April 25, 1933. A. McL. NICOLSON 1,906,214

HIGH FREQUENCY PHONOGRAPH APPARATUS

Filed March 19, 1927 3 Sheets-Sheet 1

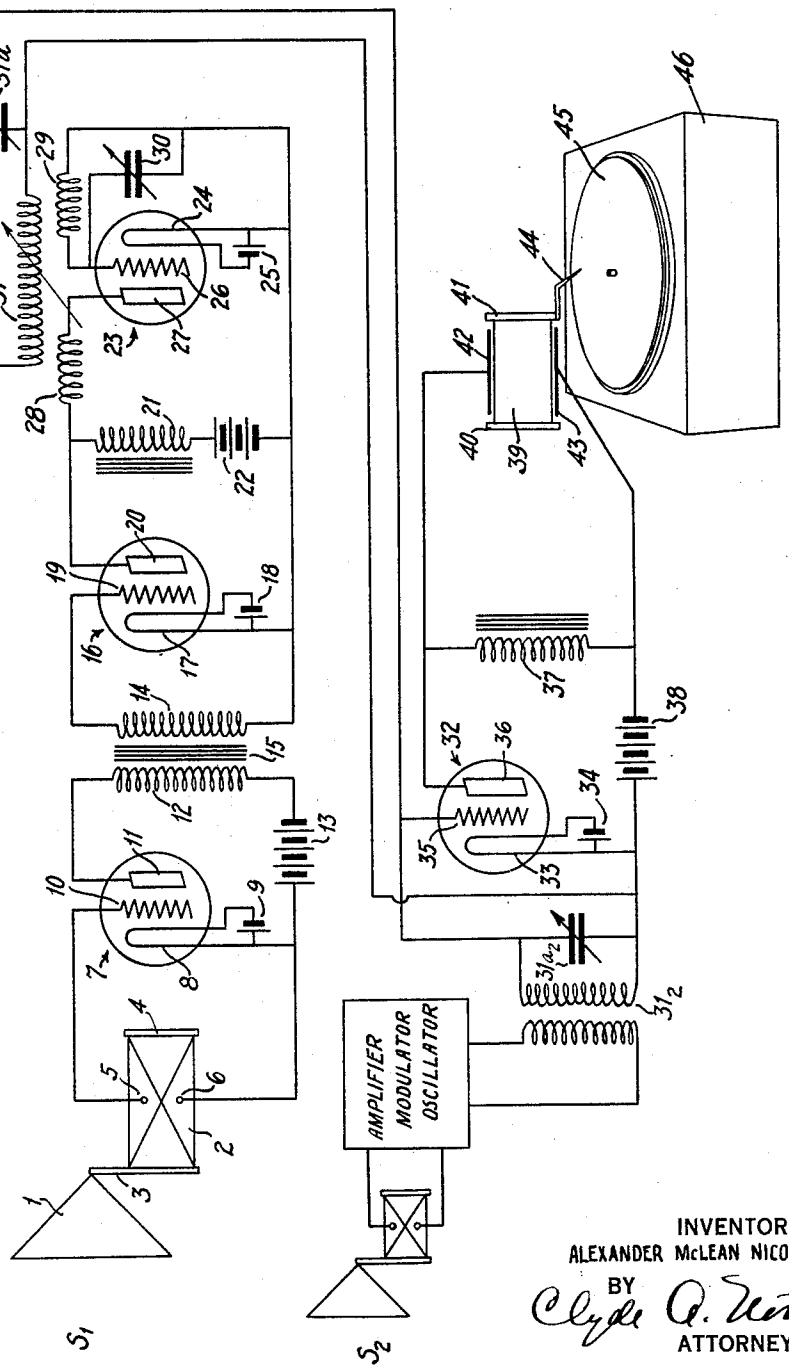



Fig. 1

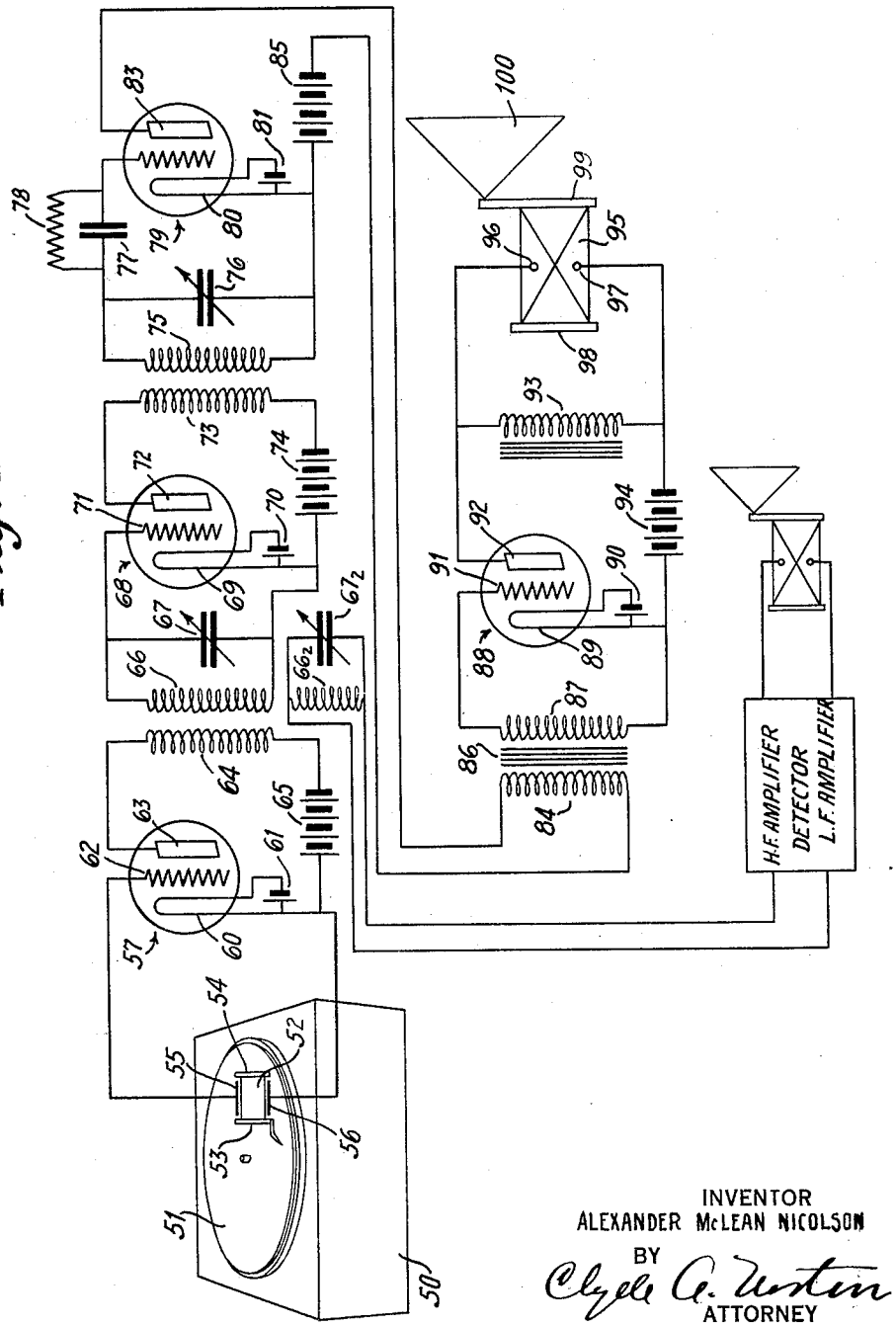
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HIGH FREQUENCY PHONOGRAPH APPARATUS

Filed March 19, 1927 3 Sheets-Sheet 2

Fig. 2



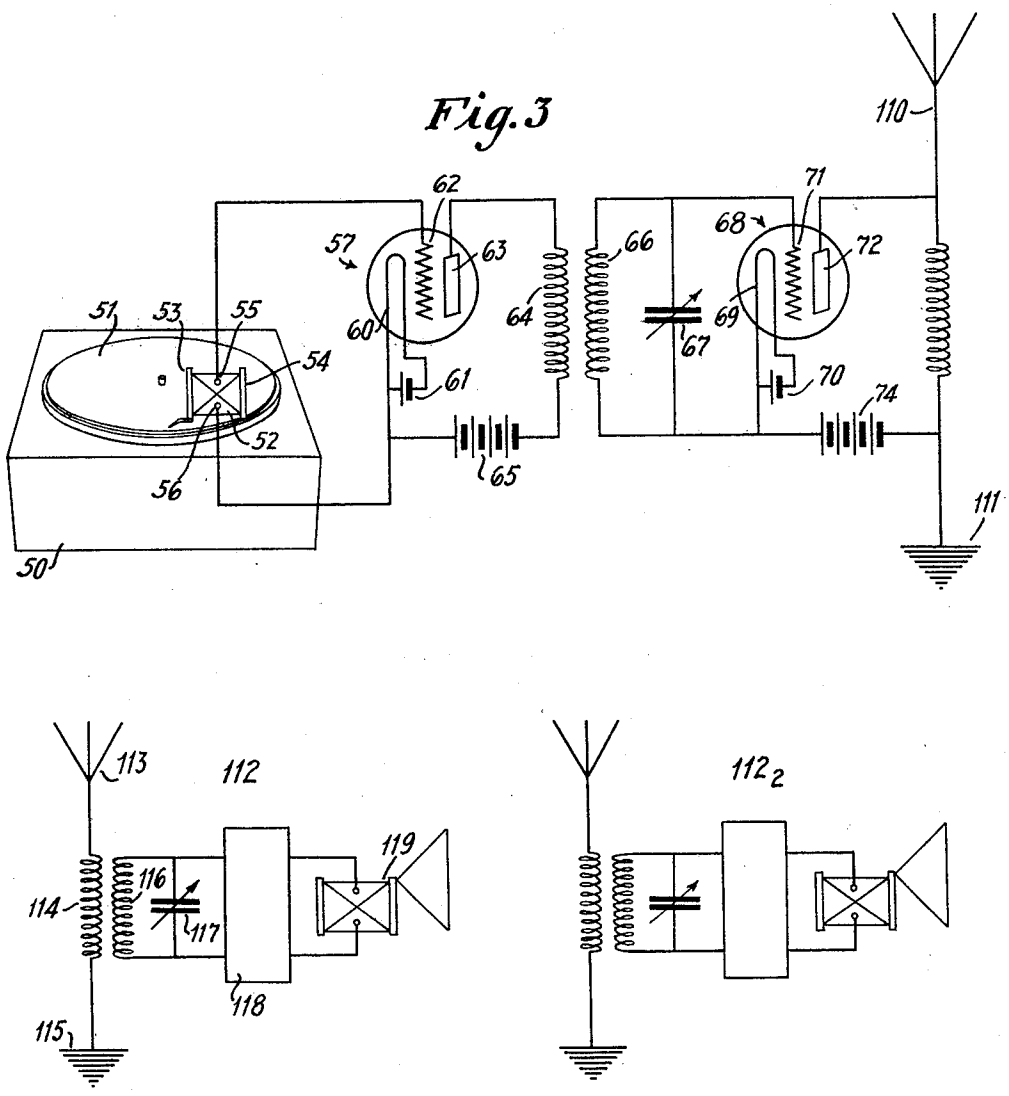

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Filed March 19, 1927 3 Sheets-Sheet 3

*Fig. 3*










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Patented Apr. 25, 1933 1,906,214

# UNITED STATES PATENT OFFICE

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## HIGH FREQUENCY PHONOGRAPH APPARATUS

Application filed March 19, 1927. Serial No. 176,677.

This invention relates to a method and apparatus for recording and reproducing sounds, and more particularly to a method and apparatus for recording sounds upon a phonograph record and reproducing the recorded sounds therefrom.

It is an object of this invention to provide a method and apparatus whereby audible sounds may be recorded upon and reproduced from phonograph records not directly as vibrations of audible frequency but as modulations of other vibrations and more particularly of superaudible vibrations.

It is a further object of this invention to provide apparatus of the class described which will permit the utilization of radio receiving apparatus to reproduce sounds recorded on phonograph apparatus.

It is still a further object of this invention to provide a method and apparatus for recording a plurality of sound records upon the same record blank, and for selecting and reproducing a plurality or all of the sound records simultaneously.

Still other objects of my invention will be apparent from the specification.

The features of novelty which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its fundamental principles and as to its practical embodiments will best be understood by reference to the specification and accompanying drawings, in which:

Fig. 1 is a circuit diagram of apparatus for recording sounds according to my invention.

Fig. 2 is a similar view of apparatus for reproducing sounds according to my invention.

Fig. 3 is a view of a system which may be used, for example in an auditorium where it is desired to reproduce sounds at a plurality of points simultaneously.

In accordance with my invention, instead of recording sounds as vibrations corresponding in frequency and amplitude to the original sounds, I record them as vibrations of a single or carrier frequency, preferably a high frequency considerably in excess of the highest frequency to be recorded, and modulated in amplitude in accordance with the sounds to be recorded. The recording may be done at any frequency from the upper limits of audibility, or approximately 10,000 cycles, to a frequency as high as it is possible to operate a vibrating device for engraving the record. Since the range of carrier and side band frequencies necessary for any channel is only approximately 10,000 cycles at a maximum, it is possible to record in a number of channels or zones on the same record simultaneously. For example: a frequency band of 20,000 to 30,000 cycles may be used or on the other hand, a band from 100,000 to 110,000 cycles may be used if only one channel is used. If more are to be used, it is possible to use a plurality of channels: for example, one set of sounds may be recorded in a frequency band extending from 20,000 to 30,000 cycles, another set of sounds in another band extending from 50,000 to 60,000 cycles and still another in the band extending from 100,000 to 110,000 cycles. In this way, it is possible to produce a multiplex record having a number of selections recorded thereon.

In order to reproduce the sounds desired, a piezo-electric transmitter may be driven by the record, and will produce electrical oscillations corresponding to the vibrations inscribed on the record; that is, high frequency oscillations modulated in accordance with the sound frequency oscillations, and the oscillations may be amplified if desired by an amplifying system, which may be tuned to the particular carrier frequency desired whereby the desired channel may be selected.

Inasmuch as the amplitudes of movement may be relatively small and the weight of the stylus and driving member relatively small, the width of the record grooves may be made relatively small, and the number per inch considerably greater than in standard practice, whereby the length of time required for the stylus to pass from the outer end of the record to the inner end can be considerably lengthened. Since a large number of selections may be recorded upon

a single record by the use of a number of different frequency channels, it becomes possible to produce what is known as a long playing record, in which, for example, an entire opera may be inscribed upon a single record. In order to reproduce all of the sounds inscribed on the record, it is only necessary to cause the record to be repeated, each time changing the tuning of the amplifying apparatus so as to respond only to the desired band of frequencies. Moreover, my invention lends itself readily to the use of radio receiving apparatus as a means for reproducing phonograph music and in this instance, it is not necessary to provide for cutting into the audio amplification of the radio receiver as is usually the case. The only requirement is that the radio receiver be tuned to the carrier frequency of the particular selection.

Referring now more particularly to Fig. 1, I have shown an apparatus adapted to record independent sounds upon a record, each as modulations of a different carrier frequency. In this arrangement $S_1$ designates one sound source, sounds from which are desired to be recorded as modulations of a carrier frequency of say 30,000 cycles, and 1 designates an acoustic diaphragm such as a cone, arranged to operate a suitable microphone, such for example as a piezo-electric crystal device 2 through the medium of a stress plate 3 at one basal plane of the crystal, to which is attached the cone 1. The stress plate 4 is secured to the other basal plane of the crystal, and a pair of electrodes 5 and 6 are provided in any desired arrangement to withdraw from the crystal the charges produced thereon by vibrations communicated thereto by the cone 1. Alternatively, the apparatus shown and described in my copending applications entitled "Composite piezo-electric acoustic device", Serial Number 160,358, filed Jan. 11, 1927, and "Internally clamped composite piezo-electric acoustic device", Serial Number 160,359, filed Jan. 11, 1927, may be utilized in place of that shown, or a conventional type of carbon microphone may be used. The oscillations corresponding to the speech or music picked up by the cone 1 are amplified by a suitable amplifying system 7, diagrammatically shown as a single vacuum tube thermionic amplifying device comprising a cathode 8 in the form of a filament adapted to be heated by a suitable source of energy such as battery 9 to electron emitting temperature, a control electrode or grid 10, and an anode or plate 11 connected through coil 12 forming the primary of a transformer, and through a suitable source of potential such as battery 13 to the filament.

A secondary coil 14 is provided inductively interlinked with coil 12 through the medium of core 15 of magnetic material. The coil 14 is connected to the input circuit of a suitable modulator tube 16 having a cathode 17 in the form of a filament adapted to be heated by battery 18, a control electrode or grid 19, and an anode or plate 20 connected through modulator choke 21 and a source of plate potential 22 to the filament circuit. An oscillator 23 is provided having a cathode 24 in the form of a filament adapted to be heated by suitable battery 25, a control electrode or grid 26, and an anode or plate 27 connected through coil 28 to choke 21 and thence through choke 21 and battery 22. The control or grid circuit of the oscillator 23 comprises coil 29, inductively coupled to coil 28, and a condenser 30 in shunt therewith, forming a feed back circuit of the type known in the art, which will be tuned to the desired frequency.

A suitable coil 31 shunted if desired by condenser 31*a* for tuning, coupled to coils 28 and 29 is connected in the input circuit of a suitable amplifier 32 comprising a cathode 33 in the form of filament heated by battery 34, a control electrode or grid 35, and an anode or plate 36. The plate 36 is connected through a suitable choke 37 and source of potential 38 to the filament; and in shunt with the choke 37 I provide a suitable piezo-electric crystal device 39 having a pair of electrodes 42 and 43 connected across choke 37 and also, if desired, provided with a pair of mounting plates 40 and 41 to one of which is secured in a suitable manner stylus 44 adapted to inscribe its vibrations upon a suitable plastic record 45 rotated by the driving apparatus 46.

Any piezo-electric crystal device particularly adapted for vibration at the desired frequency or frequencies is suitable. For example, if it is desired to record with a frequency band from 20,000 to 30,000 cycles, the crystal device will be so constructed as to operate most effectively in this range. On the other hand, if it is desired to record with this band and an additional band of 60,000 to 70,000 cycles, the crystal will be so selected as to vibrate in both these frequency ranges. The crystal may be quartz, appropriately cut and ground, or it may be Rochelle salt, suitably shaped and finished, or other suitable substance.

The operation of the system it is believed will be readily understood. Sounds from the source $S_1$ which it is desired to record as a modulated carrier wave, are permitted to actuate the diaphragm 1 and thereby stress or vibrate the crystal device 2, which produces electrical oscillations corresponding to the sounds impinging upon the cone. These electrical oscillations are amplified by the amplifying system 7 and supplied to the control circuit of the modulator tube 16. The output of the oscillator 23 is thereby

modulated in a manner known in the art: and the oscillator frequencies may be selected by predetermination and design of the constants of the apparatus as is well known in the art, and if desired, may be varied by variation of one or more of the constants. The high frequency oscillations modulated in accordance with sound frequency oscillations are supplied to the input circuit of the amplifier 32 and amplified, if desired, to the extent necessary to actuate the piezo-electric crystal device 39. As pointed out in my copending application entitled "Piezo-electric coupling", filed Dec. 20, 1926, Serial Number 155,896, these devices may respond to modulated oscillations as well as to unmodulated oscillations, and the stylus 44 is caused to vibrate with the crystal device, thereby inscribing upon the record 45 as it rotates vibrations corresponding to the modulated currents.

In case it is desired to record other sounds on the record as modulations of a different carrier frequency, as pointed out above, a similar system may be provided for each sound channel, comprising microphone, audio frequency amplifiers, modulator, and oscillator. The oscillator will be tuned to a frequency sufficiently removed from the other carrier frequencies in use to permit ready separation of the various carriers in the manner known in the art.

In the drawings, I have shown an additional sound source $S_2$, operating a second pickup, amplifying, modulating and oscillating system, and feeding a circuit tuned to the oscillator frequency, comprising coil $31_2$ and condenser $31a_2$, connected in the input circuit of amplifier 32.

It will be understood that amplifier 32 acts to amplify each set of modulated carrier oscillations and to impress them upon the crystal device 39, which is caused to vibrate in response to each carrier independently, and inscribes upon the record the resultant vibration. From the inscribed record, copies may be made in the manner known in the art.

For the purpose of reproducing sounds recorded thereon, I may utilize the apparatus shown in Fig. 2, in which 50 represents suitable driving apparatus carrying record 51 adapted to be traversed by a stylus arranged on the piezo-electric transmitter 52 having suitable mounting plates 53 and 54, and electrodes 55 and 56. The electrodes 55 and 56 may be connected to the control circuit of amplifier or coupling tube 57, comprising a filament 60, adapted to be heated by a suitable source of energy such as battery 61, control electrode or grid 62, and anode or plate 63 which is connected through the primary 64 of a suitable high frequency transformer and through a source of potential 65 to the filament circuit. The secondary of the said transformer comprises coil 66 shunted by a variable tuning condenser 67 and connected in the input circuit of amplifier 68 comprising filamentary cathode 69 adapted to be energized by battery 70, a control electrode or grid 71, and anode or plate 72, connected through the primary 73 of a suitable high frequency transformer and through suitable plate source, such as battery 74 to the filament circuit. The secondary 75 of the transformer is shunted by suitable tuning condenser 76 and connected across the input circuit of the detector 79 and comprising in series therewith grid condenser 77 and grid leak 78. The anode or plate 83 is connected through the primary 84 of a suitable audio frequency transformer and plate battery 85 to the filament circuit. Transformer 84 may comprise a core 86 of magnetic material and a secondary winding 87 which is connected in the input circuit of suitable amplifier 88 comprising cathode 89 adapted to be heated by battery 90, control electrode or grid 91, and anode or plate 92, connected through a suitable choke 93 and plate battery 94 to the filament. A suitable sound reproducer may be connected across the choke 93, such for example as piezo-electric crystal device 95 having electrodes 96 and 97, and suitable end plates 98 and 99 to one of which may be attached an acoustic diaphragm such as cone 100.

It will be understood that the operation of the record 51 will vibrate the piezo-electric crystal device 52 and cause the production of high frequency oscillations of the frequency inscribed on the record, modulated in accordance with the audible sounds. The said carrier frequency oscillations desired will be selected and amplified by tuned amplifying system provided, and the oscillations will be detected by a detector 79. The detected oscillations are amplified to the extent desired by audio frequency amplifying system 88 and applied to the reproducer 95 causing the production of mechanical vibrations corresponding to the original sounds recorded on the record.

In case it is desired to reproduce a plurality of channels simultaneously, additional tuned amplifying systems are provided one for each carrier. While I have shown diagrammatically only one extra amplifying and reproducing system, comprising coil $66_2$ and condenser $67_2$ tuned to a different carrier frequency and feeding a tuned amplifying, detecting and audio frequency amplifying and sound producing system, it will be understood that an additional system of this type will be provided for each carrier frequency.

In case it is desired to utilize a radio receiver for reproducing the sounds impressed

on the record or in case it is desired to actuate a plurality of sound reproductions from a single record, the system shown in Fig. 3 may be utilized. In this instance, the amplifier 68 instead of feeding a detector tube, radiates oscillations in the output circuit thereof into space, being provided for the purpose, with a suitable antenna 110 and a ground 111. It is to be understood, however, that this is not necessarily an actual antenna and ground but may constitute simply capacity areas attached to the circuit, or in case it is feasible to do so, they may be omitted entirely, as for example, when it is desired merely to transmit from a phonograph in one part of a room to a radio receiver located in the same room. A plurality of radio receivers may be provided, each having a suitable antenna 113, including a coil 114 and ground 115 if desired, coupled to an input coil 116 tuned by condenser 117; the tuned circuit comprising the coil 116 and condenser 117 may be connected across the input of a suitable radio receiver 118 operating a suitable loud speaker 119 herein diagrammatically shown as a piezo-electric crystal loud speaker.

It will be understood that in case the phonograph apparatus is located adjacent to the radio receiver, the antenna and ground may be omitted or may constitute a few feet of wire or capacity areas as found necessary.

It is clear that in order to receive upon the radio receiver the oscillations generated by the phonograph, it is necessary only to tune the radio receiving apparatus to the carrier frequency of the phonograph. It will be clear that a number of radio receivers may be provided for each phonograph, such for example as receivers 112 and $112_2$, which may be tuned each to the same carrier frequency if desired, as may be the case when it is desired to operate a number of loud speakers, for example around a theatre auditorium, or they may be tuned to different carrier frequencies in case the phonograph is reproducing more than one carrier frequency simultaneously.

While I have shown and described certain preferred embodiments of my invention, it will be clear that modifications and changes may be made without departing from the spirit and scope of my invention, as will be understood by those skilled in the art.

I claim:

1. The method of reproducing sound from a record engraved with super-audible frequency vibrations modulated at sound frequencies which comprises producing directly from said record oscillations of super-audible frequency, modulated at sound frequencies, radiating said modulated oscillations, receiving said radiated oscillations, and converting said received oscillations into sound waves.

2. The method of reproducing sound from a mechanical record thereof engraved with oscillations of relatively higher frequency modulated in accordance with the sounds to be recorded, which comprises producing directly from said record electrical oscillations corresponding thereto, radiating said oscillations, receiving and detecting said oscillations into sound waves.

3. A phonograph record comprising a stylus track having a plurality of sound records formed therein, each sound record comprising a channel of super-audible vibrations modulated in accordance with sound frequencies.

4. A multiplex phonograph record comprising a stylus track having vibrations inscribed therein, such vibrations comprising a plurality of carrier frequencies modulated at sound frequencies, said carrier frequencies being so chosen as to be readily separable.

5. A phonograph record having a stylus track comprising a plurality of sound channels, each sound channel comprising a vibration of carrier frequency modulated at sound frequencies inscribed on said track, said carrier frequencies being so chosen as to be readily separable.

6. The method of recording sound in a plurality of sound channels on a single record which comprises producing a plurality of electrical oscillations of super audible frequency of frequencies sufficiently different as to be readily separable, modulating said oscillations each in accordance with sounds to be recorded in one of said sound channels and vibrating a stylus on said record in accordance with said oscillations.

7. The method of reproducing sounds recorded in a plurality of sound channels on a record as modulations of separable carrier frequencies, which comprises vibrating an oscillation generating device in accordance with the vibrations inscribed on said record, selecting the oscillations of the carrier frequency desired and converting said oscillations into sound.

8. The method of reproducing sounds from separate sound channels recorded on a record as vibrations of super audible frequencies so chosen as to be readily separable, which comprises vibrating an oscillation generator in accordance with vibrations inscribed in said record, separating oscillations of different frequency, and simultaneously converting said oscillations into sound.

9. In sound recording apparatus, the combination of a plurality of sound recording channels, each comprising a pick-up system, an amplifying system, an oscillator, and means for modulating the output of said oscillator in accordance with the oscillation of sound frequency; and a stylus operable

by said modulated oscillations to inscribe a record.

10. In sound recording apparatus, the combination of a plurality of sound recording channels, each comprising a pick-up system, an amplifying system, an oscillator, means for modulating the output of said oscillator in accordance with oscillations of sound frequency, a single stylus and means for vibrating said stylus, in accordance with the oscillations generated by each of said oscillators.

11. In sound recording apparatus, the combination of a plurality of sound recording channels, each comprising a pick-up system, an amplifying system, an oscillator, means for modulating the output of said oscillator in accordance with the oscillations of sound frequency; a single stylus, and means for vibrating said stylus in accordance with the oscillations generated by each of said oscillators, each of said oscillators being tuned to a frequency such as to permit of ready separation of their frequencies.

12. In sound recording apparatus, the combination of a plurality of sound record channels each comprising a pick-up system, an amplifying system, an oscillator, means for modulating the output of said oscillator in accordance with the oscillations of sound frequency; a single stylus, and means for vibrating said stylus in accordance with the oscillations generated by each of said oscillators, each of said oscillators being tuned to a frequency such as to permit of ready separation of their frequencies, said stylus comprising a piezo-electric crystal device.

13. Apparatus for reproducing sounds from a record having sounds of a plurality of sound channels recorded thereon as modulations of readily separable carrier frequencies, said means comprising an oscillation generator adapted to be vibrated by said record, tuning means for selecting the desired carrier frequency, and means for converting said oscillations into sound.

14. Apparatus for reproducing sounds from a record having sounds of a plurality of sound channels recorded thereon as modulations of readily separable carrier frequencies, said means comprising an oscillation generator adapted to be vibrated by said record, a plurality of carrier frequency selecting channels, each of said channels being tunable to the frequency of one of said carrier frequency oscillations, and means for producing sound from each of said carrier frequencies.

15. Apparatus for reproducing sounds from a record having sounds of a plurality of sound channels recorded thereon as modulations of readily separable carrier frequencies, said means comprising an oscillation generator adapted to be driven by said record, a plurality of carrier frequency selecting and amplifying channels each tunable to one of said carrier frequencies, and means for producing sound from one of said carrier frequencies.

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