MAGNETIC PICK-UP HEAD

Filed Aug. 16, 1955 3 Sheets-Sheet 1

Fig. 1

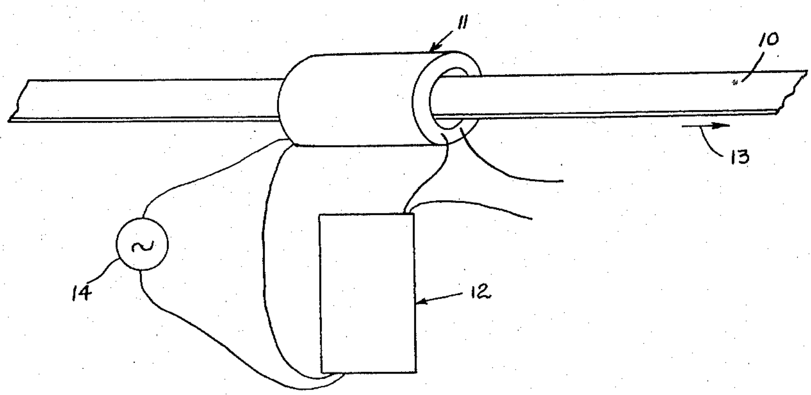


Fig. 2

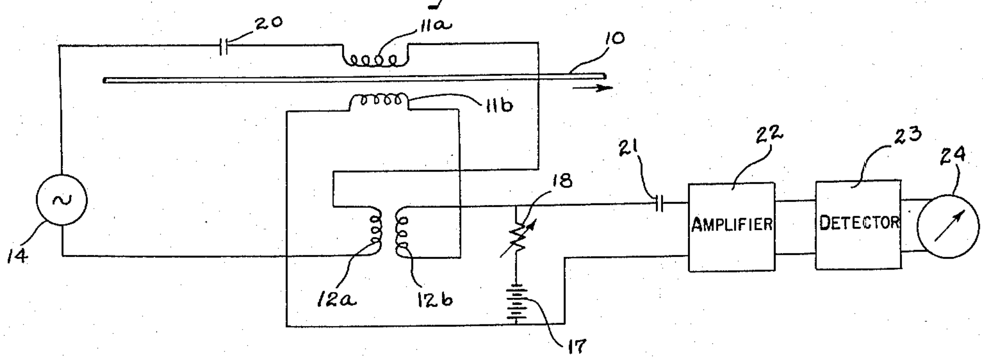
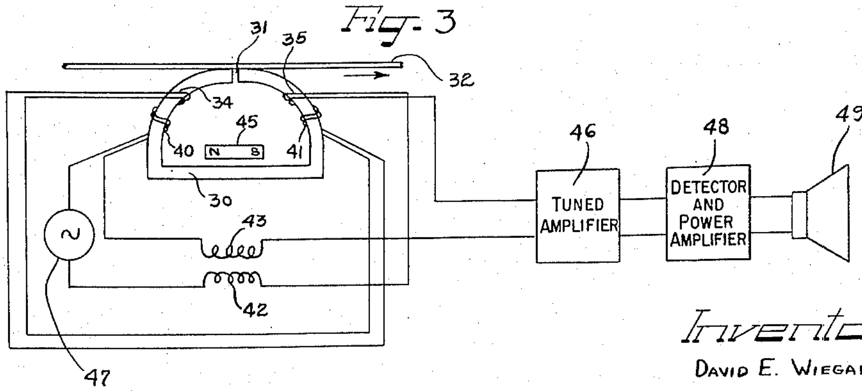


Fig. 3



Inventor
David E. Wiegand

by Hill, Sherman, Meroni, Gross & Simpson Attys.

Dec. 22, 1959 D. E. WIEGAND 2,918,535

MAGNETIC PICK-UP HEAD

Filed Aug. 16, 1955 3 Sheets-Sheet 2

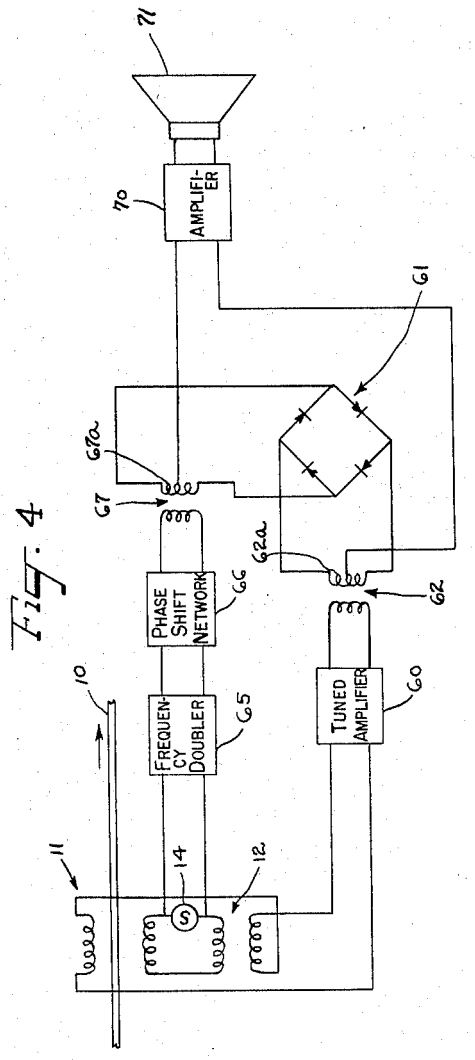


Fig. 4

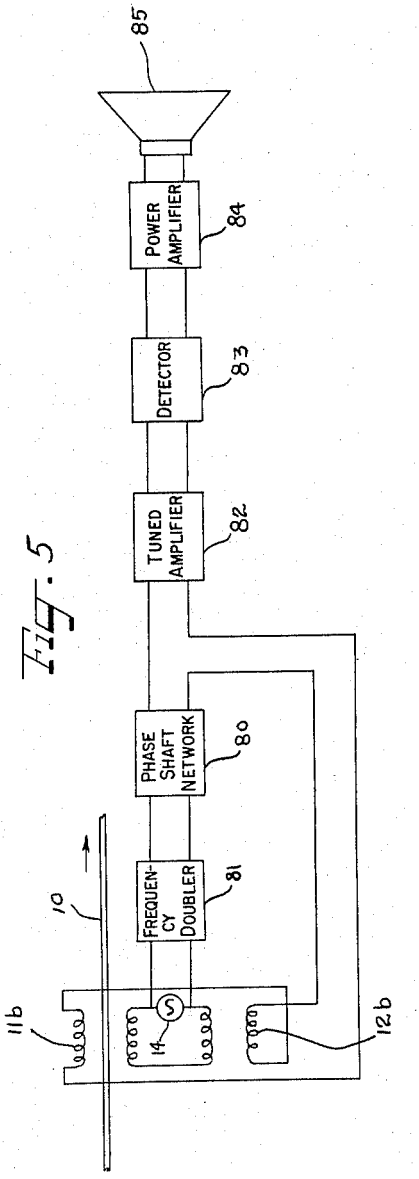


Fig. 5

Inventor
DAVID E. WIEGAND

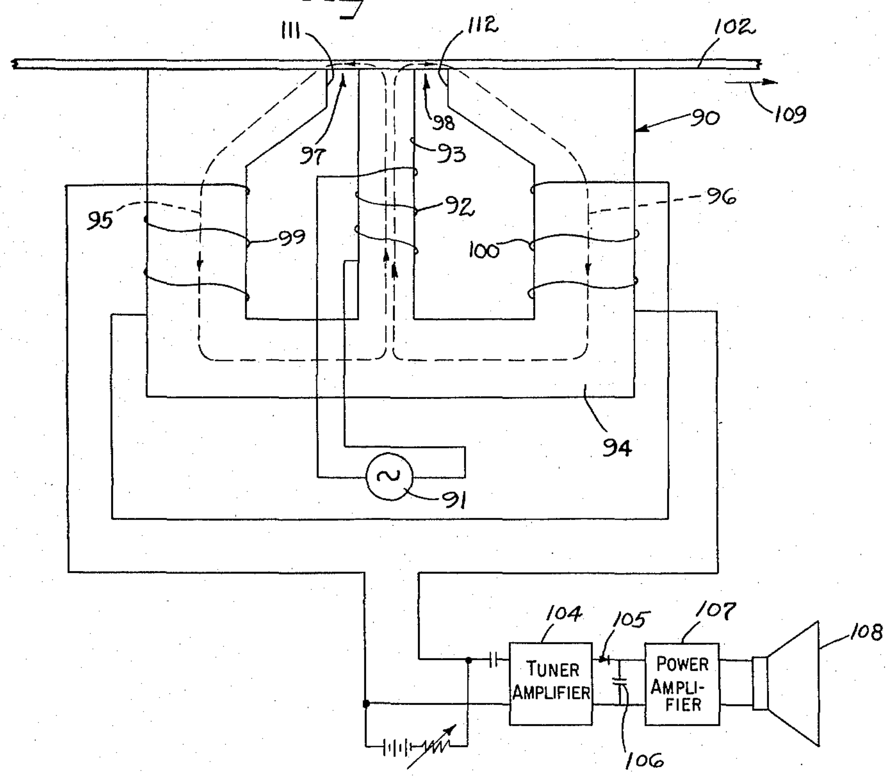
by Hill, Sherman, Meroni, Gross & Simpson Attys.

Dec. 22, 1959 D. E. WIEGAND 2,918,535

MAGNETIC PICK-UP HEAD

Filed Aug. 16, 1955 3 Sheets-Sheet 3

Fig. 6



Inventor
David E. Wiegand
by Hill, Sherman, Meroni, Gross & Simpson
Attys.

United States Patent Office 2,918,535 Patented Dec. 22, 1959

2,918,535

MAGNETIC PICK-UP HEAD

David E. Wiegand, Villa Park, Ill., assignor to Armour Research Foundation of Illinois Institute of Technology, Chicago, Ill., a corporation of Illinois

Application August 16, 1955, Serial No. 528,697

7 Claims. (Cl. 179—100.2)

This invention relates to a magnetic playback head and method of reproducing magnetically recorded signals, and more particularly to such a method and means operating in response to the internal magnetization of the record medium rather than in response to the external leakage flux.

It is an important object of the present invention to provide a novel method and means for reproducing magnetically recorded signals.

It is a further important object of the present invention to provide such a method and means which is responsive to the internal magnetization of the record member rather than to the external leakage flux.

A still further object of the present invention is to provide a novel playback head and method responding to infinitely long recorded wavelengths.

Other objects, features and advantages of the present invention will be more fully apparent from the following detailed description taken in conjunction with the accompanying drawings, in which:

Figure 1 is a diagrammatic view of a magnetic playback head constituting a first embodiment of the present invention;

Figure 2 is a circuit diagram for the head of Figure 1; and

Figure 3 is a schematic illustration of a further embodiment of the present invention;

Figure 4 is a diagrammatic view of a head similar to that of Figures 1 and 2 but utilizing an output circuit including a phase demodulator for converting the output from the head into a signal varying in polarity in accordance with the recorded signal.

Figure 5 is a diagrammatic view of an alternative output circuit for the head of Figures 1 and 2; and

Figure 6 represents a still further embodiment of the present invention for sensing the internal magnetization of a record medium.

As shown on the drawings:

The head of the present invention is believed to operate by sensing variations in the incremental permeability of a magnetic record medium due to variations in the strength of the recorded signal within the magnetic record medium. In accordance with this invention, the magnetic material of the record medium is excited by means of a high frequency excitation winding, and a pick-up winding is arranged in such a manner that the incremental permeability of the record medium governs the coupling between the exciting and pick-up windings and thus causes the induced voltage in the pick-up winding to vary with the recorded signal.

In Figures 1 and 2, a magnetized record medium **10**, is passed through coil means **11** which includes an exciting winding **11***a* and a pick-up winding **11***b*, for example in the direction of the arrow **13** in Figure 1. The winding **11***a* may be energized by a source **14** to apply a high frequency fluctuating magnetomotive force to the record medium, for example at a frequency of 228 kilocycles per second. For balancing out at least a portion

of the fundamental component in the pick-up circuit, the winding **11***a* may be in series with a winding **12***a* of coil means **12** in the oscillator circuit, while the winding **11***b* may be connected in series with a winding **12***b*. The fundamental frequency voltage induced in pick-up winding **11***b* is thus opposed by the voltage induced in winding **12***b*. A polarizing flux may be provided by means of a battery **17** and resistor **18**.

A capacitance **20** may be provided in the oscillator circuit for increasing the power to the coils **11***a* and **12***a*, while a capacitance **21** may be provided in the pick-up circuit to tune the same to the fundamental or second harmonic of the oscillator frequency, for example 228 or 456 kilocycles per second. The fundamental or harmonic may be fed into an amplifier **22** tuned to the desired frequency and then to a detector **23** such as found in a conventional radio circuit, the detector **23** delivering the output through any suitable amplifier to the output device **24**.

Fundamental operation of the head of Figures 1 and 2 is based on the fact that the slope of the B—H characteristic for the material of the record member **10** is greater at low values of recorded flux than at higher values of recorded flux. Thus a given change in the applied magnetomotive force due to the oscillator **14** produces a greater change in induction in the record member at low values of recorded flux than at high values of recorded flux, and the average incremental permeability of the record member for the oscillator excitation frequency is greater at low recorded flux than at high values of recorded flux. For fundamental operation, rather than provide a D.C. bias as indicated in Figure 2, the winding **12***a* may be adjusted so as to balance out only part of the fundamental frequency component induced in the winding **11***b* with zero recorded flux on the record medium **10**.

By way of explanation of the second harmonic operation of the head of Figure 2, it may be assumed that as the record medium travels through the coil means **11**, the high frequency M.M.F. due to the winding **11***a* causes the induction of the record member to vary along a minor hysteresis loop and that the non-linearity of this minor loop causes a second harmonic component to exist in the induction in the record medium. The degree of this non-linearity varies with the initial recorded magnetization in the energized portion of the record medium. It has been found that the amplitude of the second harmonic voltage component induced in the pickup winding **11***b* will be a function of the residual magnetization of the record medium, so that the output from the detector **23** in Figure 2 will vary in accordance with the magnetization of the record member. By utilizing values of magnetic intensity due to oscillator winding **11***a* which are below the coercive force of the record medium, it has been found that the recorded signal may be reproduced without destroying or altering the recorded signal. On the other hand, with the oscillator M.M.F. at a somewhat higher value, it is found that the record medium can be played back one or more times, but with a successive reduction in the recorded signal on the record member. Second harmonic operation is believed to be based on the fact that the slope of the B—H characteristic for the material of the record member is such as to provide a greater flux change during the positive half cycles of the oscillator excitation than for the negative half cycles of the oscillator excitation. This change in slope for positive and negative excitation currents from the oscillator is greater at low values of recorded flux so as to provide a greater second harmonic output at low values of recorded flux.

Figure 3 illustrates a ring type core **30** having a non-magnetic gap **31** for receiving a record medium **32** there-

across. In this embodiment, the core is preferably of relatively large cross section and preferably of a magnetic material having a relatively linear B—H characteristic, such as "Conpernik" having a composition of 50% nickel and the remainder iron and minor constituents, or "Perminvar" having a composition of 25% cobalt, 45% nickel and the remainder iron and minor constituents. Further, in this embodiment, the high frequency windings **34** and **35** are preferably connected in series aiding relation with respect to the gap **31** so as to excite the magnetic material of the record member **32**. The high frequency magnetic intensity at the gap **31** is preferably of a small amplitude in comparison with the coercive force of the record member. With such excitation, the magnetic material of the record member operates on a minor hysteresis loop, the incremental permeability of which depends on the residual magnetization of the portion of the record member at the gap **31**.

The head thus responds not to the external leakage flux from the record member, but to the actual internal magnetization of the record member. The signal flux acting on the head is thus independent of the recorded wave length of the signal so that a fundamental defect of heads relying on leakage flux from a record member is overcome. Signal pick-up windings **40** and **41** may be bifilar wound with windings **34** and **35** respectively, and also in series siding relation with respect to the gap **31**. The oscillator circuit is provided with an inductance **42** and the pick-up circuit is provided with an inductance **43** coupled therewith, so that the coupling between inductances **42** and **43** may be varied to balance out at least a portion of the fundamental component in the pick-up circuit in the absence of a signal flux from the tape **32**. Polarizing flux may be introduced by means of a magnet **45**. An amplifier **46** has its input connected to the pick-up circuit and is preferably tuned to the oscillator frequency or a harmonic thereof. The output of the tuned amplifier **46** is connected through a conventional amplitude modulation detector and power amplifier unit **48** to an output device **49** such as a loud speaker.

Figure 4 illustrates a system for demodulating the output from the head of Figures 1 and 2 wherein the output from the head is delivered to an amplifier **60** tuned to the second harmonic of the oscillator **14** and is then coupled to one pair of terminals of a rectifier circuit **61** by means of a transformer **62** having a secondary winding **62***a*. The output from the oscillator **14** is fed to a frequency doubler **65** and then optionally to a phase shift network **66** and is then delivered to a transformer **67** having a secondary **67***a* connected to the other pair of terminals of the rectifier network **61** to provide a phase demodulator. The demodulated output is taken from taps on the secondary windings **62***a* and **67***a* and delivered to a signal amplifier **70** and then to an output device such as loudspeaker **71**.

Figure 5 illustrates a different method of demodulating the output from the head of Figure 2 wherein the output from the pick-up windings **11***b* and **12***b* in series is added to the output of a phase shifter network **80** which is supplied by means of a frequency doubler **81** connected to the oscillator **14**. The resultant modulated output is delivered to a tuned amplifier **82** tuned to the second harmonic of the frequency of the oscillator **14** and then to a detector such as a simple diode detector **83**, a power amplifier **84** and an output device such as a loud speaker **85**.

Figure 6 illustrates a head **90** for operating on a harmonic of the excitation frequency of the oscillator **91**. In this instance, an exciting winding **92** is wound on the center leg **93** of E-shaped core **94** to provide oppositely directed exciting fluxes **95** and **96** at the gaps **97** and **98**. The frequency of the exciting fluxes is preferably higher than the highest recorded frequency on the record member. The core **94** may be of a material having a relatively linear B—H characteristic. A second harmonic output signal is induced in windings **99** and **100** by the exciting fluxes **95** and **96** which varies in accordance with the recorded signal on the portion of the record medium **102** threaded by the exciting fluxes. The output windings **99** and **100** are connected with an amplifier **104** tuned to the second harmonic of the excitation frequency. The output from the amplifier is delivered to a simple rectifier **105** in series with a capacitance **106** and a power amplifier **107** is connected across the capacitance **106** to deliver the output to a suitable device such as loud speaker **108**.

The width of the center leg in the direction of travel of the record member indicated by arrow **109** may be equal to the width of the gaps **97** and **98**, and the recorded wave lengths are preferably long in comparison to the separation between poles **111** and **112** provided by the outer legs of core **94**. The voltages induced in the output windings **99** and **100** by the exciting fluxes **95** and **96** are opposing so that the fundamental frequency component is balanced out, and only a second harmonic signal appears at the tuned amplifier **104**. The oscillator coil **92** may be split with part placed on each of the outer legs or base legs of the core **94**, so long as the desired balanced of the excitation frequency with respect to the signal windings **99** and **100** is maintained. The signal windings also may be placed on the base legs of the core.

The present application is a continuation-in-part of my copending application Serial No. 492,013 filed March 3, 1955.

It will be apparent that many further modifications and variations may be effected without departing from the scope of the novel concepts of the present invention.

I claim as my invention:

1. A magnetic playback head comprising an exciting winding for establishing a fluctuating exciting flux along a predetermined flux path, said path being disposed to intersect the path of travel of a magnetic record medium, means whereby said path has a substantially linear B—H characteristic over the range of values of magnetic flux to which said path is subjected, and a pick-up winding linking said flux path for inducing a voltage therein dependent upon the incremental permeability of the record medium.

2. A magnetic playback head comprising an exciting winding for establishing a fluctuating exciting flux along a predetermined flux path, said path being disposed to intersect the path of travel of a magnetic record medium, a pick-up winding linking said flux path for inducing a voltage therein dependent upon the incremental permeability of the record medium, and means whereby said flux path is in air except for said record medium.

3. A magnetic playback head comprising an exciting winding for establishing a fluctuating exciting flux along a predetermined flux path, said path being disposed to intersect the path of travel of a magnetic record medium, and means comprising a pick-up winding linking said flux path for inducing a voltage therein dependent upon the incremental permeability of the record medium, said exciting flux being of magnitude less than the coercive force of the record medium.

4. A magnetic playback head comprising an exciting winding for establishing a fluctuating exciting flux along a predetermined flux path, said path being disposed to intersect the path of travel of a magnetic record medium, means comprising a pick-up winding linking said flux path for inducing a voltage therein principally dependent upon the incremental permeability of the record medium, and means for balancing out the fundamental frequency component of voltage induced in said pick-up winding due to said exciting flux.

5. A magnetic head comprising an E-shaped core having closely spaced non-magnetic gaps, excitor means for

establishing oppositely directed rapidly fluctuating exciting fluxes at the respective gaps, and output inductor means including portions each coupled to the flux path including one of the gaps and displaced from the flux path including the other of said gaps, said portions being connected to induce opposed voltages upon energization of said excitor means, and said flux path having a substantially linear B—H characteristic.

6. A magnetic transducer head comprising means for establishing a fluctuating exciting flux along a predetermined flux path, said path being disposed to intersect the path of travel of a magnetic record medium, output means coupled to said flux path for producing an electrical output, means whereby said output means in conjunction with said flux path is substantially insensitive to external leakage flux produced by the internal magnetization of said record medium to provide an output from said output means substantially independent of said external leakage flux, and means whereby said output means in conjunction with said flux path is directly responsive to the internal magnetization of said record medium to cause said output to vary substantially directly with the internal magnetization of the record medium and to be substantially independent of the external leakage flux produced by said internal magnetization.

7. A magnetic transducer head comprising means for establishing a fluctuating exciting flux along a predetermined flux path, said path being disposed to intersect the path of a magnetic record medium, means whereby said path has a substantially linear B—H characteristic over the range of values of magnetic flux to which said path is subjected, output means coupled to said flux path for producing an electrical output, means whereby said output means in conjunction with said flux path is substantially insensitive to external leakage flux produced by the internal magnetization of said record medium, and means whereby said output means in conjunction with said flux path is directly responsive to the internal magnetization of said record medium.

References Cited in the file of this patent

UNITED STATES PATENTS

900,304	Pedersen	Oct. 6, 1908
2,608,621	Peterson	Aug. 26, 1952
2,675,429	Rohling	Apr. 13, 1954
2,722,569	Loper	Nov. 1, 1955
2,804,506	Schurch	Aug. 27, 1957

OTHER REFERENCES

EDVAC Progress Report #2, June 30, 1946, pages 4–22, 4–23, PY–O–164, PY–O–165.