April 19, 1938. A. C. KELLER ET AL 2,114,471

SOUND RECORDING AND REPRODUCING SYSTEM

Filed June 20, 1936 2 Sheets-Sheet 1

FIG. 1

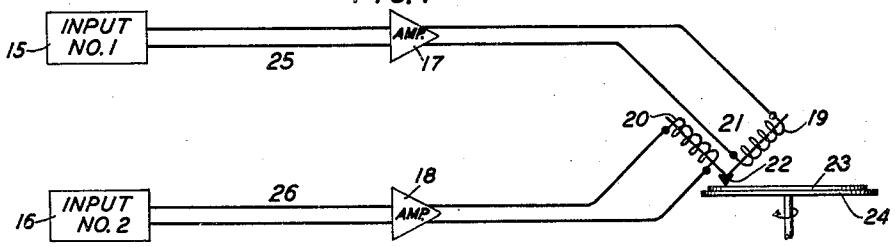


FIG. 2

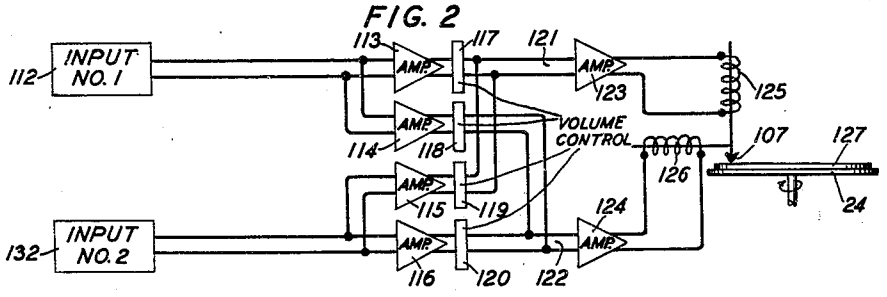


FIG. 3

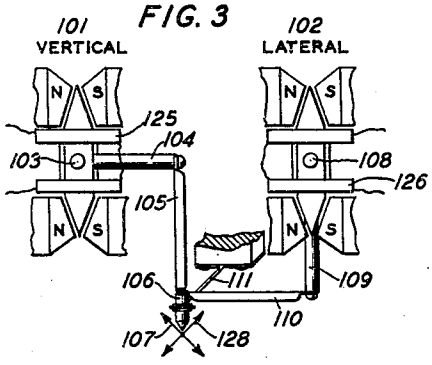
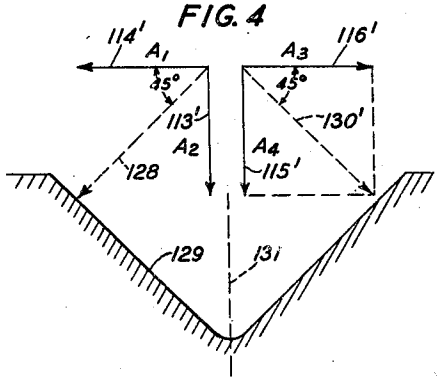


FIG. 4



INVENTORS: A. C. KELLER
I. S. RAFUSE

BY

ATTORNEY

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FIG. 5

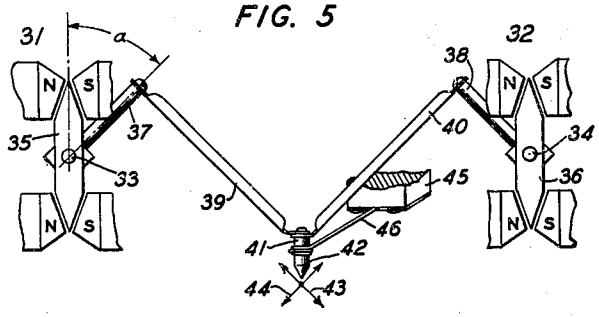


FIG. 8

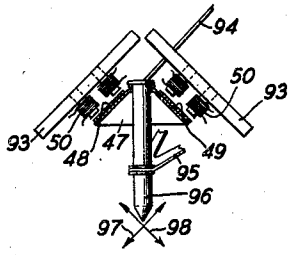


FIG 6

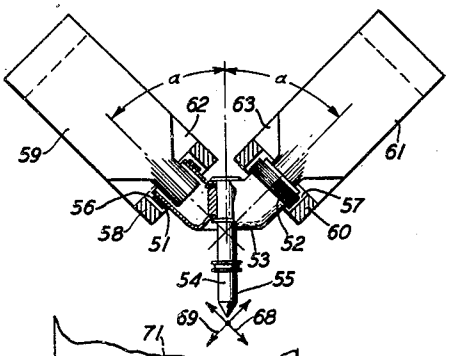
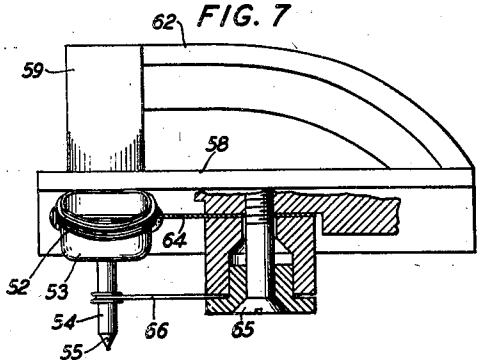


FIG. 7



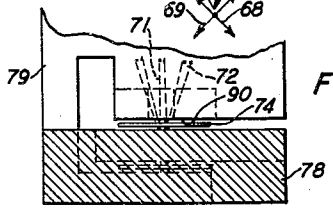


FIG. 9

FIG. 10

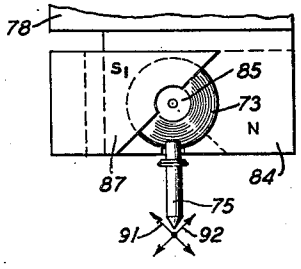


FIG. 11

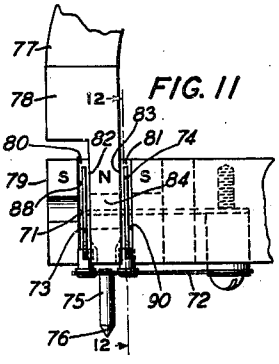
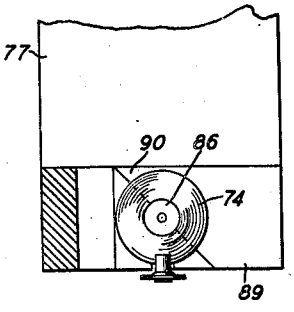


FIG. 12



INVENTORS: A.C. KELLER
I.S. RAFUSE

BY

G. M. Campbell

ATTORNEY

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UNITED STATES PATENT OFFICE

2,114,471

SOUND RECORDING AND REPRODUCING SYSTEM

Arthur C. Keller, Mount Vernon and Irad S. Rafuse, Hempstead, N. Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application June 20, 1936, Serial No. 86,228

7 Claims. (Cl. 179—100.4)

This invention relates to sound recording and reproducing systems and particularly to those in which two separable recordings are made in a single groove of a record.

In the systems of this general type proposed heretofore the two recordings have usually been made as vertical and lateral undulations respectively. With a system of this type, however, it is very difficult to obtain identical quality of reproduction from the two recordings. This may be due to differences in the frequency characteristics or in the amplitudes of the distortion products of the two types of recorders, reproducers, or systems or it may be due to various other causes, but in any case the resulting quality differences in the two reproductions are often quite apparent and they are particularly objectionable in cases where the records are to be used for the stereophonic reproduction of sound.

The object of this invention is to eliminate these quality differences in the reproductions of multiple recordings in a single groove.

In accordance with the general features of the invention the two recordings are formed by a single stylus which vibrates in two planes at an angle to each other and at equal angles to its own axis and to the surface of the record. In the preferred embodiment the planes of vibration are normal to each other and at 45 degrees to the surface of the record but they may be disposed at some other angle such as 60 degrees, if desired, in which case each plane would also be inclined at an angle of 60 degrees to the surface of the record. The recorder may consist of two suitable recorder units of any known type connected by suitable linkages to the common stylus and the reproducer also preferably has two generating elements each responsive to undulations in only one of the groove walls so that the two records may be reproduced separately without using external networks.

Since the recordings are disposed at the same angle to the record surface, quality differences may be substantially eliminated and for this reason the invention is particularly useful in stereophonic reproducing systems.

The invention will be more clearly understood from the following detailed description and the accompanying drawings in which:

Fig. 1 is a schematic of a two-channel recording system according to the invention in which the two recorder units are so disposed that each unit drives the stylus in one of the recording planes;

Fig. 2 is a schematic of an alternative recording system according to the invention which utilizes any combination recorder adapted to cut hill-and-dale and lateral undulations in the same groove;

Fig. 3 shows the vibrating system of one type of vibration translating device (recorder or reproducer) suitable for the system of Fig. 2;

Fig. 4 is a vector diagram illustrating the operation of the device of Fig. 3;

Fig. 5 shows the vibrating system of an electromagnetic type of recorder or reproducer suitable for the system of Fig. 1;

Figs. 6 and 7 show a cylindrical coil type recorder or reproducer for the system of Fig. 1;

Fig. 8 shows another electromagnetic type of device for the system of Fig. 1; and

Figs. 9 to 12, inclusive, show a flat coil type recorder or reproducer for the system of Fig. 1.

In the system of Fig. 1 two sources 15, 16 of currents representing sound are connected through amplifiers 17 and 18 to the windings 19 and 20, respectively, of the recorder 21 which has a single stylus 22 for forming a groove in the recording blank 23 on the turntable 24. It will be understood that the currents in the two channels 25 and 26 may be entirely unrelated or they may represent the same sounds as received at different pick-up positions as in a stereophonic system of any of the types discussed in Patent 2,019,616 to Maxfield, November 5, 1935.

The recorder 21 has been shown diagrammatically to represent any one of the various types in which each recorder unit effects vibrations of the stylus in one recording plane independently of the other unit. In the recorder of Fig. 5, two balanced armature electromagnetic units 31, 32 of the general type disclosed in Patent 1,663,884 to Harrison, March 27, 1928, are disposed side by side. Extending upwardly at an angle of 45 degrees (or any other desired angle α) from the shafts 33 and 34 on which the armatures 35 and 36 are mounted, there are driving arms 37, 38 connected by linkages 39 and 40 to the stylus holder 41 in which is mounted the stylus 42. In order to restrain the stylus to move only in the directions indicated by the lines 43 and 44 the stylus holder is secured to the stationary structure 45 of the recorder by a cantilever spring 46.

When the currents representing the sounds to be recorded are supplied to the windings 19 and 20 of the recorder units, the armatures 35 and 36 will be vibrated in accordance with these currents as fully explained in the Harrison patent referred to above. The linkage 39 will vibrate the stylus

parallel to the line 43 and the linkage 40 will vibrate it parallel to the line 44 and since each linkage, as indicated in the drawings, has a section of reduced stiffness at each end at which bending can occur, each unit of the recorder may impart motion to the stylus without interfering with the driving action of the other unit. As in the case of a single recorder unit, the stylus of this recorder will cut a plain or unmodulated groove of uniform depth when no current is applied to either unit. When only the unit 31 is energized the stylus is vibrated at an angle of 45 degrees to the record surface along lines parallel to line 43 and when both units are energized the stylus will have components of motion parallel to both of the lines 43 and 44.

Another type of recorder suitable for use with the system of Fig. 1 is shown in Figs. 6 and 7. In this construction the signal currents are applied to the coils 51, 52 which are mounted on the lightweight form 53 on opposite sides of and at an angle of 45 degrees (or any other angle α at which the recording planes are to be inclined to the surface of the recording material) to the tube 54 carrying the stylus 55. The coils are disposed in the air-gaps 56 and 57 defined by the pole-pieces 58, 59 and 60, 61 and the necessary steady flux is set up in the air-gaps by the magnets 62, 63. The springs for supporting this vibratory system may be of the type disclosed in Patent 2,027,168 to Harrison, January 7, 1936, namely, a V-shaped cantilever upper spring 64 secured to the stationary structure by the screw 65 and riveted to the tube 54 so as to be free to deflect both vertically and torsionally and a single wire spring 66 or its equivalent which stabilizes the system in its proper position.

Since the spring 64 is free to deflect both vertically and torsionally and is of high lateral stiffness due to its V-shaped construction, the vibrations of the coils 51 and 52 due to the reaction of the signal currents with the flux in the air-gaps will produce a motion of the stylus which has both horizontal and vertical components as in the structure previously described. The lines of the axes of the coils 51 and 52 pass below at the point of attachment of the pivot spring 64 so that the coil 51 vibrates the stylus along lines parallel to line 68 and coil 52 vibrates the stylus along lines parallel to line 69 and cuts a V-shaped groove having recordings in two planes at equal angles to the record surface.

A magnetic type recorder similar in operation to the moving coil structure just described is shown in Fig. 8. In this device a triangular form 47 carries two magnetic armatures 48 and 49 which are disposed at right angles to each other and are driven by the signal coils 50 on the pole-pieces of magnets 93. This vibrating system is supported by springs similar to those used for the device of Figs. 6 and 7 except that their relative position is preferably reversed, the single wire spring 94 being at the top and the V-shaped spring 95 being intermediate the armature and the stylus 96. Under the faces set up by the signal currents the system spring 95 will be deflected vertically and torsionally as in the structure of Fig. 6, but in this case the left-hand unit vibrates the stylus along line 97 and the right-hand unit vibrates it along line 98.

Another type of recorder suitable for the system of Fig. 1 is shown in Figs. 9 to 12. This device is a double flat coil recorder which is somewhat similar in principle to the single coil reproducer disclosed in Patent 2,034,872 to A. C. Keller, March 24, 1936. In this device the vibrating system is supported by two spaced parallel cantilever springs, the upper spring 71 being a single wire and the lower spring 72 being V-shaped to provide a vertically resilient pivot as in the reproducer of the Keller patent. This recorder also has pole-pieces defining a working gap for only one-half of each of the coils 73 and 74 which are mounted on the tubular member 75 carrying the stylus 76. The magnet 77 supplies flux to the pole-pieces 73 and 74 which are mounted on the tubular member 75 carrying the stylus 76. The magnet 77 supplies flux to the pole-pieces 78 and 79 which define the gaps 80, 81 for the coils 73, 74. The pole-piece 78 extends downwardly between the coils and presents pole-faces 82, 83 to the coils over their entire area but has a circular opening 84 opposite the coil core members 85 and 86 to provide vibrating clearance for the upper spring 71. The extension piece 87 of the pole-piece 79 presents a pole-face 88 to one diagonal half of the coil 73 and the extension piece 89 of the pole-piece 79 presents a pole-face 90 to the other diagonal half of the coil 74. The currents in the coil 73 from one of the sources 15 or 16 will drive the moving system about the pivot spring 72 to impart motion to the stylus along lines parallel to line 91. Similarly, currents in the coil 74 will drive the system to impart a vibratory motion to the stylus along lines parallel to line 92 and as in the case of the devices, previously described, both coils may drive the stylus simultaneously to produce separate recordings in the two walls of the groove.

The system of Fig. 2 produces a V-groove of the type already described by means of a recorder adapted to cut hill-and-dale and lateral undulations in the same groove. One such recorder, as shown in Fig. 3, comprises two electromagnetic units 101, 102 of the type disclosed in the Harrison patent referred to above. In this recorder the shaft 103 of the unit 101 has a horizontal arm 104 connected to the vertical arm 105 which is secured to the stylus holder 106 and is adapted to drive the stylus 107 vertically to cut a hill-and-dale record. The shaft 108 of the unit 102 has a vertically depending arm 109 and a horizontal arm 110 secured to the stylus holder 106 for driving the stylus laterally to produce a lateral cut record. The arm 110 has a section of reduced stiffness at each end and the arm 105 has a similar section at its upper end so that both units may drive the stylus simultaneously without reacting on one another and the vibrating system is constrained to move only in the desired modes by the cantilever spring 111.

In the system of Fig. 2 each of the sources 112 and 113 of signal currents is connected through amplifiers 113 to 116 and volume controls 117 to 120 to both of the recording channels 121 and 122 and these two channels are connected by the amplifiers 123 and 124 to the windings 125 and 126 of the units 101 and 102, respectively, of the recorder which is shown more in detail in Fig. 3. The volume controls 117 to 120 are adjusted so that the energy from each signal source is divided between the two recorder units in the proportions necessary to give equal vibratory amplitudes of the stylus in the two recording planes and the connections from the two sources to the units are so poled that the resulting stylus motions are normal to each other. With this arrangement, the signal currents from either of the sources 112 or 113 will actuate both recorder units. The unit 101 will tend to drive the stylus vertically and the

unit 102 will tend to drive it laterally so that the actual motion of the stylus due to signals from either source will be in accordance with the resultant of these forces and will be at an angle of 45 degrees to the surface of the record 127.

This will be more clearly understood from the vector diagram of Fig. 4 in which the vectors are designated by prime numbers corresponding to the amplifiers which tend to produce motion of the stylus in the direction indicated. At a given instant the output of amplifier 113 will actuate the unit 101 of the recorder to drive the stylus downwardly as indicated by vector 113' and at the same instant the output of amplifier 114 will actuate unit 102 to move the stylus to the left as indicated by the vector 114' so that the actual motion of the stylus at the instant chosen due to the currents from the source 112 will be along the vector 128 (Figs. 3 and 4) and corresponding undulations will be cut in the groove 129. Similarly the output of amplifier 115 associated with the source 132 will actuate unit 101 to move the stylus along the vector 115', and the output of amplifier 116, being connected with relatively opposite polarity to the channel 122 as compared with the connection of amplifier 114 to that channel, will actuate unit 102 to move the stylus along vector 116', that is, in the direction opposite to that of vector 114'. The resultant of these two forces produced by the sounds from the source 113 moves the stylus along the vector 130 and cuts undulations in groove 129 which are normal to those produced by the source 112.

When no signal currents are applied to either unit of any of the recorders discussed above, each will cut a V-shaped groove of uniform cross-section and of the average depth required to record the maximum amplitude variations without "cutting out" of the record material as in the case of any conventional recorder. When signal currents are applied, the groove will remain symmetrical with respect to the line 131 so long as the horizontal components of the faces applied to the stylus by the two recorder units are equal and opposite. This condition would obtain when the signal currents in the two recording channels are identical and the resulting recording would be merely a V-shaped hill-and-dale groove.

In practice, however, the two channels will carry currents which ordinarily differ in amplitude, frequency content, or phase relationship or any combination of these differences so that the resulting groove will undulate both laterally and vertically and the undulations in one recording plane will often be entirely different from those in the other recording plane.

The various structures shown in Fig. 3 and Figs. 5 to 12, inclusive, have been described as recorders, but it will be obvious to those skilled in the art that when proportioned according to well-known reproducer requirements they will also serve to reproduce both recordings in the groove simultaneously when connected to suitable amplifiers and loud-speakers.

While the principal advantage of this invention over the combination hill-and-dale lateral system is its ability to give two reproductions of identical quality as required in certain applications such as thereophonic reproduction, the invention may be used in various other ways. For example, one of the recording units may be used to make a record in which the volume range is compressed and the other unit may cut a control record to effect a complementary expansion in the volume range during reproduction.

Since the two recordings have vertical components in common, surface noise in reproduction can be materially reduced by cutting a sound record in only one of the recording planes and feeding back in reverse phase the output of the reproducer unit which is driven in the other plane into the circuit of the reproducer unit which is reproducing the recorded sounds.

Various modifications of and other uses for the systems and apparatus described will occur to those skilled in the art, but the invention is intended to be limited only by the scope of the following claims.

What is claimed is:

1. In a sound recording system, a record member, a stylus for forming grooves in the member, two stylus driving units having members vibrating in accordance with currents to be recorded and driving the stylus simultaneously in two planes at equal angles to the surface of the record member.

2. A vibration translating device comprising a stylus, means for supporting the stylus for vibration simultaneously in two planes at equal angles to the axis of the stylus, two vibration translating units, each having an element vibrating in one of the planes, and linkages connecting the elements to the stylus.

3. In a sound recording system, a record member, a stylus for forming grooves in the member, means for supporting the stylus for vibration simultaneously in two planes at equal angles to the surface of the member, two sources of currents to be recorded, and means responsive to the currents from each source for driving the stylus in one of the planes.

4. In a sound recording system, a record member, a hill-and-dale recording unit, a lateral recording unit, a stylus, linkages connecting the units to the stylus, two sources of currents to be recorded, unilaterally conducting circuits connecting each source to both recording units, and means in the circuits for varying the division energy from each source between the recording units.

5. A vibration translating device comprising a stylus, means for supporting the stylus for vibration simultaneously in two planes forming equal angles with the vertical axis of the stylus, two electromagnetic translating units disposed on opposite sides of the stylus, a vibrating armature in each of the units, and a driving connection between the stylus and each of the armatures.

6. A vibration translating device having a moving system comprising a stylus, a stylus holder and two coils mounted in spaced relation on the holder, means for producing a flux for each of the coils, and spaced parallel springs supporting the system for stylus vibrations in two planes forming equal angles with the vertical axis of the stylus.

7. In a sound recording system, a record member, a hill and dale recording unit, a lateral recording unit, a common stylus for the units, linkages connecting the units to the stylus, two sources of currents to be recorded, separate unilaterally conducting circuits supplying currents of the same polarity from the sources to the hill and dale unit and separate unilaterally conducting circuits simultaneously supplying currents of opposite polarities from the sources to the lateral unit.

ARTHUR C. KELLER.
IRAD S. RAFUSE.