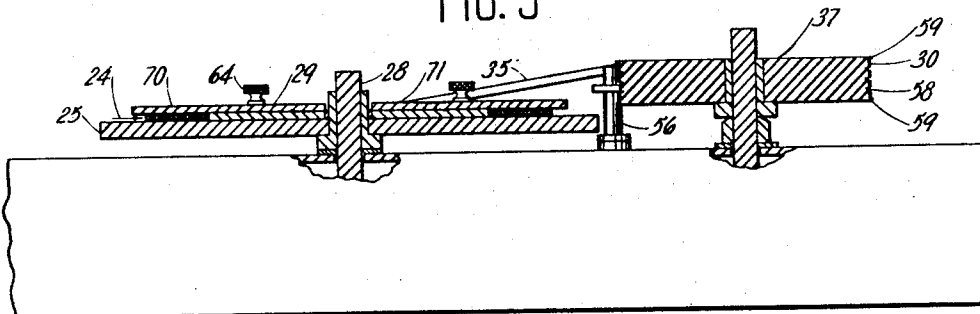


FIG. 4

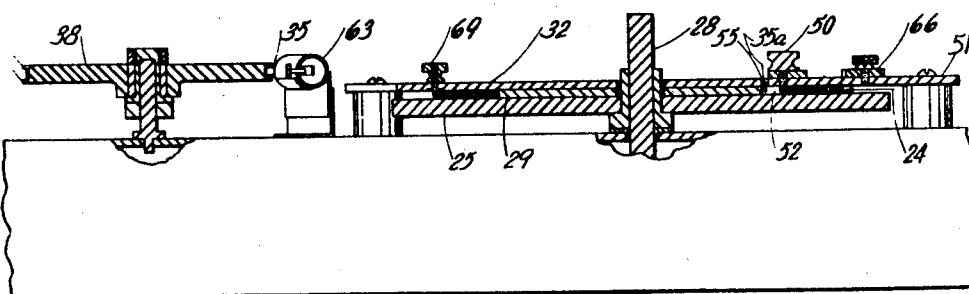


FIG. 5

INVENTOR.  
HARRY B. MILLER  
BY *Pinilla & Greene*  
attorneys

Sept. 2, 1947.

H. B. MILLER

2,426,838

ENDLESS TAPE MAGNETIC RECORDING-REPRODUCING DEVICE

Filed April 18, 1945

7 Sheets-Sheet 3

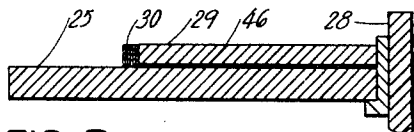


FIG. 6

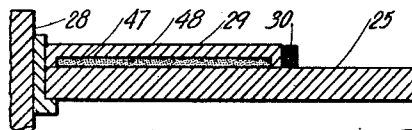


FIG. 7

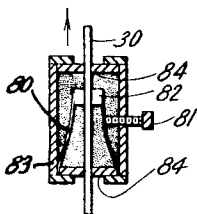


FIG. 8

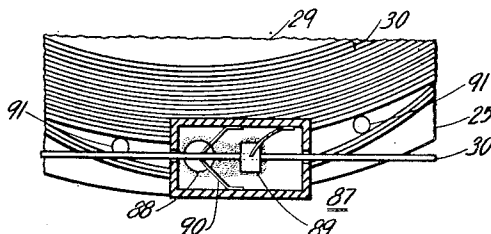


FIG. 9

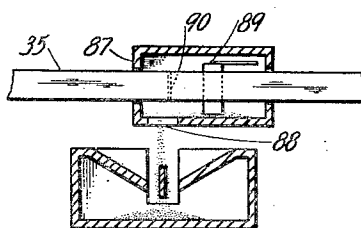


FIG. 10

INVENTOR.  
HARRY B. MILLER  
BY *Pinella & Greene*  
attorneys

Sept. 2, 1947.

H. B. MILLER

2,426,838

ENDLESS TAPE MAGNETIC RECORDING-REPRODUCING DEVICE

Filed April 18, 1945

7 Sheets-Sheet 4

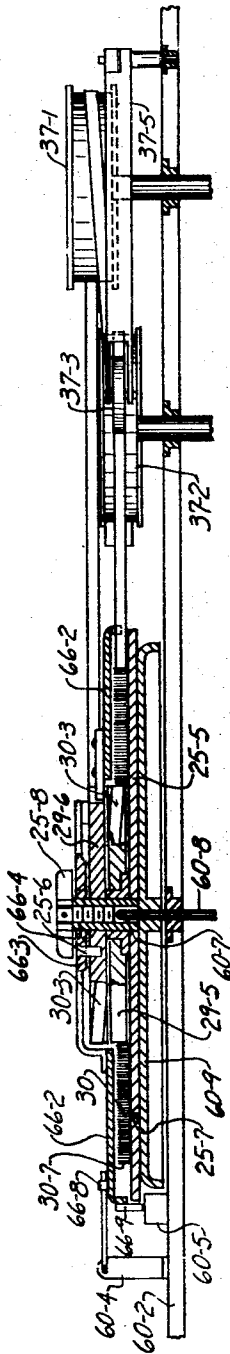


FIG. 11

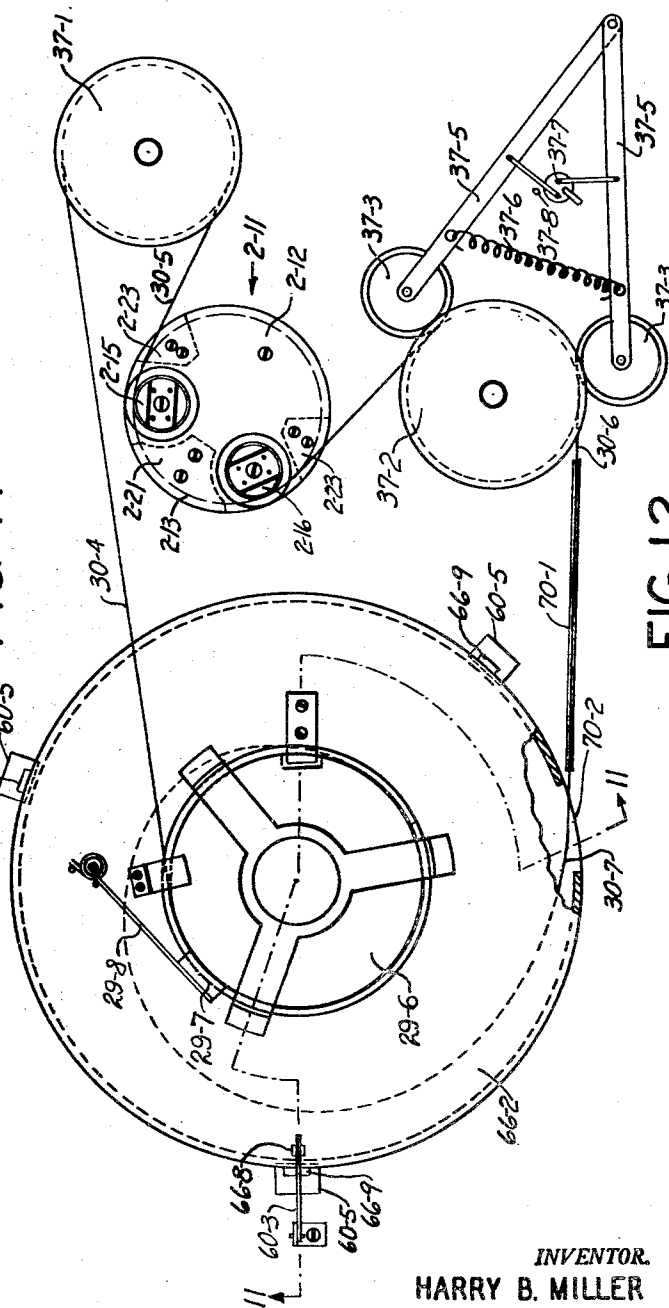


FIG. 12

INVENTOR.  
HARRY B. MILLER  
BY *Pruett & Greene*  
ATTORNEY

Sept. 2, 1947.

H. B. MILLER

2,426,838

ENDLESS TAPE MAGNETIC RECORDING-REPRODUCING DEVICE

Filed April 18, 1945

7 Sheets-Sheet 5

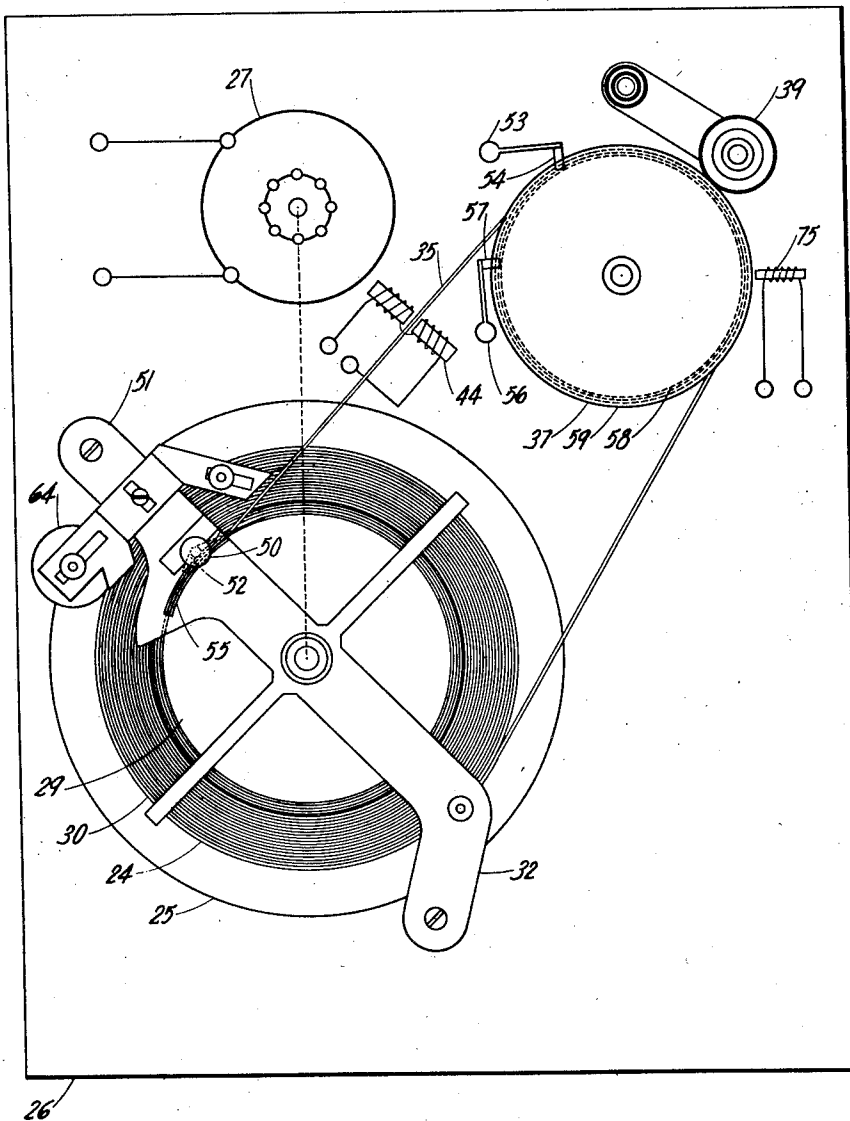


FIG. 13

BY

INVENTOR.  
HARRY B. MILLER  
Eber J. Hyde  
ATTORNEY.

Sept. 2, 1947.

H. B. MILLER

2,426,838

ENDLESS TAPE MAGNETIC RECORDING-REPRODUCING DEVICE

Filed April 18, 1945

7 Sheets-Sheet 6

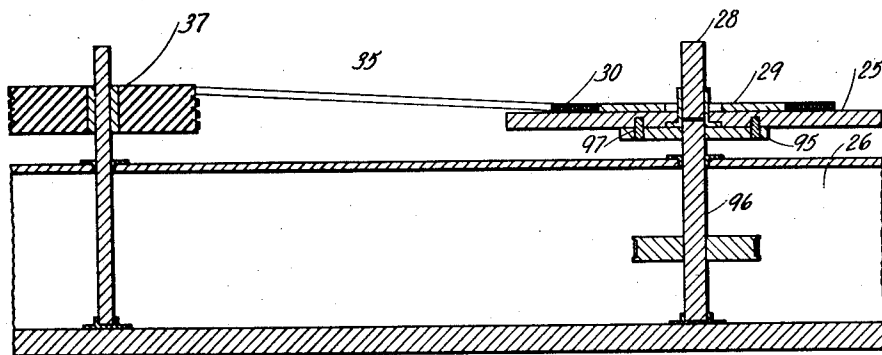


FIG. 14

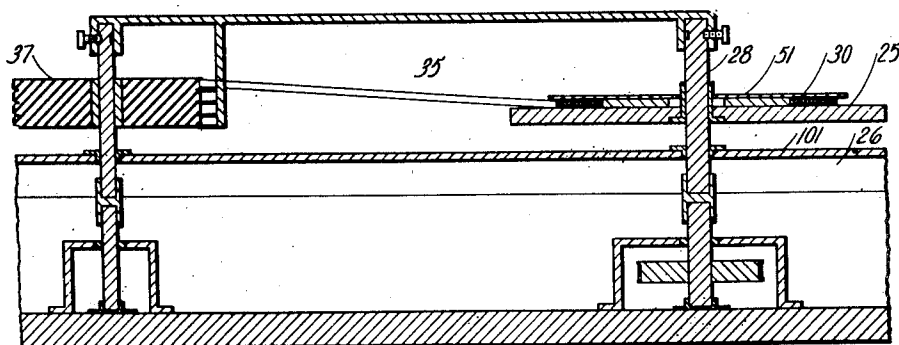


FIG. 15

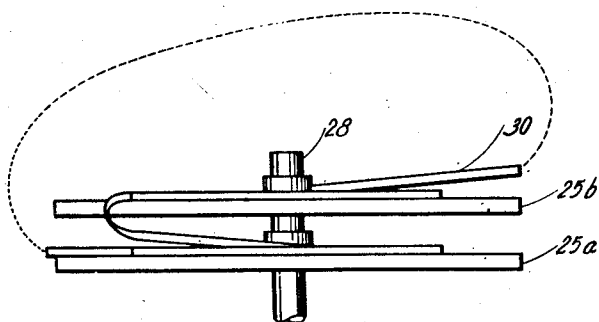


FIG. 16

INVENTOR.  
HARRY B. MILLER  
BY *Miller & Greene*  
Attorneys

Sept. 2, 1947.

H. B. MILLER

2,426,838

ENDLESS TAPE MAGNETIC RECORDING-REPRODUCING DEVICE

Filed April 18, 1945

7 Sheets-Sheet 7

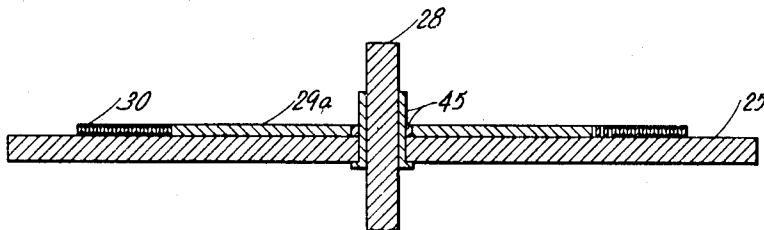


FIG. 17

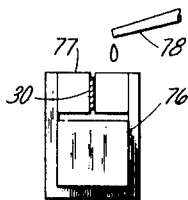


FIG. 18

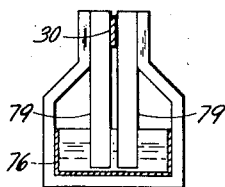


FIG. 19

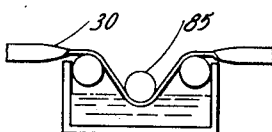


FIG. 20

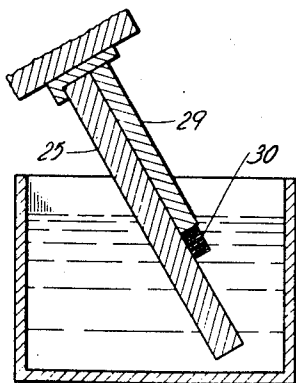


FIG. 21

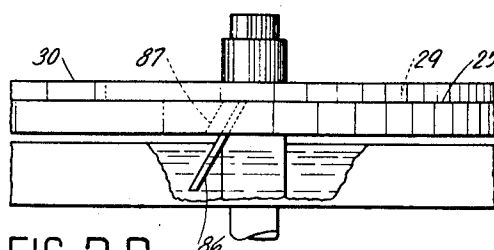


FIG. 22

INVENTOR.  
HARRY B. MILLER

BY

*Paul & Greene*  
Attorneys

## UNITED STATES PATENT OFFICE

2,426,838

ENDLESS TAPE MAGNETIC RECORDING-  
REPRODUCING DEVICE

Harry B. Miller, Cleveland, Ohio, assignor to The  
Brush Development Company, Cleveland, Ohio,  
a corporation of Ohio

Application April 18, 1945, Serial No. 588,911

15 Claims. (Cl. 179—100.2)

1

This application is a continuation-in-part of application Serial No. 440,312, filed April 24, 1942.

This invention relates to magnetic recording and reproducing devices and more particularly to magnetic recording devices utilizing a flexible spirally-coiled record track of magnetic material which is impelled past a magnetic record transducing head for magnetically recording signals on the record track and for reproducing the magnetically recorded signals.

Among the objects of the invention is a novel magnetic recording device of the foregoing type utilizing an endless magnetic recording tape having a length spirally wound into a flat tape coil with overlapping tape coil convolutions arranged in a layer, which is free from difficulties encountered with prior devices of this type.

A more particular object of the invention is a novel magnetic recording device embodying novel constant speed drive means for impelling an intermediate length of a spirally wound record track through the magnetic transducer head at a constant speed.

The foregoing and other objects of the invention will be best understood from the following description of exemplifications thereof, reference being had to the accompanying drawings wherein

Fig. 1 is a plan view of a magnetic recording device exemplifying the invention;

Fig. 2 is a side view similar to that seen by looking in the direction of the arrow 2 of Fig. 1;

Fig. 3 is a sectional view similar to Fig. 1 of a portion of the device shown in Fig. 2;

Fig. 4 is a sectional view along line 4—4 of Fig. 1;

Fig. 5 is a sectional view along line 5—5 of Fig. 1;

Figs. 6 to 10, inclusive, are views illustrating various forms of devices for applying a graphite lubricant to an endless tape recording device in accordance with the principles of the invention;

Fig. 11 is a cross sectional view along line 11—11 of Fig. 12 of another magnetic recording device exemplifying the principles of the invention;

Fig. 12 is a top view of the elements of Fig. 11;

Fig. 13 is a plan view of another magnetic recording device exemplifying the invention;

Figs. 14 and 15 are diagrammatic sectional views of recording devices of the invention having replaceable tape storage units;

Fig. 16 is a diagrammatic elevational view of a plurality of endless tape storage reel devices arranged in tandem; and

2

Figs. 17 to 22, inclusive, are views showing different forms of devices for applying an oil lubricant to a magnetic tape of a recording device of the invention.

In the past many efforts have been made to provide a practical transducer device utilizing an endless record material such as magnetic tape or magnetic wire. It has been realized that to store a long endless record material, a spirally wound flat coil offers the best space-economy, and is well adapted for use in connection with disk recording and phonograph devices, especially if such endless record material device could be made in a form which is readily interchangeable.

Referring to Figs. 1 to 5, one form of endless record material device which exemplifies my invention uses a magnetizable tape in the form of a long endless strip of magnetizable material which is about .003 inch thick and which is spirally wound about an inner coil convolution, each successive coil convolution overlapping the previous coil convolution and arranged in a coil layer 30. The last or outside coil convolution is connected to the first or inside coil convolution by means of a cross-over loop 35. In operation the tape is guided and driven by suitable means along the path of its coil convolutions in the direction from its inner coil convolution 34 through the cross-over loop 35 to the outside coil convolution 36 and thence through the successive spirally wound coil convolutions of the coil 30 to the inside coil convolution. The entire length of tape moves continuously, and each incremental portion follows a path described by the tape as a whole, and the coil layer and cross-over loop retain substantially their general shape during operation of the device.

One embodiment of my invention is shown in Figure 1, in which a storage disk 25 is revolvably mounted on a base 26 and is adapted to be driven by a motor 27. The storage disk 25 is mounted on the base 26 by means of a bearing and the rotatable shaft 28, and mounted on the same shaft 28 and rotatable with respect thereto is a center disk 29. The center disk 29 is rotatable with respect to the storage disk 25 and may rest upon it in order to be frictionally driven by the storage disk, or may be spaced from the storage disk in order to be entirely independent of the motion of the storage disk 25. As shown in Figure 1, the center disk 29 rests on and is in frictional engagement with the storage disk 25 whereby it partakes of the movement of the storage disk, but the movement of the center disk



may be slowed by the action of the magnetizable tape 30 which is coiled about it, thereby introducing a relative movement between the storage disk 25 and the center disk 29. Another means of introducing relative movement between the storage disk 25 and the center disk 29 is to mount the center disk on the revolving shaft 28 away from frictional engagement with the storage disk and to provide a friction pad 31 between the center disk and a stationary arm 32. An adjusting screw 33 may be provided to adjust the pressure of the friction pad 31 against the center disk 29.

The magnetizable tape is endless and is spirally wound around the center disk 29 in a series of coil convolutions 24. The innermost coil convolution 34 is in frictional engagement with the center disk 29 substantially entirely throughout its length, and is connected to the outermost coil convolution 36 by means of a cross-loop of tape 35 which extends around a weighted fly-wheel 37 at a certain elevation, then, after passing through the magnetic transducer head 43, around a light guide wheel 38, then back around the weighted fly-wheel 37 at the same or a different elevation, and then back to the outside coil convolution 36 on the storage disk 25.

As illustrated in Figure 1, the weighted fly-wheel 37 is driven by the motor 27. Since the transducer head 43 engages an intermediate portion 35c of the cross-over loop extending between two loop portions which are in engagement with the motor-driven fly-wheel 37, the intermediate loop portion 35c passing through the transducer head will at all times be driven at the constant speed maintained by the action of fly-wheel 35. The drive may be directly from the motor or through a belt. The transducer head means 43 are shown located on the cross-loop 35 between the first and third loops of tape about the fly-wheel 37. A coupling wheel 39 may be provided to assure sufficient frictional engagement between the tape 30 and the weighted fly-wheel 37. A spring about the shaft of the coupling wheel biases the coupling wheel toward the fly-wheel. The coupling wheel 39 may have a rubber tire 40, and the spring 41 (Figure 2) may be adjustable. A frictional resistance pad 49 may be provided between the fly-wheel 37 and the transducer 44.

The motor 27 is also shown provided with a driving connection to the coil storage and supporting disk 25 so as to rotate the disk in the direction of the motion of the convolutions of the tape coil 30. The rotary motion imparted to the storage disk 25 causes it to impart to the edges of the tape convolutions frictionally engaged thereby, outwardly directed forces tending to expand the coil convolutions so as to reduce the frictional engagement and suppress interfacial friction between adjacent convolutions of the tape coil 30 as they move past each other.

Each incremental portion of the tape is guided and impelled in a path which extends from the innermost coil convolution 34 through the cross-loop 35, to the outermost coil convolution 36, and through the successive spirally wound coil convolutions on the storage disk 25 back to the innermost coil convolution 34.

One of the most important problems in signal recording and reproducing is to get the record material to move through the recording transducer and through the play-back transducer at a uniform rate of speed. What may appear to the eye to have a very uniform speed, may actually have rapid fluctuations which will show up acoustically as wow or flutter. These fluctua-

tions may be objectionable, especially if it is piano music which is being recorded and reproduced. The device of the invention reduces wow and flutter to the extent that it is no longer objectionable. In order to achieve this result it is necessary that all driving parts and all reproducing parts and all parts which exert any friction whatsoever on the tape should be suppressed as far as possible. Further, the positioning of the major parts such as the storage disk 25, the fly-wheel 37, and the transducer means 43 with respect to each other is important.

According to the invention to reduce wow and flutter, is to provide a pin or a plurality of pins 50 extending downwardly from a stationary cross arm 51, and positioned between the innermost coil convolution 34 and the adjacent coil convolution to establish an open space 52. This open space gives the cross-over loop 35a of the tape 30 a chance to rise and clear the coil convolutions 24 as it moves in a path substantially tangent to the center disk 29 and which extends across the coil convolutions. The cross-over loop 35a of the tape 30 is guided to the top of the weighted fly wheel 37 where it is at an elevation T—1 above the plane of the tape coil convolutions 24, by means of a guide support 53 having a plurality of guide fingers 54. This causes the cross-over loop 35a of tape 30 to rise as it leaves the inside coil convolution 34, and to clear the adjacent coil convolutions as it crosses over them; for if the bottom edge of the tape in the cross-over loop 35a scraped the top edge of the tape in the coil convolutions, a periodic wow or flutter or both would be set up. A slot 55 is provided in the extending stationary cross arm 51 to accommodate the rising tape. In Figure 1 the head of one of the separating pins 50 is shown, and in Figure 2 the shank of the pin is illustrated extending between the coil convolutions. Slots may be provided in the cross arm 51 through which the pins 50 extend, and the pins may be provided with a threaded clamping device. With this arrangement the pins 50 are adjustable to regulate the size of the open space 52.

Each incremental portion of tape which leaves the storage disk is guided toward the top of the weighted fly wheel 37 where it may be coupled to the wheel 37 by means of a coupling wheel such as 39, or by one or more turns about the fly wheel. If it is coupled by several turns about the fly wheel one or more guide supports such as 53 and 56 with guide fingers 54 and 57 may be provided to cause each successive turn of tape about the fly wheel to be at a lower elevation than the preceding one. The guide fingers 54 and 57 may be thin and extend into slots 58 cut into the weighted fly wheel 37 and the weighted fly wheel may have top and bottom flanges 59 to prevent the tape from sliding off of it. The diameter of the fly wheel 37 should be great enough that the tape 35 can be spirally wound around it without too much force being exerted on the guide fingers 57. The wider the tape 35, the greater should be the diameter of the fly wheel 37. I have found that for a tape 1/8 inch wide, a fly wheel diameter of about 3 inches is satisfactory. After the tape 30 engages the flywheel 37 for a sufficient length to establish good frictional coupling, it passes to the relatively light guide wheel 38 and then back to the fly wheel 37 at a lower elevation where frictional coupling is again effected by either a coupling wheel or by wrapping the tape several times about the wheel. Between the first

5

and the second frictional engagement there are transducer means 43 and an obliterating head 44. The transducer means 43 may be a recording head and a play-back head in one unit or it may be separate recording and play-back heads, and it has terminals which are adapted to be connected to a signal circuit. The obliterating head 44 has terminals adapted to be connected to a circuit including a source of obliterating current such as a polarizing D. C. battery adapted to saturate the tape 30, or to an A. C. source. Thus by coupling the cross-over loop 35 to the fly wheel 37 at two spaced points or areas, and by placing the transducing means 43 between those two points or areas substantially all of the wow and flutter may be taken out of the device.

In a spiral coil of material which is moving, and in which each portion of material is traveling at the same average linear speed, there is relative movement between the successive coil convolutions. This arises from the fact that each coil convolution has a slightly longer periphery than the next adjacent inner coil convolution. The outer coil convolutions must, therefore, move with less angular velocity. As a result, adjacent coil convolutions must continually slip past each other, and if they are in actual physical contact, friction between the coil convolutions will take place. Sometimes the frictional forces arising from a tight tape are sufficient to break the tape. This tightening action, in spite of the fly wheel 37, would also tend to cause some wow. By imparting to the storage disc 25 an overdrive, that is a speed which causes the outermost convolution to move at a speed at least as great as the speed at which the inner convolution is withdrawn from the tape coil, the successive coil convolutions are spread apart so that each coil convolution becomes somewhat independent of its neighbors thereby reducing the interfacial friction between adjacent convolutions to a level which is not disturbing. By reducing the interfacial friction, such "overdrive" materially increases the amount of tape which can be stored in such a device and the duration of its maximum recording and play-back period with which such device can be operated. The principles underlying the construction and operation of a magnetic recording device utilizing an endless flat coil tape operating with such overdrive are described and claimed in the application of S. J. Begun, Ser. No. 454,094 filed August 8, 1942 as a continuation of application Ser. No. 359,177 filed September 23, 1940.

In a device utilizing an endless strip of record material such as magnetizable tape wound in a spiral coil, the adjacent linearly impelled convolutions of such a coil may be kept in a loose condition, as required. Excessive interfacial slippage friction between the coil convolutions can be prevented if the lower edges of the tape coil convolutions are held in a generally horizontal position and in frictional engagement with the rotating surface of an underlying revolvably mounted disc member 25. The disc member 25 is made to rotate at sufficient speed so that it acts as a convolution expander by subjecting the lower edges of the tape coil convolutions expander by subjecting the lower edges of the tape coil convolutions to frictional forces which tend to expand and loosen them in an outward direction. These expanding forces may be made to counter-balance or overbalance the interfacial frictional forces which tend to contract and tighten the tape coil convolutions in

6

an inward direction till they finally jam around a center post.

The convolutions of the tape 30 are stored in a substantially flat plane on the storage disc 25 which holds and guides the coil convolutions in a horizontal operating position. The disc 25 also serves as a coil guiding and expanding member and exerts an impelling force on the outwardly moving portion 35a of the cross-over loop 35. Any action which tends to expand the coil convolutions may be termed "overdrive," and as shown in Figure 1, one way of obtaining "overdrive" is to rotate the supporting storage disc 25 on its center shaft 28. Due to the fact that the storage disc 25 is solid and must rotate as a unit, each portion of it, at whatever radial distance, must move at the same angular speed. Accordingly, each portion at an outer radial distance must move at a greater linear speed than each inner portion. This differs from the action of the coiled recording material in which each incremental portion must move at the same average linear speed, but may move at a different angular speed than the other incremental portions of the record material. If the innermost coil convolution 34 is moving at the same angular and linear speed as the portion of the storage disc 25 which is immediately beneath it, then the outermost coil convolution 36 must be moving at an angular velocity which is less than the angular velocity of the portion of the storage disc 25 which is immediately beneath it, and also at a slower linear velocity than the linear velocity of the corresponding disc portion. Due to the frictional engagement between the lower edge of the coil convolution and the top face of the storage disc 25, this difference in linear velocities between the coil convolutions and the storage disc 25, exerts on the coil convolutions forces tending to drive the coil convolutions faster, and this force has a tangential component which tends to expand the coil convolutions radially away from the center.

The innermost coil can be maintained around an empty center, but its diameter may then fluctuate, thereby giving a variable speed to the loop 35a. In order to provide the innermost coil convolution 34 with a fixed diameter, a solid center 29 is provided about which the coil convolutions are wound. The solid center 29 may be mounted on the shaft 28 with its lower face in frictional engagement with the upper face of the storage disc 25. It can rotate with respect to the storage disc 25 and with respect to the shaft 28.

Many actions may take place in such a device. Among them is the action which takes place when the average linear speed of the coil convolution tends to be slower than the linear speed of the periphery of the driven fly wheel 37. The cross-over loop 35a of the tape 30 is coupled to the driven fly wheel 37 and is thereby pulled out of the center of the coil convolutions at the same linear speed as the tape at the periphery of the fly wheel 37. The inner tape loop 34 is coupled to the floating center disc 29. Therefore, the speed of rotation of the center disc 29 may be under the control of the fly wheel 37, and for short intervals of time may be driven solely by the fly wheel 37, and at a rate slightly faster than it would otherwise travel.

Another action of such device occurs when the average linear speed of the coil convolutions tends to be faster than the linear speed of the

periphery of the driven fly wheel 37. When this condition exists, the center disc 29, which is normally slightly braked, provides a resistance to the emerging loop 35a, thereby preventing the tape from emerging too fast. The frictional force necessary to move the center disc 29 with respect to the storage disc 25 should be enough to always maintain a slight tension in the cross loop 35. For with an empty center, or a floating solid disc unbraked, the loop 35a will sometimes emerge faster than fly wheel 37 can take it up. Such speed fluctuation shows up as flutter and wow.

In the operation of such devices it may happen that groups of sticking convolutions and gaps are apt to originate near the innermost coil convolution, and then move rapidly outward to the outside coil convolution, which meanwhile has been expanding. When a group arrives at the outside coil convolution, it suddenly decreases the expanding diameter of the storage reel and thus suddenly changes with a "snap," the linear rate at which the tape is being wound onto the storage coil. In order to provide a good commercial device the number of these snaps must be kept at a minimum, and the change in speed of the tape due to the change in diameter of the storage reel must be kept as small as possible.

I have accordingly balanced out substantially all of the operating forces, partly by means of "overdrive," partly by the floating center disc 29, and partly by a pressure wheel 64 and a separating pin 65 which will enable the device to run for a long time without any lubrication.

The pressure wheel 64 is mounted on the cross arm 51 and engages the outer tape convolution substantially on the extension of a line from the shaft 28 to the point where the inner tape convolution separates tangentially from the center disc 29. I have found that a rotatable wheel 64 or a pin mounted at this point will help to prevent the snapping which accompanies a group of coil convolutions sticking together. The snapping arises from successive outside coil convolutions joining the sticking group, and the sticking group and the gap which accompanies it travelling from the inside of the storage coil to the outside of the storage coil by adding more convolutions with a snap to the outside of the group. These sticking groups are more apt to start where the tape is loosest. Accordingly, they most often form on the side of the storage disc toward the fly wheel. This is due to the fact that the cross-over loop 35b arriving at the storage disc has a slight amount of tension which tends to cause most of the slack in the storage disc to be on the side toward the fly wheel 37. The positioning of the pressure wheel 64 at the above described location places it substantially at the start of the slackness in the reel, thereby, reducing the number and severity of sticking groups of tape.

In spite of the pressure wheel 64, occasional non-slipping groups of coil convolutions are apt to form and travel toward the outside coil convolution. If they reach the outside convolution 36, they momentarily abruptly change the linear velocity of the incoming tape, and if it were not for the fly wheel filter system, and sometimes in spite of it, would cause a certain amount of wow. To materially reduce the effect of the stuck-together convolutions, I provide the pin 65 between two adjacent coil convolutions and near the outer convolution 36. This pin is most useful in the region where the greatest amount of tape

slack is apt to be. That is: on the side near the fly wheel 37. I prefer to connect it to the cross arm 51 by means of the arm 66. Both the pressure wheel 64 and the separating pin 65 may be mounted on the arm 66, and both may be adjustable by means of slots 67 and 68 in the arm. It is evident that more than one pressure wheel 64 and more than one pin 65 may be used if desired, and that the exact location is not critical. The separating pin 65 serves to break up radially traveling groups of stuck convolutions, after they have formed and it is probable that it does it by momentarily increasing the tension on the coil convolution whose turn it is to be peeled onto the sticking group. If the tension is sufficient, it causes slippage between the faces of adjacent coil convolutions of the stuck group," and restores the device to normal operation.

Another means for preventing the formation of "stuck-together" convolutions and for breaking them up after they have formed may be a strip of leather 73 attached underneath one of the retaining arms 70 and in frictional engagement with the top edge of the convolutions of tape.

A pin 69 may be provided projecting below the cross arm 32 at substantially the point where the cross-over loop 35b joins the tape or material which is coiled on the storage disc 25. This pin 69 helps to limit the amplitude of movement of the coil of material, and fix the point at which the cross-over loop connects with it, thereby reducing wow in the machine.

Figure 2 is an elevation of a device substantially the same as the device illustrated in Figure 1 and looking in the direction of the arrow at the top of Figure 1. Figure 2 shows more clearly the several turns of record material 30 about the fly wheel 37. A motor 27 is shown driving the storage disc 25. The fly wheel 37 is different in this figure as it is driven solely by the cross-over loop 35. The motor 27 may be placed in the base 26 upon which the turntable or storage disc 25 and the various other parts are mounted. The coil convolutions of the record material are stored in a plane 24 on the storage disc 25, and the lower edge of each convolution is held in frictional engagement with the storage disc 25 by means of the arms 32 (not shown in Figure 2) and 51, and by means of the arms 70 and 71. The cross-over loop 35a of record material rises steeply from the plane of convolutions 24 on the storage disc 25 to a higher elevation E-1 at the top of the fly wheel 37. A complete turn is taken about the fly wheel, and the guide fingers 54 and 57 on the guide supports 53 and 56 cause the record material to drop to an elevation E-2 just below the first turn about the fly wheel. As heretofore described, the record material then passes about the light guide wheel 38 and then back to the fly wheel 37 at elevation E-3 and substantially a complete turn is taken about the fly wheel, and the cross-over loop of the record material 35 drops to elevation E-4, then going at a very slight angle back to the storage disc 25. The coupling wheel 39 may have a tire 40 which extends across all four elevations E-1, E-2, E-3, and E-4 or the tire may be only wide enough to cover one turn of record material. It is to be understood that any number of separately established coupling wheels similar to wheel 39 may be used.

Figure 3 is a fragmentary enlargement showing a plurality of separating pins 65 extending downwardly from the arm 66 and adapted to separate the coil convolutions of the record material

at a plurality of places in order to reduce the number and size of the aforementioned sticking convolutions.

Figure 4 is a cross-sectional view taken along line 4—4 of Figure 1, and showing the structure of the fly wheel 37 in detail. The fly wheel is mounted on a shaft which extends into the base 26 and may or may not be driven by the motor 27 or 27<sup>1</sup>. The wheel is thick enough to accommodate four turns of record material 30 and has top and bottom flanges 59 raised with respect to the body portion of the wheel in order to prevent the top and bottom turns of record material from slipping off. The fly wheel 37 also has three slots 58 adapted to receive the ends of guide fingers 54 and 57.

Figure 5 is a cross-sectional view taken along line 5—5 of Figure 1, and showing in particular the positioning of the pins 50, 69, and how the record material 35a rises in the open space established by the pin 50. The light guide wheel is thick enough to accommodate one turn of record material and may have top and bottom flanges 59 similar to the flanges 59 on the fly wheel 37, in order to prevent the record material from slipping off. The guide wheel 38 may or may not be motor driven. I prefer to use no drive except the record material itself, and I prefer that the wheel be light in weight. However, if it is desirable it may be made heavy to establish a second fly wheel. The pin 50 extends downwardly from the stationary supporting arm 51, and all of the record material convolutions except the innermost one 34 pass around the outside of the pin. This establishes the open space 52 between the rotatable center disc 29 and the coil convolutions. This assures that no wow or flutter will be produced by the cross-over loop 35a engaging other portions of the machine as it passes from the storage reel 25 to the fly wheel 37.

The constant speed drive of the magnetic recording device described above in connection with Figs. 1 to 5 is characterized by the following features: A long flexible magnetic record track which is stored in coiled form has an intermediate track section extending between the tape portions 35a and 35b which is impelled past the transducing head shown formed of the elements 44, 43, for establishing magnetic flux interlinkage between the transducing head and successive elements of the magnetic record track moving past it. The constant speed drive has a revolvably mounted circular fly wheel member 37 and at least one additional revolvably mounted circular guide member 38 which may likewise be a fly wheel. The fly wheel member 37 and the additional circular guide member 38 have each a circular periphery engaged by an intermediate track length of the record track section which is impelled past the transducing head.

The magnetic record track is so guided and impelled along the two circular revolving members 37, 38 that at least two spaced portions of an intermediate record track length passing through the transducer head—shown in the form of loop 35c—are held in engagement with portions of the circular guide periphery of the fly wheel member 37 for maintaining said intermediate track length 35c passing through the transducer head at a substantially constant speed. In the arrangement shown, the fly wheel member 37 is driven by the motor 27 and the other circular guide member 38 is an idler. However, the additional circular guide member 38 may be likewise made in the form of a fly wheel. Further-

more, instead of applying the driving forces to the fly wheel member 37, the driving forces may be applied to another member to which a portion of the moving record track is coupled, such as the storage disc 25 on which the tape coil is stored.

The essential elements of such constant speed drive are of value in other types of magnetic recording devices. Thus, for instance, the two reel magnetic recording device of the type described in connection with Figs. 1 to 3 and 12 to 14 of the application of S. J. Begun, Serial No. 524,479, filed February 29, 1944, as a continuation-in-part of the application Serial No. 340,030, filed June 12, 1940, may be advantageously combined with a constant speed drive of the type described above in connection with Figs. 1 to 5 for driving therewith the intermediate section of the record track moving from one reel to the other past the transducing head so as to maintain the portion of the record track moving past the transducing head at a substantially constant speed during the recording and playback operations.

Because of their more complicated mechanical structure and the inherently limited recording capacity of the prior art endless magnetic tape recorders utilizing an endless tape guided in the form of a helix over a plurality of spaced guide rollers—many efforts have been made in the past to devise a practical endless magnetic tape recorder operating with an endless tape arranged in the form of a spirally wound flat coil of the general type described above in connection with the various exemplifications of the invention. However, such flat tape coil endless magnetic recorders have always been subject to unpredictable operating difficulties which prevented their adoption for commercial applications.

Although flatly coiled endless magnetic tape recording devices of the type described in the Begun application Serial No. 454,094, filed August 8, 1942, and in the present application, overcome most of the difficulties responsible for the troubles encountered with the prior art devices of this type, they nevertheless developed from time to time unpredictable difficulties which cannot be taken care of by a person without skill in servicing such devices. As a result, flatly coiled endless magnetic tape recording devices had only a limited field of use.

According to the invention, the difficulties responsible for the limited field of use of such improved flatly coiled endless magnetic recording devices are overcome by utilizing in such recording device a magnetic tape the surface of which has adheringly united thereto a thin layer of a carbonaceous lubricating medium in the form of graphite. I have found that when graphite is applied to a metallic magnetic tape and rubbed and inflected onto its surface, an extremely thin layer of lubricant becomes adheringly united to the surface of the tape and that such thin layer does not detrimentally effect the magnetic recording and reproducing process.

I have found that by applying graphite to the surface of a metallic magnetic tape, an interfacial bond is formed between the graphite particles or molecules and the surface of the magnetic tape. I believe that this bond is due to an interfacial tension between the metal surface of the tape and the molecular layer of the graphite applied thereto. This bond is sufficiently strong so that once a graphite coating is applied to the magnetic tape, the graphite layer or coat will remain on the tape, and when a coiled tape provided with such graphite coating is subjected to

coiling operations of the type described above, involving tangential motion between successive layers of the coil, the bond between the metal surface of the tape and the graphite layer is maintained substantially indefinitely, thereby assuring that the interfacial friction is permanently reduced and that the operation of such flatly coiled endless magnetic tape recorders is rendered fool-proof.

Another advantage of the graphite lubricant resides in the fact that it maintains on the surface of the magnetic tape an electrical conducting surface film which is effective in keeping dust away from the surface of the tape.

Figs. 6 to 10 show various forms of devices which are effective in applying graphite lubricant to the top of a flatly coiled endless tape magnetic recorder of the type described above. I have found that if a magnetic tape of an endless flatly coiled magnetic tape recorder has applied thereto graphite for a period of a few hours, the interfacial slippage between adjacent tape convolutions will spread the graphite evenly over the exposed surfaces of the tape and will rub it down to the desired thin layer which remains permanently and adheringly united thereto.

Once the magnetic tape of such flatly coiled endless magnetic tape recorder has been properly graphited, such recorder will operate practically for the life of the device without requiring attention on the part of the user, because the electrical conductivity of the graphited tape prevents the tape from electrostatically attracting the dust. This is important because, although the tape in itself is an electric conductor and is maintained grounded, it will sooner or later be covered by a film of dust which forms an electrically insulating layer, the exposed surface of which will be electrostatically charged as a result of frictional engagement with the adjacent convolutions of the tape and such electrostatically charged surface layers are apt to attract and hold dust particles, resulting in the development of gummy masses which increase the frictional resistance between adjacent tape layers to a disturbing level after a short period of use. The graphite being a good electrical conductor makes it possible to provide at all times a ground for any electrostatic charges, and, as a result, the surface of a flatly coiled endless magnetic tape recorder will not tend to attract dust to it.

Fig. 6 illustrates one arrangement for assuring that the surface of the tape of a flat tape coil endless tape magnetic recorder remains always coated with a layer of graphite lubricant. The shaft 28 of a recording device, such as described in connection with Figs. 1 to 5 has connected thereto a tape coil storage disc 25 as by a force fit so that the disc 25 rotates with the shaft 28. The flat tape coil 30 is coiled about the inner or center disc 29—1 which is concentric with the shaft and rotates relatively thereto, the bearing member 45 being arranged so as to allow the inner or center disc 29—1 to rotate independently of the shaft 28 and the tape coil supporting disc 25. The disc 29—1 may be made of metal, synthetic resin or other suitable material.

As shown in Fig. 6, a thin wafer of hard graphite 46 is placed between the facing surfaces of the inner disc 29—1 and the tape coil supporting disc 25 so that relative motion between the storage disc 25 and the inner disc 29—1 provides a slight grinding action which slowly releases small particles of the lubricating graphite wafer 46. Many of the small particles of graphite will find

their way to the tape and are ground into its surface. It should be noted that under normal operation of such device, there is little pressure between the tape coil supporting disc 25 and the center disc 29—1. Accordingly, the life of a lubricating graphite wafer 46 will be very long and the rate at which graphite will be removed therefrom will be very slow.

Fig. 7 illustrates a somewhat similar lubricating device in which a hollow space 47 is provided beneath the center disc 29—2 and the space is filled with a powdered lubricant 48 which slowly finds its way underneath the disc 29—2 and onto the tape 30.

Fig. 8 shows a form of lubricating device in which small pieces of a dry or solid lubricant, such as graphite or talc 82, are held against the tape 30 by means of springs 80. An adjustment 81 is provided to regulate the spring pressure. A housing 83 is provided around the lubricating device and scrapers 84 may be provided to remove dirt from the tape as it enters the housing, and to smooth the lubricant which is deposited on the tape and to help to rub it into close contact with the surface of the tape.

Fig. 8 shows the internal construction of the lubricating device 63 of Fig. 1. The reference character 82 indicates leather pads, or the like, held against the tape 30 by means of springs 80, the bias of which may be adjusted by the screw 81. The reservoir 63 may be filled with loose graphite, and as the tape 30 moves through the reservoir a small amount of the powdered lubricant is picked up by the faces and is rubbed in by the pads 82. Dust or other dirt is scraped off of the tape 30 prior to its entrance into the reservoir 63 by the entrance pad 84, and excess graphite is scraped off of the tape 30 as it leaves the reservoir by the exit pad 84.

Fig. 9 shows a portion of the center disc 29, a portion of the tape coil convolutions, and a portion of the supporting disc 25 in association with a lubricating device indicated generally by the reference character 87. The device 87 is suspended by any convenient means above the coil convolutions and has a hole 88 in the bottom thereof through which powdered lubricant may fall onto the coil convolution. A small supply of the powdered lubricant may be placed inside the device 87 and an agitator 89 provided to cause the powdered material to fall through the hole 88 onto the coil convolution below it. The agitator may be a piece of leather suspended by a spring connected to the housing of the device and in contact with the moving tape. The piece of leather may extend downwardly into the supply of lubricant or the vibration transmitted through the spring to the housing may be sufficient to cause the lubricant to fall through the hole. A pair of scrapers 90 may be provided for scraping excess lubricant off of portions of tape. In order to assure that most of the lubricant is deposited on the face of the tape one or more pins 91 are provided which divide the tape convolutions under the hole 88.

Fig. 10 illustrates another manner of using the lubricating device 87 shown in Fig. 9. It may be mounted on the cross-over loop 35 of the tape immediately above another portion of this cross-over loop so that part of the falling lubricant will come in contact with the lower portion of tape. Both of these methods have the advantage of using over and over again the original supply of lubricant.

Figs. 11 and 12 show another form of flat tape

coil endless tape magnetic recording device exemplifying the invention. The convolutions of the substantially flat compact tape coil 30 are held and guided in a horizontal operating position by an upwardly facing surface of a circular wall member 25-5. Within the center of the tape coil 30 is mounted a center disc 29-5 and the inner tape coil convolution 30-3 is withdrawn therefrom by guiding it along a helical path as indicated in Fig. 11 over a portion of the cylindrical periphery of a similar disc 29-6 of the same diameter and mounted thereover in alignment therewith.

The so withdrawn inner convolution 30-3 of the tape coil is shown guided over two revolvably mounted guide rollers 37-1, 37-2 toward the outermost tape convolution 30-7 of the tape coil, a portion of the cross-over tape section withdrawn from the tape coil being shown guided past a magnetic transducer head 2-11 which engages an intermediate length 30-5 of the tape moving between the two guide rollers 37-1, 37-2. Guide roller 37-2 forms part of a fly wheel structure and serves to maintain the motion of the tape length 30-5 passing through the transducer head at a constant speed. There is also shown provided a brake pad 29-7 which is pressed by a resilient brake arm 29-8 held by the cover plate 66-2 so as to apply a braking force to the portion of the crossover loop 30-3 which engages the periphery of the fixed guide disc 29-6, for subjecting the crossover loop portion 30-4, moving over the transducer head 2-21, to proper tension forces.

The portion of the cross-over tape length which is engaged by the fly wheel member 37-2 may be wound thereover several times, for instance, in the manner explained in connection with Figs. 1 to 5, so as to assure that good coupling engagement is at all times maintained between the fly wheel member 37-2 and the portion of the tape engaged thereby. Alternatively, as indicated in Fig. 12, two coupling rollers 37-3 are arranged to press against the portion of the tape moving over the fly wheel member 37-2 and maintain it positively coupled with the underlying circular surface of the fly wheel member 37-2 which may be a friction surface. The two coupling rollers 37-3 are shown supported by two pivotally mounted arms 37-5 which are subject to the action of a biasing spring 37-6 which maintains their coupling rollers 37-3 in their tape coupling position. The two coupling arms 37-5 may be actuated to their uncoupling position, for instance, by interconnecting them through operating links with a pivotally mounted junction disc 37-6 so that by turning the junction disc 37-7 on its pivot, its actuating lever is brought against a stop pin 37-8, for instance.

The magnetic head 2-11 is of the general type described in the copending application of S. J. Begun, Serial No. 550,573, filed August 22, 1944. It is shown formed of two wall members 2-12 of circular form which are provided along their exposed edge with an outwardly tapering circular guide channel 2-13 the deepest portion of which has a channel track of a width equal to the width of the tape 30, in the manner described in the application of Williams and Begun, Serial No. 546,808, filed July 27, 1944, in connection with Figs. 10 and 11. Between the two wall members are held clamped the pole piece edge portions of a double pole piece obliterating head unit 2-15 and a similar double pole piece transducer head unit 2-16 constructed in the manner described, for

instance, in the above identified Williams and Begun application, so that the pole faces of the double pole piece unit are exposed along the bottom region of the guide track into operative engagement with the record track moving thereover.

The deepest portion of the guide channel 2-13 between the pole faces of the two double pole piece units 2-15, 2-16 and their adjoining outer regions are formed by the arcuate surface portions of flat plate members 2-21, 2-22, 2-23 held clamped between the two outer wall members 2-12 of the transducer head. The two plate members 2-22, 2-23 may be formed of ceramic material, so that their edge surface shall provide a firm positive guide surface for the flat tape moving thereover toward and away from the pole face region of the two double pole piece units 2-15, 2-16 of the transducer head.

In the arrangement shown in Figs. 11 and 12, the supporting disc 25 is shown provided with a hollow shaft section 25-6 on which is seated the inner revolvable disc 29-5 and the upper stationary guide disc 29-6. The convolutions of the tape are confined in their position within the coil layer 30 by a circular cover plate 66-2 which is held in its position by a central supporting member 66-3 having a hole fitting over the shaft 25-6 and retained thereon by a head of a screw 25-8 threadedly engaging an inner threaded surface portion of the hollow shaft 25-6. The stationary surface member 29-6 is shown affixed to the supporting member 66-3 of the cover wall 66-2 as by a screw 66-4. The supporting wall member 66-2 is shown provided with three legs 66-9 which rest on supports 60-5 of the top wall 60-2 of the recording device. To prevent rotation of the cover wall 66-2, it is provided with two retainer projections 66-8 arranged for engagement with a latch arm 60-3 pivotally mounted on a bracket 60-4 affixed to the exposed top wall 60-2 of the device.

In the arrangement shown, the wall member 25-5 with the cover wall 66-2 are arranged to form a detachable tape coil holding unit which may be removed from its position shown by lifting it from the centering post 60-7 of a shaft member 60-8 suitably held within the cover wall member 60-2. In the arrangement shown, the center post 60-7 forms part of a turn table 60-9 arranged to be suitably driven by a turn table drive supported on the inner side of the cover wall 60-2.

The coil supporting disc 25-5 is also shown provided with a coupling hole 25-7 which is engaged with a coupling projection extending from the turn table 60-9 so that the rotation of the turn table is positively imparted to the tape coil supporting disc 25-5. The device of Figs. 11 and 12 may be operated so that the coil supporting disc 25-5 drives the tape through the transducer head while at the same time imparting to the tape coil convolutions of the coil 30 outward expanding forces tending to maintain the coil convolutions in loose condition.

If the tape coil does not have an excessive number of convolutions, and the tape surface has united thereto a layer of graphite, it will operate in a foolproof manner even if the coil supporting wall 25-5 is not driven with an overdrive, as long as provision is made to impart to the outermost tape coil convolution 30-7 outwardly expanding forces. Such outwardly expanding forces may be imparted to the outermost tape coil convolutions 30-7 by providing a rail 70-1 having two close-



15

ly spaced walls within which is confined the tape length 30—6 which is moving from the driven roller 37—2 toward the opening in the rim of the cover wall 66—2 through which it passes into the outer convolution of the tape coil 30 surrounding the center disc 29—5.

Fig. 13 illustrates another form of my invention in which the storage disc 25 is mounted on the base 26 and a plurality of coil convolutions are wound about the floating center portion 29, and a cross-over loop 35 of the record material passes to a fly-wheel 37 and then directly back to the storage disc 25. As in the previously described device, a cross arm 51 may be provided with a pin 50 to provide an open space 52, and have a slot 55. The open space 52 and the slot 55 allow the cross-over loop to rise rapidly as it passes to the top of the fly-wheel 37. The tape 30 may make several turns about the fly wheel and guide supports 53, 56 with guide fingers 54, 57 may be used to assure that each successive turn of the tape about the wheel will be at a slightly lower elevation. The fly wheel may be substantially the same as the wheel in Figs. 1 and 5, and have top and bottom flanges 59 and a plurality of slots 58 for the fingers 54, 57. A coupling wheel 39 may also be employed.

In the device of Fig. 13, the motor directly drives only the storage disc 25, and the storage disc frictionally drives the tape, and the tape frictionally drives the fly wheel 37 which is idling. It is to be understood, however, that the motor may drive only the fly wheel or that a direct motor drive can be applied to both the fly wheel and the storage reel in order that both will have direct motor drive. An obliterating head 44 is positioned adjacent to the path of the outgoing cross-over loop of tape 35 and is adapted to demagnetize or saturate the tape according to the particular process used. The recording and reproducing head is positioned close to one of the turns of tape about the fly wheel 37 and is indicated generally by the reference character 75. The preferred position of the head 75 may be best illustrated by the following examples although many other arrangements may be made. The transducer 75 is best positioned adjacent a portion of the tape which has uniform speed due to good frictional coupling to the fly wheel.

One of the features of my device is that the storage disc 25 and its associated fly wheel 37 and tape 30 may easily be made as a replaceable unit. For many uses it is valuable to have a tape which may be removed from the device and stored away for future reference or sent to some other part of the country for use by some other person. It is not always satisfactory to remove the tape 30 from the storage reel 25 as my device is capable of handling so much tape that when removed from the device it becomes awkward to handle.

Fig. 14 indicates in a general manner one way of removing the storage disc 25 and tape from the device. A drive disc 95 is provided on the shaft 96 and has one or more drive pins 97 which register with holes in the bottom of the storage disc 25. The rotatable shaft 28 of the storage disc 25 is separate from the drive shaft 96 which is driven by the motor 27. The tape 30 can be unwound from around the fly wheel 37, and the storage disc 25 lifted from the drive disc 95. The complete cartridge comprising storage disc 25, tape 30 and center disc 29, all in normal position, can now be removed as a unit. Means are provided so that cross-over loop 35 can be re-

16

moved from or replaced on the flywheel 37 with ease. In this manner the tape is easily taken off of the device and can easily be replaced on the device.

Fig. 15 indicates another type of device having a removable tape 30. The top plate 101 of the base 26 may be removed and the storage disc 25, fly wheel 37, tape 30 and associated transducer heads and guide fingers are removed with the top plate 101.

Fig. 16 shows how a plurality of storage discs 25 with their coiled tape may be arranged "in series" and driven from the same shaft 28. The tape 30 feeds from the inside of the lower disc 25a to the outside of disc 25b. From the inside of 25b the tape passes to the fly wheel and transducer heads and then back to the outside of the lower storage disc 25a.

Figs. 17 to 20 show different effective ways for lubricating the recording track of a magnetic recording device, such as described above, with a film of wet lubricant, such as oil, whenever such device is operated by qualified personnel who can be relied upon to keep it supervised.

Fig. 17 illustrates a method of oiling my device which is practical as it requires no servicing and does not create an oily mess which would be objectionable. The shaft 28 is adapted to be driven by the motor 27, and the storage disc 25 is connected to it by a force fit which causes the disc 25 to rotate as the shaft 28 turns. The magnetizable tape is coiled about center portion 29a which is concentric with the shaft 28, and a bearing 45 is provided between the shaft 28 and the disc 29a to allow the disc 29a to turn independently of the shaft 28 and the storage disc 25 at the will of the tape 30. In this respect, the device of Fig. 17 is similar to those heretofore described. However, in the device of Fig. 17, the disc 29a is shown made of a material impregnated with lubricant, such as "Oilite." The very slight amount of lubrication which the disc 29a deposits on the storage disc 25, and the slight amount of lubrication which the tape 30 derives from facial contact with the edge of the disc 29a is sufficient to provide lubrication for a long time, but is insufficient to give an oily mess.

Fig. 18 illustrates a lubricating device comprising a cup 76 having the oil soaked pads 77 between which the tape 30 passes. An oil spout 78 connected to an oil supply may be arranged to drip onto the pads, or an operator may periodically put a few drops of oil on the pads 77.

Fig. 19 illustrates an oiling device comprising a cup 76 which contains oil and two wicks 79. The tape 30 passes between and in contact with the upper portion of the wicks 79 and a small quantity of oil is wiped onto the tape 30. The wicks also serve to clean the tape of foreign matter, thereby maintaining the lubricating properties of clean oil.

Fig. 20 shows an oiling device in which the tape 30 is turned about 90° and passes under a roller 85 which is submerged in oil. The tape is then rotated back to its original position.

In Fig. 21, the tape storage disc 25 is tilted at an angle to cause the outer convolutions of the coiled tape 30 to dip into an oil reservoir.

Fig. 22 shows a directing fin 86 mounted on the bottom of the storage disc 25 and extending into an oil supply. Rotation of the disc 25 causes a small amount of oil to be splashed through the slit 87 onto the tape 30.

If a flat tape coil endless magnetic tape recorder is to operate in a broadcast studio or other places

where engineers and persons skilled in maintenance are in attendance, then oil lubricating devices such as shown in Figs. 17 to 22 may be used as they will operate for long periods of time without adjustment and without changing oil or clearing the tape. Eventually, however, the tape may need clearing due to the accumulation of dust, and the oil will need replenishing. The operators will know when and how to service the machine and it will not cause an undue amount of work.

For home use, however, one cannot depend upon the average householder to realize when a device needs service, or to service the device even if he realizes it needs some attention. Thus devices which are designed for use in the home should be as near foolproof as possible and they have to use a magnetic record tape having a layer of graphite united to the surface of the tape.

It will be apparent to those skilled in the art that the novel principles of the invention disclosed herein in connection with specific exemplifications thereof will suggest various other modifications and applications of the same. It is accordingly desired that in construing the breadth of the appended claims they shall not be limited to the specific exemplifications of the invention described herein.

I claim:

1. In a magnetic transducing apparatus for recording signals on or reproducing signals from a moving magnetic record track, the combination of: an endless magnetic tape part of which is spirally wound in a flat coil; said tape having a cross-over loop connecting the innermost convolution of the coil with the outermost convolution of the coil and so arranged that as the tape is withdrawn from one end of the coil into the cross-over loop it is returned to the other end of the coil from the cross-over loop the tape in each of the individual tape convolutions of the coil sliding past each other at different angular velocities and being subject to a tendency to cause frictional binding between the convolutions and undesired variation in the linear speed with which the tape slides along the convolutions; a supporting structure under the flat coil for holding the coil; guiding means including means for defining the path of the tape in the cross-over loop portion; magnetic record transducing means magnetically linked with a portion of the tape in the cross-over loop; said guiding means including impelling means in driving engagement with the tape in the return portion of the cross-over loop, and imparting thereto a velocity equal to the velocity with which the tape is withdrawn from the coil, and tape guide means extending from a position proximate the said impelling means to a position proximate the outer convolution of the coil, whereby said tape is actively urged on said coil so as to impart to at least the outer convolutions thereof outwardly expanding forces to decrease the frictional engagement between the convolutions to counteract the tendency of convolutions to bind; the tape having adherently united to its surface a thin coating of graphite-like lubricant further diminishing friction between convolutions and making possible a substantially constant linear speed of tape movement, the lubricant being maintained impacted in place by the sliding frictional engagement of the convolutions.

2. In a magnetic transducing apparatus for recording signals on and reproducing signals from a moving magnetic record track, the combination of: an endless metallic magnetic tape part of

which is spirally wound in a flat coil; said tape having a cross-over loop connecting the innermost convolution of the coil with the outermost convolution of the coil and so arranged that as the tape is withdrawn from one end of the coil into the cross-over loop it is returned to the other end of the coil from the cross-over loop the tape in each of the individual tape convolutions of the coil sliding past each other at different angular velocities subject to a tendency to cause frictional binding between the convolutions and undesired variation in the linear speed with which the tape slides along the convolutions; a supporting structure under the flat coil for holding the coil; guiding means including means for defining the path of the tape in the cross-over loop portion; magnetic record transducing means magnetically linked with a portion of the tape in the cross-over loop; said guiding means including impelling means positioned in the coil return portion of the cross-over loop having a surface in frictional engagement with the tape and having a surface velocity at least equal to the velocity of the tape in the coil withdrawing portion of the cross-over loop; tape lateral motion restraining means positioned between said impelling means and the said other end of the coil; said impelling means and said lateral motion restraining means exerting a pushing effect on the tape at the said other end of the coil whereby the tape is urged thereon to impart radially outwardly expanding forces to the convolutions of the coil for decreasing the frictional engagement between the convolutions to counteract the tendency of the convolutions to bind; the tape having adherently united to its surface a thin coating of graphite lubricant further diminishing friction between convolutions and making possible a substantially constant linear speed of tape movement, the lubricant being maintained impacted in place by the sliding frictional engagement of the convolutions.

3. In a magnetic transducing apparatus for recording signals on or reproducing signals from a moving magnetic record track, the combination of: an endless magnetic tape part of which is spirally wound in a flat coil; said tape having a cross-over loop connecting the innermost convolution of the coil with the outermost convolution of the coil and so arranged that as the tape is withdrawn from one end of the coil into the cross-over loop it is returned to the other end of the coil from the cross-over loop the tape in each of the individual tape convolutions of the coil sliding past each other at different angular velocities tending to cause frictional binding between the convolutions and undesired variation in the linear speed with which the tape slides along the convolutions; a supporting structure under the flat coil engaging the lower edges of the coil convolutions and holding the coil; guiding means for leading the tape across the cross-over loop portion; magnetic record transducing means magnetically linked with a portion of the tape in the cross-over loop; impelling means connected to the said supporting structure independently of the tape for rotating the supporting structure at an angular velocity at least as high as that of the innermost convolution for imparting radially outwardly expanding forces to the convolutions of the coil to decrease the frictional engagement between the convolutions and substantially diminish the tendency of convolutions to bind; the tape having adherently united to its surface a thin coating of a graphite lubricant further diminishing friction between convolutions and



making possible a substantially constant linear speed of tape movement, the lubricant being maintained impacted in place by the sliding frictional engagement of the convolutions.

4. In a magnetic transducing apparatus for recording signals on and reproducing signals from a moving magnetic record track, the combination of: an endless metallic magnetic tape part of which is spirally wound in a flat coil; said tape having a cross-over loop connecting the innermost convolution of the coil with the outermost convolution of the coil and so arranged that as the tape is withdrawn from one end of the coil into the cross-over loop it is returned to the other end of the coil from the cross-over loop the tape in each of the individual take convolutions of the coil sliding past each other at different angular velocities tending to cause frictional binding between the convolutions and undesired variation in the linear speed with which the tape slides along the convolutions, a supporting structure under the flat coil engaging the lower edges of the coil convolutions and holding the coil; guiding means including means for leading the tape across the cross-over loop portion; magnetic record transducing means magnetically linked with a portion of the tape in the cross-over loop; and impelling means connected to the said supporting structure independently of the tape for rotating the supporting structure for imparting radially outwardly expanding forces to the convolutions of the coil to decrease the frictional engagement between the convolutions and substantially diminish the tendency of convolutions to bind; said guiding means also including lubricating means comprising a graphite tape-contacting surface.

5. In a magnetic recording or reproducing apparatus: an endless magnetic recording tape; a center disc about which said tape is spirally wound in a coil with overlapping coil convolutions arranged in a layer, and said tape having a cross over loop connecting the inner tape convolution to the outer tape convolution; guide means for guiding and impelling the elements of said tape along the path of its coil convolutions in the direction from the inner convolution through the cross over loop toward the outer convolution, magnetic signal transducing means located along the path of motion of and in engagement with said tape for magnetically recording or reproducing signals; and separating means positioned between the innermost tape convolution and the second innermost tape convolution substantially adjacent the point where the innermost tape convolution leaves the center disc.

6. In a magnetic recording or reproducing device: a fly wheel; means for driving said fly wheel; and endless record material in engagement with and adapted to be driven solely by said fly wheel; a single storage reel upon which much of said record material is adapted to be spirally wound in a coil with overlapping coil convolutions, said record material having a cross over loop connecting the inner and outer coil convolutions and being adapted to move from the inner coil convolution through the cross over loop to the outer coil convolution; and means separating said innermost tape convolution from the next adjacent tape convolution before said inner tape convolution passes into said cross over loop.

7. In a magnetic recording or reproducing apparatus: an endless magnetic tape spirally wound in a coil with overlapping coil convolutions arranged in a layer and having a cross over loop

connecting the inner tape convolution to the outer tape convolution; means for impelling said tape in the direction from the inner convolution through the cross over loop toward the outer convolution; signal transducing means associated with said cross over loop of tape for recording or reproducing signals; and means in engagement with and held stationary with respect to said tape for causing the innermost tape convolution to be separated from the next adjacent tape convolution before said inner tape convolution passes into said cross over loop.

8. In a magnetic recording or reproducing apparatus: an endless magnetic recording tape; a center disc about which said tape is spirally wound in a coil with overlapping coil convolutions arranged in a layer, and said tape having a cross over loop connecting the inner tape convolution to the outer tape convolution; means for guiding and impelling the elements of said tape along the path of its coil convolutions in the direction from the inner convolution through the cross over loop toward the outer convolution, magnetic signal transducing means located along the path of motion of and in engagement with said tape for magnetically recording or reproducing signals; and a fly wheel, said tape being coupled to said fly wheel by being wrapped around said fly wheel a plurality of times, and means for separating the turns of tape about the fly wheel.

9. In a magnetic recording or reproducing apparatus: an endless magnetic recording tape; a center disc about which said tape is spirally wound in a coil with overlapping coil convolutions arranged in a layer, and said tape having a cross over loop connecting the inner tape convolution to the outer tape convolution; guiding means for guiding and impelling the elements of said tape along the path of its coil convolutions, said center disc being frictionally coupled to and rotatable relative to said guide means; a fly wheel frictionally coupled to said cross over loop of tape to establish in a portion of the tape substantially constant motion, the frictional forces coupling said fly wheel to said tape being greater than the frictional forces coupling said center disc to said guiding means; means independent of the tape for driving the guiding means; and magnetic signal transducing means located along the path of motion of and in engagement with the portion of said tape which has substantially constant motion for magnetically recording or reproducing signals.

10. In a magnetic recording or reproducing apparatus: a guiding and driving plate; an endless magnetic tape in engagement with said guiding plate and spirally wound in a coil with overlapping coil convolutions arranged in a layer, and said tape having a cross over loop connecting the inner tape convolution to the outer tape convolution; a fly wheel; said cross over loop having a first and a second portion coupled to said fly wheel and a third portion located between said first and said second coupled portions; a pivot wheel; said third portion of said cross over loop being coupled to said pivot wheel; and magnetic signal transducing means associated with said third portion of said cross over loop.

11. In a magnetic recording or reproducing apparatus: an endless magnetic tape spirally wound in a coil with overlapping coil convolutions arranged in a layer and having a cross over loop connecting the inner tape convolution to the outer tape convolution; means for impelling said tape; signal transducing means associated with said

cross over loop of tape for recording or reproducing signals; and spacing means held stationary with respect to said tape means and adapted to separate adjacent coil convolutions to keep peak values of interfacial friction down to a normal value.

12. In a magnetic recording or reproducing apparatus: an endless magnetic tape; center means about which said tape is spirally wound in a coil with overlapping coil convolutions arranged in a layer; said tape having a cross-over loop connecting the inner tape convolution to the outer tape convolution; means for guiding and impelling the elements of said tape along the path of its coil convolutions in the direction from the inner convolution through the cross-over loop toward the outer convolution; a fly wheel; said cross-over loop being wound about said fly wheel a plurality of times and having a loop extending away from and out of contact with said fly wheel and then extending toward and into contact with said fly wheel; both ends of said loop being coupled to said fly wheel whereby the motion of said loop is controlled by said fly wheel; and magnetic signal transducing means in flux linkage relationship with said fly wheel controlled loop portion of the cross-over loop.

13. In a magnetic record transducing device for transducing magnetic records, such as recording or reproducing magnetic signals by magnetic flux interlinkage between a magnetic transducer head and elements of a relatively moving magnetic record track: a long flexible magnetic record track; guide means for guiding and storing said record track in spirally coiled form and causing an intermediate track section of said record track to move past said transducing head for establishing magnetic flux interlinkage with successive elements of said track; said guide means comprising constant speed drive means including a revolvably mounted circular fly wheel member and at least one additional revolvably mounted circular guide member; said fly wheel member and said guide member having each a circular periphery engaged by the intermediate track length of said record track; said guide means being arranged to maintain at least two spaced portions of a track length of said track section in engagement with portions of the circular periphery of said fly wheel member for maintaining said intermediate track length at a substantially constant speed; said transducer head being operatively engaged by said intermediate track length.

14. In a magnetic record transducing device for transducing magnetic records, such as recording or reproducing magnetic signals by magnetic flux interlinkage between a magnetic transducer head and elements of a relatively moving magnetic record track: a long flexible magnetic record track; guide means for guiding and storing said record track in spirally coiled form and causing

an intermediate track section of said record track to move past said transducing head for establishing magnetic flux interlinkage with successive elements of said track section; said guide means comprising constant speed drive means including a revolvably mounted circular fly wheel member and at least one additional revolvably mounted circular guide member; said fly wheel member and said guide member having each a circular periphery engaged by the intermediate track length of said record track; said guide means being arranged to maintain at least two spaced portions of a track length of said track section in engagement with portions of the circular periphery of said fly wheel member for maintaining said intermediate track length at a substantially constant speed; said fly wheel member being driven and said transducer head being operatively engaged by said intermediate track length.

15. In a magnetic record transducing device for transducing magnetic records, such as recording or reproducing magnetic signals by magnetic flux interlinkage between a magnetic transducer head and elements of a relatively moving magnetic record track: a long flexible magnetic record track; guide means for guiding and storing said record track in spirally coiled form and causing an intermediate track section of said record track to move past said transducing head for establishing magnetic flux interlinkage with successive elements of said track section; said guide means comprising constant speed drive means including a revolvably mounted circular fly wheel member and at least one additional revolvably mounted circular guide member; said fly wheel member and said guide member having each a circular periphery engaged by the intermediate track length of said record track; said guide means being arranged to maintain at least two spaced portions of a track length of said track section in engagement with portions of the circular periphery of said fly wheel member for maintaining said intermediate track length at a substantially constant speed; said fly wheel member being driven, said additional circular member being an idler, and said transducer head being operatively engaged by said intermediate track length.

HARRY B. MILLER.

#### REFERENCES CITED

The following references are of record in the file of this patent:

#### UNITED STATES PATENTS

| Number    | Name     | Date          |
|-----------|----------|---------------|
| 1,462,855 | Gerleman | July 24, 1923 |
| 2,004,386 | Wherly   | June 11, 1935 |
| 2,013,120 | Wellcome | Sept. 5, 1935 |
| 2,158,721 | Jackson  | May 16, 1939  |
| 2,199,493 | Johnson  | May 7, 1940   |
| 2,288,983 | Weiss    | July 7, 1942  |