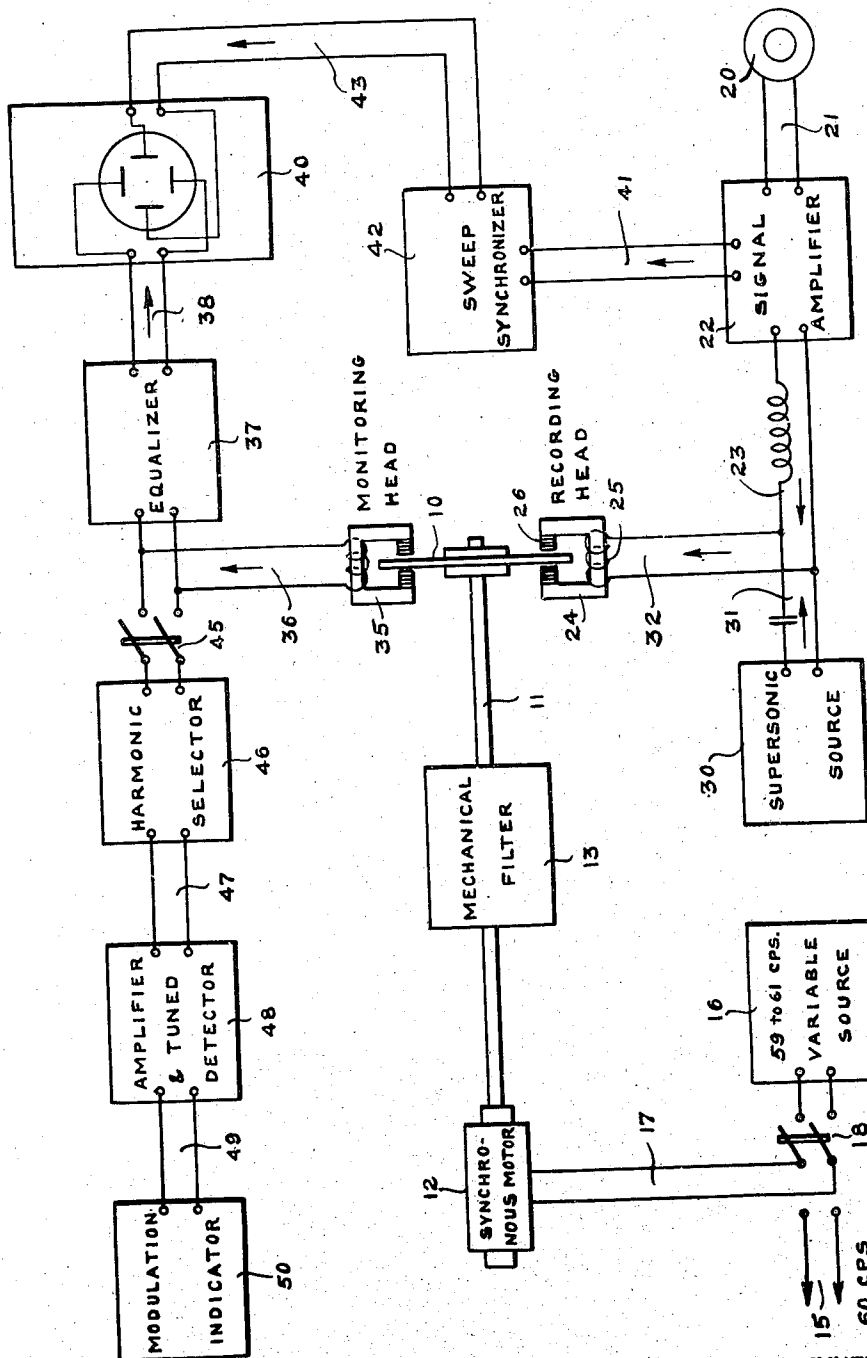


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INVENTOR
JOHN HAYS HAMMOND, JR.
BY *H. Leek*
ATTORNEY

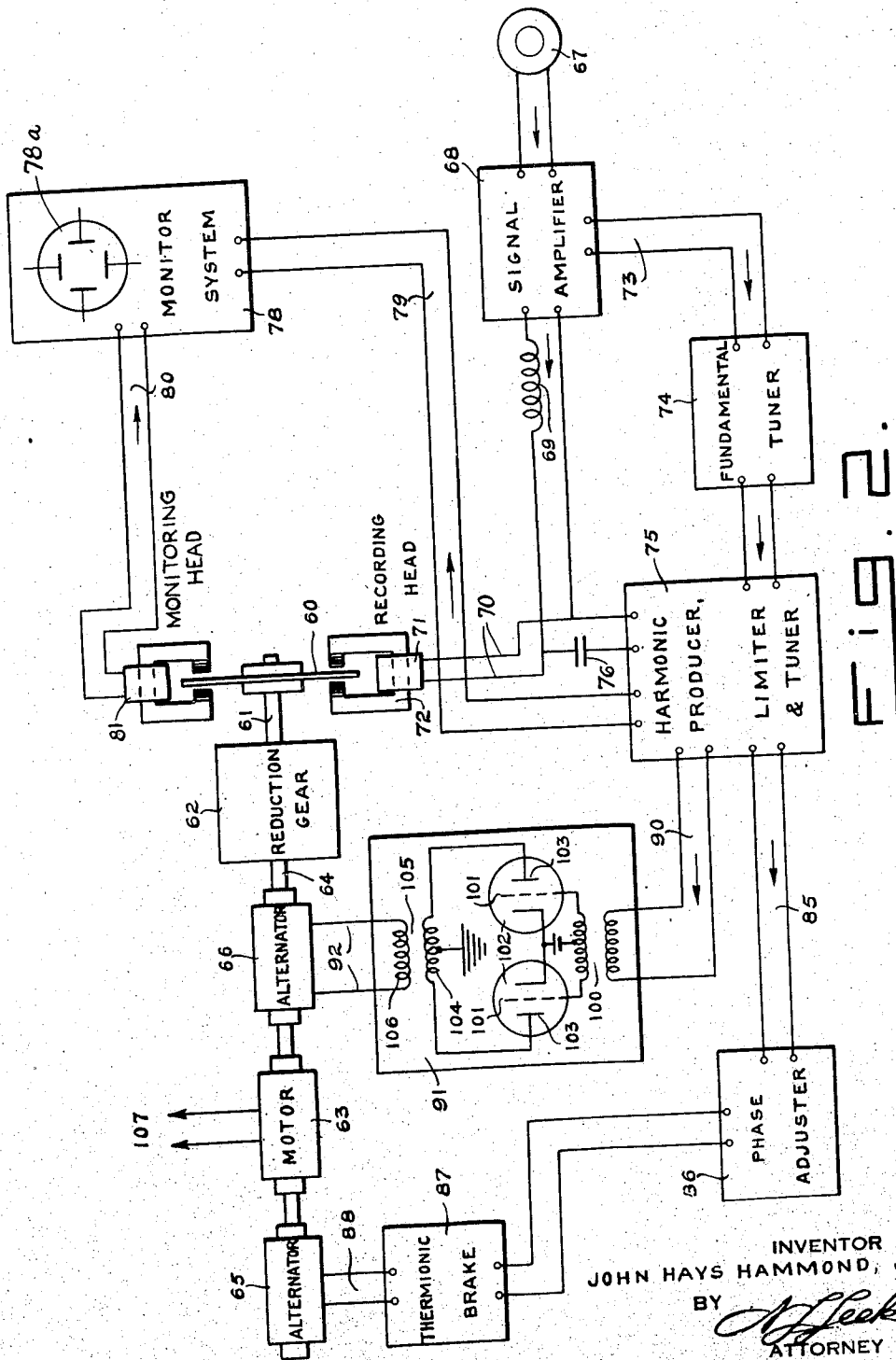
July 12, 1949.

J. H. HAMMOND, JR.
APPARATUS FOR PRODUCING
REENTRANT MAGNETIC RECORDS

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APPARATUS FOR PRODUCING REENTRANT
MAGNETIC RECORDS

John Hays Hammond, Jr., Gloucester, Mass.

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7 Claims. (Cl. 179—100.2)

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This invention relates to magnetic sound recordings and more particularly to a system for making a reentrant magnetic sound record on a disc.

An object of the invention is to provide for recording a continuous tone on a reentrant sound track on a disc with accurate phase registration between the joining ends of the sound record so that the sound may be reproduced as a continuous tone from the constantly rotating disc.

Another object is to provide a system for synchronizing the speed of rotation of the disc with the signal being recorded so that the sound record will contain an integral number of complete waves.

Another object is to provide an automatic synchronizing system of the above type.

Various other objects and advantages will be apparent as the nature of the invention is more fully disclosed.

In accordance with one embodiment of the present invention, the disc is driven by a variable speed motor the speed of rotation of which is varied by manual means. A monitoring head is provided for picking up the recorded signal from the disc. The picked-up signal is compared with a signal from the source by a suitable comparing device such as a cathode ray oscilloscope and the speed of the motor is adjusted until the proper wave form appears on the comparing device. The recording is then effected and the master record thus obtained may be used for making the usual duplicate records therefrom.

The system also provides for deriving from the disc a signal having the frequency of rotation of the disc. The presence of such a signal indicates non-uniformity in the sound record due for example to a phase shift at the adjoining ends of the record. Synchronization is effected by regulating the speed of the disc to eliminate this derived frequency.

In another embodiment of the invention the control of the driving motor is effected automatically by providing one or more alternators operating at frequencies which are harmonics of the frequency of the signal being recorded. The corresponding harmonic is derived from the signal and is applied to an electronic brake which causes the alternator to lock into step with the derived harmonics. The speed of rotation of the disc is thus varied in accordance with the frequency of the signal being recorded so as to attain the correct relationship between the length of the sound record and the length of each individual wave of which the record is composed.

Although the novel features which are believed to be characteristic of this invention are pointed out more particularly in the claims appended hereto the nature of the invention will be more clearly understood by referring to the following

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description taken in connection with the accompanying drawings in which specific embodiments have been set forth for purposes of illustration.

In the drawings:

Fig. 1 is a block diagram illustrating one embodiment of the invention; and

Fig. 2 is a similar block diagram illustrating another embodiment of the invention in which automatic speed control is effected.

Referring to Fig. 1 more in detail the invention is shown as applied to the recording of a signal on a magnetic disc 10 which is mounted on a shaft 11 driven by a motor 12. A mechanical filter 13 may be provided to eliminate variations in the drive. The motor 12 may be of the synchronous type normally designed to operate at a fixed speed from a 60 cycle line 15. For control purposes a source of variable frequency 16 is provided which may be regulated in a range of, for example, from 59 to 61 cycles. The motor 12 is connected by a line 17 to a switch 18 which is adapted to connect the same to either the 60 cycle line 15 or to the control frequency 16.

The sound source is indicated as a pick up 20 such as a microphone. The pick-up microphone 20 is connected by a line 21 to a signal amplifier 22 and thence through a low pass filter 23 to a recording head 24 comprising an exciting winding 25 and pole pieces 26 which register with the disc 10 and may be of any standard type for recording magnetically on the disc 10 the signal received from the pick up device 20. One example of a recording head suitable for this purpose is shown in my co-pending application Serial No. 643,290, filed January 25, 1946, for Sound recording and pick-up device, now abandoned.

A source 30 of supersonic energy is connected through a high pass filter 31 and line 32 to winding 25 of the recording head 24. The supersonic energy provides a bias voltage for controlling the magnetic characteristics of the disc 10 and improving the quality of the recorded sound in the manner well known in the art.

A pick-up head 35, which is similar to the recording head 24, is connected by a line 36 to an equalizer 37 which makes the signal correspond to the signal from the pick-up 20 and thence by a line 38 to one set of sweep electrodes of a comparing device shown as a cathode ray tube 40. A signal derived from the amplifier 22 is fed by a line 41 to a sweep synchronizer 42 and thence by a line 43 to another pair of sweep electrodes of the cathode ray tube 40. The line 43 may, for example, be connected to the horizontal sweep electrodes and the line 38 to the vertical sweep electrodes of the tube 40.

The line 36 is also connected through a switch 45 to a harmonic selecting filter 46, thence through a line 47 to an amplifier and tuned de-

tector indicated at 48, thence by a line 49 to a suitable modulation indicator 50.

In the operation of this device the size of the record disc 10 and the speed of rotation thereof is preselected in accordance with the frequency of the signal to be recorded thereon so as to obtain an integral number of recorded waves. However, due to variations in the frequency of the signal or inaccuracies of the system, exact synchronism may not be obtained. For a preliminary check the switch 18 may be actuated to connect the motor 12 to the 60 cycle source 15 and the tube 40 observed while the signal from the pick up 20 is being recorded on the disc 10. Synchronism will be indicated by the wave form on the screen of the cathode ray tube. If it is found that this wave form is not correct, the switch 18 is shifted to connect the motor 12 to the control frequency source 16. The frequency of the source 16 is then adjusted until the trace of the cathode ray has the correct wave form. When this occurs the recording is correct and synchronization has been effected to eliminate any phase shift at the joined ends of the sound record.

For a further indication of synchronization, the switch 45 may be closed in which case the filter network 46 is set to select a harmonic of the recorded frequency. This harmonic is amplified and detected in the tuned amplifier detector 48. The detector 48 is tuned to respond to a signal of the frequency of rotation of the disc 10 and to reject signals of higher frequency. The output of the detector is made available on the indicator 50 which may constitute a head phone or a visual indicator.

With the correct synchronization there will be no signal of the frequency corresponding to the speed of rotation of the disc 10. Hence there will be no indication in the device 50. However, any error in synchronization will cause the selected harmonic to be modulated by a signal of disc frequency and this will appear at the indicator 50.

The absence of the signal on the indicator 50 will indicate that synchronization has been correctly established not only for the fundamental frequency, but for harmonics up to the selected harmonic.

In order to obtain a more accurate control the automatic system shown in Fig. 2 may be employed. In this system the record disc 60 is mounted on a shaft 61 and driven through a reduction gear 62 by a motor 63. Mounted on the shaft 64 of the motor 63 are a pair of alternators 65 and 66 which may be set to operate at different harmonics of the recorded signal frequency.

In the system of Fig. 2 the signal pick-up 67 is connected to an amplifier 68 and thence through a low pass filter 69 and line 70 to a winding 71 of a recording head 72 similar to the head 24 described above and positioned to record a signal magnetically upon the disc 60 as the latter rotates.

In this embodiment the supersonic biasing voltage is obtained from the signal amplifier 68 through a line 73, a filter 74 tuned to pass the fundamental and a harmonic producer, limiter and tuner 75 which is designed to produce a plurality of different harmonic frequencies of controlled amplitude. One harmonic derived from the frequency multiplier 75 which is suitable for a supersonic bias is supplied through a high pass filter 76 to the line 70.

A suitable monitor system 78 including a cathode ray tube 78a and the usual controls is con-

nected by a line 79 to the harmonic producer 75 and by a line 80 to a pick-up head 81 which is similar to the pick-up head 35 above described. The harmonic producer 75 is designed to supply a harmonic or the fundamental to the line 79 according to the comparison desired.

The harmonic producer 75 is designed to produce two additional sets of higher harmonics, for example, the fourth and eighth harmonics of the applied signal. The fourth harmonic may be supplied by a line 85 through a phase adjusting network 86 to an electronic brake network 87 which is connected by lines 88 to constitute a load upon the alternator 65. The eighth harmonic may be supplied through line 90 to an electronic brake network 91 which is connected by lines 92 to supply a load across the alternator 66.

The electronic braking networks 87 and 91 may be of any standard type which is designed to cause the alternator to lock into step with the applied voltage. One type is shown for example in this figure wherein the line 90 is connected to the primary of a transformer 100, the secondary of which is connected to the grids 101 of a pair of space discharge tubes 102 operating as a push-pull amplifier. The space discharge tubes include anodes 103 connected in push-pull to the primary 104 of an output transformer, 105 the secondary 106 of which is connected to lines 82.

The motor 63 is preferably a direct current motor connected by lines 107 to a D. C. source and is of the type which is variable in speed in response to changes in torque.

In the operation of this device the picked up signal is amplified in the signal amplifier 68 and is applied to the recording head 72 for making a record on the disc 60 which is driven by the motor 63 at approximately the correct speed for making a reentrant record. The fourth and eighth harmonics of the applied signal are derived from the frequency multiplier 75 and are supplied to the electronic brake networks 87 and 91 respectively to constitute loads on the alternators 65 and 66. In practice the thermionic brake 87 which is responsive to the lower harmonic will lock in first to obtain approximate synchronization. Thereafter the electronic brake 91 will cause the alternator 66 to lock into step for more exact synchronization. If, as in the example given above, the alternator 65 is operating on the fourth harmonic the alternator 66 on the eighth harmonic of the applied signal and the alternator 66 is synchronized within 20°, the fourth harmonic wave will be synchronized within 5°, and the fundamental will be synchronized within 1.25°. This is sufficiently accurate to eliminate any appreciable error in the signal reproduced from the disc 60. The synchronization can be observed by the cathode ray pattern as in the case of Fig. 1.

Other recordings can then be made from the master record without exact synchronization by placing the records on the same shaft with the master record so that they are all driven at the same speed. Any minor variation in driving speed would then not affect the final recordings as the record has already been made re-entrant on the master disc and would necessarily be re-entrant on the secondary discs.

By the above described system I am enabled to make master recordings of continuous tones on record discs which are re-entrant to a high degree of accuracy. Such discs, for example, are suitable for use in a magnetic musical instrument of the type set forth in my co-pending applica-

tion Serial No. 646,040, filed February 7, 1946, for Electromagnetic organ.

Although certain specific embodiments of the invention have been shown for purposes of illustration, it is to be understood that various changes and modifications may be made therein as will be readily apparent to a person skilled in the art. The invention is only to be restricted in accordance with the scope of the following claims.

What is claimed is:

1. A system for making a reentrant magnetic sound record of a continuous tone on a circular sound track of magnetic material, comprising a driving motor connected to drive said circular track at a substantially uniform speed, a sound pick-up device, a recording head adapted to make a magnetic record on said track, a channel connecting said pick-up device to said head, a monitoring pick-up head responsive to the signal recorded on said record, comparing means to compare the signal from said monitoring head with the signal from said pick-up device, and means adjusting the speed of said drive to bring the recorded signal into synchronism with the signal from said pick-up device so as to obtain a continuous reentrant sound record of the signal.

2. A system for making a reentrant magnetic sound record of a continuous tone on a circular sound track of magnetic material, comprising a driving motor connected to drive said circular track at a substantially uniform speed, a sound pick-up device, a recording head adapted to make a magnetic record on said track, a channel connecting said pick-up device to said head, a monitoring pick-up head responsive to the signal recorded on said record, a cathode ray oscilloscope having a pair of sweep electrodes connected to said monitoring head and another pair of sweep electrodes connected to be actuated by the signal from said pick-up device for comparing the recorded signal with the picked-up signal, and means adjusting the speed of said drive to bring the recorded signal into synchronism with the signal from said pick-up device so as to obtain a continuous reentrant sound record of the signal.

3. A system for making a reentrant magnetic sound record of a continuous tone on a circular sound track of magnetic material, comprising a driving motor connected to drive said circular track at a substantially uniform speed, a sound pick-up device, a recording head adapted to make a magnetic record on said track, a channel connecting said pick-up device to said head, a monitoring pick-up head responsive to the signal recorded on said record, filter means selecting a harmonic of the signal derived from said monitoring head, means selecting a modulation component of said harmonic having a frequency corresponding to the speed of rotation of said track, means indicating the presence of said component, and means adjusting the speed of said drive to eliminate said component whereby the recorded signal is brought into synchronism with the rotation of the track so as to obtain a continuous reentrant sound record of said signal.

4. A system for making a reentrant magnetic sound record of a continuous tone on a circular sound track of magnetic material, comprising a driving motor connected to drive said circular track at a substantially uniform speed, a sound

pick-up device, a recording head adapted to make a magnetic record on said track, a channel connecting said pick-up device to said head, a pair of alternators driven by said motor and generating frequencies corresponding to different harmonics of the picked-up signal, means deriving the corresponding harmonics from said signal, a load circuit for said alternators and means supplying the respective harmonics to said load circuits to act as brakes on said alternators for causing the latter to lock into step with said harmonics so that the speed of rotation of the track is brought into exact synchronism with the picked-up signal.

5. A system for making a reentrant magnetic sound record of a continuous tone on a circular sound track of magnetic material, comprising a driving motor connected to drive said circular track at a substantially uniform speed, a sound pick-up device, a recording head adapted to make a magnetic record on said track, a channel connecting said pick-up device to said head, means deriving a pair of different harmonics of the picked-up signal, and means utilizing said harmonics as a variable brake on said motor to cause said motor to operate at a speed such that the circular record track is synchronized with the picked-up signal.

6. A system for making a reentrant magnetic sound record of a continuous tone on a circular sound track of magnetic material, comprising a driving motor connected to drive said circular track at a substantially uniform speed, a sound pick-up device, a recording head adapted to make a magnetic record on said track, a channel connecting said pick-up device to said head, an alternator driven by said motor and adapted to generate a frequency which is a harmonic of the picked-up signal, means deriving the corresponding harmonic from said picked-up signal, and means supplying said harmonic to said alternator as a load for causing said alternator to lock into step therewith whereby the circular record track is brought into synchronism with the picked-up signal.

7. A system for making a reentrant magnetic sound record of a continuous tone on a circular sound track of magnetic material, comprising a driving motor connected to drive said circular track at a substantially uniform speed, a sound pick-up device, a recording head adapted to make a magnetic record on said track, a channel connecting said pick-up device to said head, an alternator driven by said motor and adapted to generate a frequency which is a harmonic of the picked-up signal, means deriving a corresponding harmonic from said signal, an electronic braking circuit connected to said alternator, means exciting said circuit by said derived harmonic whereby said alternator is caused to lock into step therewith and to bring the rotation of the circular disc into synchronism with the picked-up signal.

JOHN HAYS HAMMOND, JR.

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