

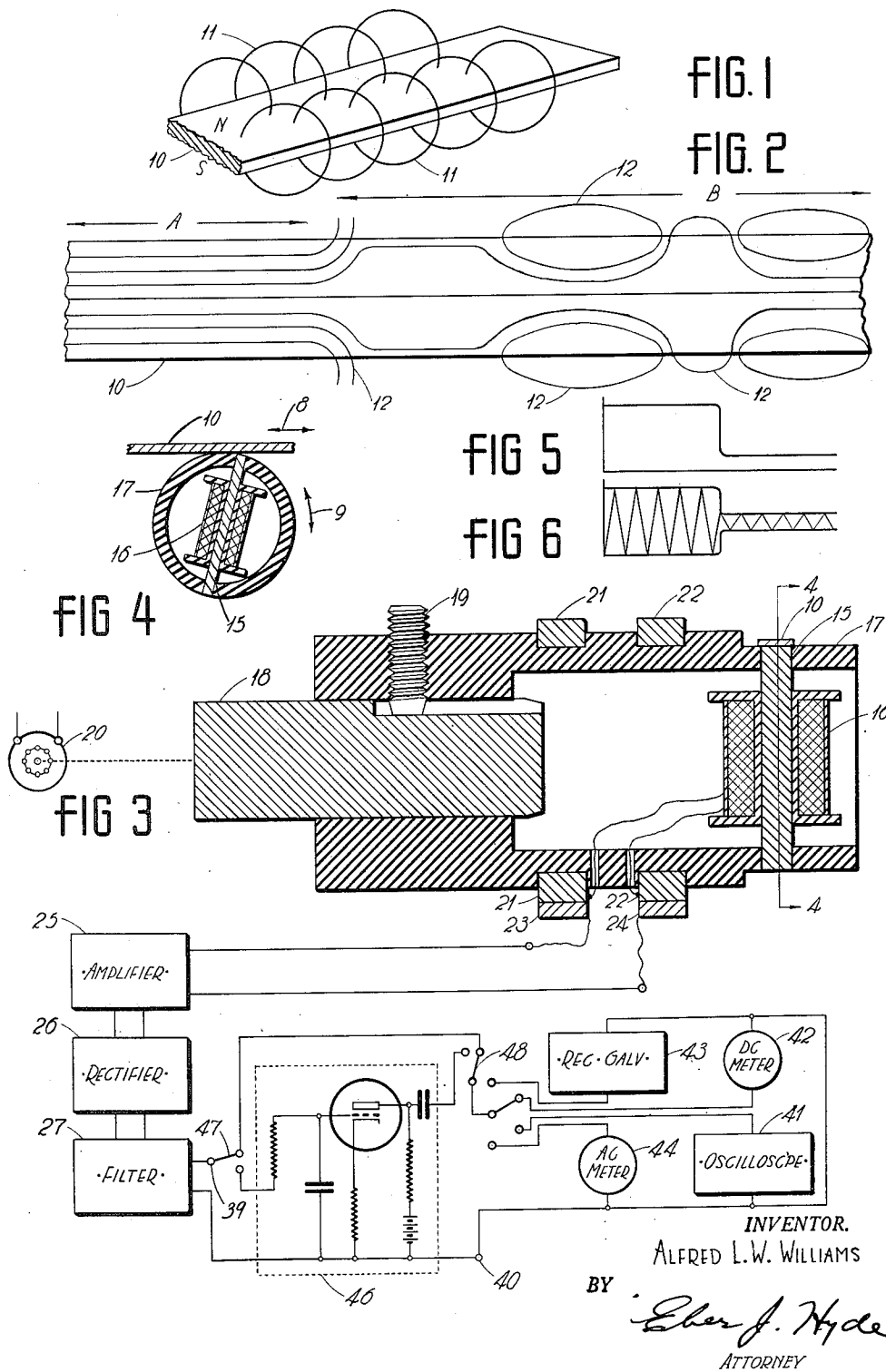
July 22, 1947.

A. L. W. WILLIAMS

2,424,295

ROTATABLE MAGNETIC REPRODUCING MEANS

Filed July 21, 1943



UNITED STATES PATENT OFFICE

2,424,295

ROTATABLE MAGNETIC REPRODUCING
MEANS

Alfred L. W. Williams, Cleveland Heights, Ohio,
assignor to The Brush Development Company,
Cleveland, Ohio, a corporation of Ohio

Application July 21, 1943, Serial No. 495,792

6 Claims. (Cl. 179—100.2)

1

My invention pertains to magnetic reproducing means and systems and more particularly to reproducing heads for reproducing a magnetic signal from a magnetized material.

An object of my invention is to provide a new and improved magnetic reproducing system and head for use therewith.

Another object of my invention is to provide a magnetic pickup for reproducing a signal having a useful relationship to low frequency and direct current signals.

A further object of my invention is to provide a moving magnetic reproducing head.

Other objects and a fuller understanding of my invention may be had by referring to the following description and claims in conjunction with the drawings.

Briefly, my invention comprises a magnetic pickup and system for scanning a material upon which a signal has previously been magnetically recorded in such a manner that leakage flux exists outside of the material; and the pickup includes means such as a coil in flux linkage relationship to the existing leakage field and means such as mechanical means for varying in a predetermined manner the flux linking the coil. The pickup is adapted to cooperate with the magnetic material while the material is either moving or stationary with respect to the pickup; and under certain circumstances when the material is moving a carrier signal amplitude modulated by the recorded signal results.

A preferred mode of practicing my invention is shown in detail in the accompanying drawings in which:

Figure 1 illustrates a direct current magnetic signal recorded on a short length of magnetizable material by the perpendicular method of recording, and shows the external or leakage flux field which exists outside of the magnetizable material.

Figure 2 illustrates a direct current magnetic signal and an alternating current magnetic signal recorded on a short length of magnetizable material by the longitudinal method of recording, and shows the external or leakage flux field which exists outside of the magnetizable material due to the alternating current magnetic signal.

Figure 3 is a sectional view of my magnetic reproducing head, showing a circuit which may be used with it.

Figure 4 is a smaller sized view of my magnetic reproducing head, partially in section along line 4—4 of Figure 3.

2

Figure 5 illustrates an external or leakage flux field, and

Figure 6 graphically illustrates the action of my head in generating a signal corresponding to the flux field shown in Figure 5.

In the art of magnetic recording and reproducing it has been possible to record low frequency and direct current magnetic signals on a magnetizable material, but due to the low frequency limitation which has been present in reproducing heads it has not been possible to reproduce the recorded signal.

This low frequency limitation arises from the fact that in the generation of electricity by cutting a coil with magnetic flux, the voltage produced is proportional to the rate of change of the flux through the coil. Accordingly, in a magnetic signal reproducing system in which magnetic flux threads a coil in a reproducing head, there must be sufficient change in the amount of the flux through the coil to generate a useful voltage. When the change of flux is insufficient then the signal output from the reproducing head is insufficient. If the magnetic signal recorded on the signal storage material is an alternating one, and the magnetized material passes a reproducing head at a sufficient rate of speed, then the magnetic flux threading the coil of the reproducing head will change sufficiently to establish a usable voltage across the output of the coil. If, however, the speed of the magnetized material past the reproducing head were decreased, or if the signal which is recorded on the material were a low frequency signal, then the rate of change of flux through the reproducing head coil might not be great enough to produce a usable voltage output. Accordingly, it will be realized that for a given speed of the magnetized material past the reproducing head, and a given strength of recording there will be a critical frequency, and that recorded frequencies higher than the critical frequency can be successfully reproduced, and that recorded frequencies lower than the critical frequency cannot be successfully reproduced. In the past this low frequency limitation has meant that for a given reproducing system there has been a point in the frequency range below which satisfactory reproduction cannot be made.

In the application of S. J. Begun, Serial Number 399,909, filed June 26, 1941, he shows and describes a means and method for reproducing signals of frequencies below the above mentioned critical frequency and extending down to zero frequency or D. C. signals, utilizing a signal modulated alternating carrier current; but this

3

method requires special recording means for recording the signal modulated carrier on the magnetizable material. In my present invention, I provide means for reproducing a signal which bears a useful relationship to the signals (including low frequency or direct current signal) which have been recorded by conventional recording means.

My new reproducing head is well suited for co-operation with a material such as a tape or wire upon which a signal has previously been recorded by magnetic recording means. My reproducing head differs from the usual reproducing head in that the output from the head is substantially independent of the velocity of the tape. This feature of my new reproducing head makes it possible to examine the flux condition on a recorded material such as tape or wire with the material moving slowly with respect to the head, and when a particularly interesting part of the recording is approached, the recording medium may be stopped and individual points examined with greater care. My system is also effective when the tape or wire is moving rapidly with respect to the reproducing head thereby causing a succession of points on the tape to be examined in succession, in which case, as is explained more fully later, the output from the head is a signal modulated carrier.

My reproducing head is effective with the types of magnetic recording which exhibit external leakage flux or flux lines which are outside of the magnetized material. Two of these types of recording are shown in Figures 1 and 2.

In Figure 1 there is shown a magnetizable material 10 in the form of a length of tape, and there has been recorded on the tape 10 a direct current magnetic signal. This signal has been recorded by the perpendicular method of magnetic recording which, for the polarity of the signal used, has resulted in the top surface having a north magnetic polarity, and the underneath surface having a south magnetic polarity.

In the perpendicular method of magnetic recording two recording head pole pieces are positioned on opposite sides of the material to be magnetized, and are aligned with respect to each other. Flux passing from one pole piece to the other pole piece goes through the magnetizable material in a direction perpendicular to the line or plane of the magnetizable material.

Flux lines exist through the tape 10 between the top and bottom surfaces, and these flux lines must close on themselves through the air. These flux lines are indicated by the reference character 11 and constitute an external leakage flux field. An alternating magnetic signal which has been recorded by the perpendicular method will also have external leakage flux, but the flux will vary in strength from point to point substantially in accordance with the signal that caused the flux to be recorded.

Figure 2 is an edge view of a small piece of magnetized tape and illustrates the longitudinal type of magnetic recording.

In the longitudinal method of magnetic recording two recording head pole pieces are positioned on opposite sides of the material to be magnetized, and are slightly off-set with respect to each other in a direction in which the magnetizable material is adapted to move. Flux passing from one pole piece to the other pole piece goes through the magnetizable material at an angle other than 90 degrees to the line or plane of the magnetizable material, and the flux

4

through the material will have a component in a direction which is substantially parallel to the direction in which the magnetizable material is adapted to move.

On the portion of the tape marked "A," a direct current signal has been recorded and no external leakage flux lines exist outside of the tape. On the portion of the tape marked "B," however, which diagrammatically illustrates the flux distribution in the tape caused by an alternating magnetic flux field, there exists outside of the tape external leakage flux represented by the reference character 12.

My system is operable with all recordings which have leakage flux, and may be used to reproduce a signal bearing a useful relation to signals of any frequency which have been recorded on the magnetizable material by using alternating current, direct current, or unidirectional current. The term unidirectional current includes not only direct current but a direct current (bias) upon which has been superimposed an alternating signal.

A well-known type of magnetic recording and reproducing system utilizes this unidirectional current. In this system the magnetic tape is prepared for a record by saturating the tape. Then a signal current comprised of a polarizing current (D. C.) of a polarity opposite the polarity of the saturating current and upon which is superimposed an alternating current which is to be recorded, is applied to the recording head which is associated with the tape. The value of the D. C. polarizing current may be chosen so that in the absence of an alternating signal current superimposed on the polarizing current, the flux induced in the tape will be sufficient to bring the tape to a substantially non-magnetized condition.

Figures 3 and 4 illustrate one embodiment of my magnetic reproducing head which comprises a pole piece or core of magnetic flux conductive material 15 about which is wound a coil 16 which may be formed of many turns of fine wire. The core and coil are mounted in a holder 17 which is formed of some non-magnetic material such as "Bakelite," and the holder 17 is suitably mounted on a shaft 18 as by means of set-screw 19. Means is provided to move the previously magnetized material such as tape 10 in either of the directions indicated by the arrow 8 and to engage the holder 17 at the location where the holder is round. The pole piece extends through the round portion of the holder 17 at two points for contact with the tape, and the holder is adapted to be rotated in either of the directions indicated by the arrow 9 by means of a motor 20 or other such device. The holder 17 is provided with two slip rings 21 and 22 to which are connected the output wires from the coil 16, and two stationary brushes 23 and 24 are provided in engagement with the rings 21, 22, which may be connected to an outside circuit. As the holder rotates with respect to the tape 10 the core and the coil are rotated and first one end of the core comes into engagement with the tape 10 and then the other end. If the tape is not moving then the same point on the tape will be repeatedly examined by the pickup head, and if the tape is moving then successive points on the tape will be examined.

If there has been recorded on the magnetic material a magnetic signal which, at the moment under consideration, has leakage flux at the point where the tape touches the holder 17, the rotating core passes through the external magnetic field and there will be induced in the coil 16 an

electromotive force. This electromotive force is substantially proportional to the external flux at the point of investigation.

My magnetic reproducing system may be likened to a two pole alternating current generator, the rotating head corresponding to the armature of the generator. In place of the usual generator field structure I use the recorded magnetic tape 10 so that the field excitation depends on the strength of the leakage flux at the particular point contacted by the rotating head. As in an alternating current generator the magnitude of the output voltage of my reproducing head depends on the number of turns of wire in the coil 16, the strength of flux threading through the coil and the rate of rotation of the coil. The frequency of the alternating voltage in cycles per second is equal to the number of complete rotations of the head per second. As in an alternating current generator my reproducing head may be provided with a plurality of pairs of pole pieces, and a plurality of coils of wire connected in series or parallel in which case the frequency of the generated voltage would be equal to one-half the number of poles multiplied by the number of rotations per second.

By longitudinally moving either the head or the tape with respect to the other at a rate which is slow with respect to the rate of rotation of the head, the external leakage flux of successive points of the tape will induce in the rotating head an alternating voltage, the amplitude of which will correspond to the magnitude of the external flux, and the frequency of which will be entirely a function of the rate of rotation of the head. Therefore, a modulated carrier frequency results in which the envelope curve is directly related to the magnitude of the leakage flux at successive points on the tape.

Figure 5 graphically illustrates an existing external leakage flux condition of a portion of recorded tape, and Figure 6 graphically illustrates a signal modulated carrier which results from scanning this existing external leakage flux with my rotating reproducing head. In Figure 6 the alternating carrier results from rotating the reproducing head, and the peak amplitude of each cycle of the carrier is related to the magnitude of the leakage flux field at the point where the rotating pole piece contacted it.

In perpendicular recording the leakage flux has over a given intensity range a linear relation to the impressed signal.

In longitudinal recording the magnitude of the external flux is proportional to the rate of change of the magnitude of the impressed signal. Thus the envelope curve of the reproduced carrier frequency, if a perpendicularly recorded signal is reproduced, is directly proportional to the impressed signal, and if a longitudinally recorded signal is reproduced the reproduced carrier signal must be integrated to be directly proportional to the impressed signal.

A circuit for demodulating the carrier signal is connected to the brushes 23, 24, and comprises an amplifier 25, a rectifier 26, and a filter 27; and the demodulated output consisting substantially only of a facsimile of the recorded signal is obtained between the output terminals 39, 40.

When my reproducing head is used with this circuit and a magnetic tape on which a signal has been recorded by either the perpendicular or the longitudinal method, the output at terminals 39, 40 will be proportional to the external field linking the playback head. For perpendicular re-

cording, as has been pointed out, the external field is proportional to the impressed signal and therefore the output at terminals 39, 40 will be proportional to the impressed signal. For longitudinal recording the external field is proportional to the rate of change of the impressed signal, and, accordingly, the output at terminals 39, 40 will be proportional to the rate of change of the impressed signal.

It should be realized that it is possible to have the tape moving at one speed during recording and at a different speed during reproduction. The frequency of the signal at the output appearing between terminals 39, 40 therefore depends not only on the frequency of the signal originally recorded but also on the speed of the tape during playback in relation to the speed during recording. If the speeds are the same, the frequencies will be the same. If the playback speed is, for example, at $1/100$ of the recording speed, then the playback frequency will be $1/100$ of the recorded frequency.

In Figure 3 I have shown a cathode ray oscillograph, a zero center D. C. meter, a recording galvanometer, and an A. C. meter, selectable by means of a four-position switch. I have also shown an integrating network and amplifier 46 which may be cut into or out of the circuit by means of switches 47, 48. The zero center D. C. meter 42 is most useful when the tape is moved slowly enough so that the meter can accurately follow the variations in output and so that the observer can write down the various readings. A plot of the readings of this meter will be substantially a plot of the original recorded signal if the perpendicular recording method was used. It will be substantially a plot of the differential of the original signal if the longitudinal method was used. In the latter case the curve may be integrated by well-known means to obtain a picture of the original signal.

The recording galvanometer 43 obviates the necessity for plotting individual meter readings and if it is a high speed type, such as is shown and described in Gravley et al. Patent 2,244,690, dated June 10, 1941, then an accurate plot of the original signal or the differential thereof, as the case may be, may be obtained with much greater tape speeds than in the case of the D. C. meter.

If the tape speed is sufficiently high so that the lowest frequency appearing at terminals 39, 40 is about one cycle per second or higher, then the integrating network and auxiliary amplifier 46 may be switched into the circuit for playing back signals recorded by the longitudinal method, in which case the curve traced by the recording galvanometer will be substantially a facsimile of the original recorded signal.

If the signal appearing between terminals 39, 40 contains only relatively high frequency components, then the cathode ray oscillograph 41 may advantageously be employed for observing the signal. In this case the integrating network would also be used if the original signal were recorded by the longitudinal method.

If it is only desired to determine the peak or average or R. M. S. value of the recorded signal, then a suitable alternating current meter 44 may be employed with or without the integrating network, depending on the recording method. The tape speed must be high enough and the time constant of the meter long enough so that the meter will not tend to follow individual cycles of the playback wave.

Although I have described my in-

certain degree of particularity, it is to be understood that numerous changes in the details and parts of the illustrated device can be made without departing from the spirit and scope of my invention. Such changes, for example, as using a commutator instead of the slip rings 21, 22, in which case the output from the head would be a unidirectional signal, thereby making it unnecessary to use a rectifier; and the pole piece of the reproducing head need not rotate with respect to the tape but may oscillate with respect to it.

I claim as my invention:

1. In a magnetic reproducing system for reproducing records corresponding to a signal-time sequence and magnetically recorded on a permanently magnetizable record track as variations of magnetic flux along the length of the record track: a record reproducing device including a mounting structure having an exposed surface and movably mounted for contact between its exposed surface and the record track; a magnetic core element secured to the mounting structure and having exposed portions for magnetic linkage with the record track contacting the exposed surface of the mounting structure; windings interlinked with said core element; actuating means for moving said mounting structure with respect to the record track so that the mounting structure and core element move through predetermined cycles as successive portions of said record track are brought into magnetic linkage with said core element for inducing in said windings an electric output corresponding to the cycles of core element movement modulated by the magnetic flux variations; and demodulating means for separating the modulating flux variations from the output of the windings.

2. In a magnetic reproducing system for reproducing records corresponding to a signal-time sequence and magnetically recorded on a permanently magnetizable record track as variations of magnetic flux along the length of the record track: a record reproducing device including a mounting structure having an exposed surface and rotatably mounted for contact between its exposed surface and the record track; a magnetic core element secured to the mounting structure and having exposed portions for magnetic linkage with the record track contacting the exposed surface of the mounting structure; windings interlinked with said core element; actuating means for moving said mounting structure with respect to the record track so that the mounting structure and core element move through predetermined cycles as successive portions of said record track are brought into magnetic linkage with said core element for inducing in said windings an electric output corresponding to the cycles of core element movement modulated by the magnetic flux variations; and rectifying means for converting the output of the windings to a rectified output whose envelope corresponds to the recorded flux variations.

3. In a magnetic reproducing system for reproducing records corresponding to a signal-time sequence and magnetically recorded on a permanently magnetizable record track as variations of magnetic flux along the length of the record track: a record reproducing device including a mounting structure having an exposed surface and movably mounted for contact between its exposed surface and the record track; a magnetic core element secured to the mounting structure

and having exposed portions for magnetic linkage with the record track contacting the exposed surface of the mounting structure; windings interlinked with said core element; actuating means for moving said mounting structure with respect to the record track so that the mounting structure and core element move through predetermined cycles as successive portions of said record track are brought into magnetic linkage with said core element for inducing in said windings an electric output corresponding to the cycles of core element movement modulated by the magnetic flux variations; and rectifying means for converting the output of the windings to a rectified output whose envelope corresponds to the recorded flux variations.

4. In a magnetic reproducing system for reproducing records corresponding to a signal-time sequence and magnetically recorded on a permanently magnetizable record track as variations of magnetic flux along the length of the record track: a record reproducing device including a mounting structure having an exposed surface and movably mounted for contact between its exposed surface and the record track; a magnetic core element secured to the mounting structure and having exposed portions for magnetic linkage with the record track contacting the exposed surface of the mounting structure; windings interlinked with said core element; actuating means for moving said mounting structure with respect to the record track so that the mounting structure and core element move through predetermined cycles as successive portions of said record track are brought into magnetic linkage with said core element for inducing in said windings an electric output corresponding to the cycles of core element movement modulated by the magnetic flux variations; and demodulating means for separating the modulating flux variations from the output of the windings.

5. In a magnetic reproducing system for reproducing records corresponding to a signal-time sequence and magnetically recorded on a permanently magnetizable record track as variations of magnetic flux along the length of the record track: a record reproducing device including a mounting structure having an exposed surface and movably mounted for contact between its exposed surface and the record track; a magnetic core element secured to the mounting structure and having exposed portions lying in the exposed surface of the mounting structure for magnetic linkage with the record track contacting the exposed surface of the mounting structure; and windings interlinked with said core element; actuating means for moving said mounting structure and magnetic core with respect to the record track so that the core element moves through predetermined cycles as successive portions of said record track are brought into magnetic linkage with said core element for inducing in said windings an electric output corresponding to the cycles of core element movement modulated by the magnetic flux variations; and demodulating means for separating the modulating flux variations from the output of the windings.

6. In a magnetic reproducing system for reproducing records corresponding to a signal-time sequence and magnetically recorded on a permanently magnetizable record track as variations of magnetic flux along the length of the record track: a record reproducing device including a non-magnetic mounting structure having an

exposed surface and movably mounted for contact between its exposed surface and the record track; a magnetic core element secured to the mounting structure and having exposed portions lying in the exposed surface of the mounting structure for magnetic linkage with the record track contacting the exposed surface of the mounting structure; and windings interlinked with said core element; actuating means for moving said mounting structure and magnetic core with respect to the record track so that the core element moves through predetermined cycles as successive portions of said record track are brought into magnetic linkage with said core element for inducing in said windings an electric output corresponding to the cycles of core ele-

ment movement modulated by the magnetic flux variations; and demodulating means for separating the modulating flux variations from the output of the windings.

ALFRED L. W. WILLIAMS.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,245,286	Marzocchi -----	June 10, 1941
2,170,751	Gabrilovitch -----	Aug. 22, 1939
1,892,826	Bettison -----	Jan. 3, 1933
2,382,743	Penther -----	Aug. 14, 1945