Aug. 6, 1946. E. F. WATSON 2,405,246

SOUND RECORDING SYSTEM

Filed May 21, 1943 3 Sheets-Sheet 1

FIG. 1

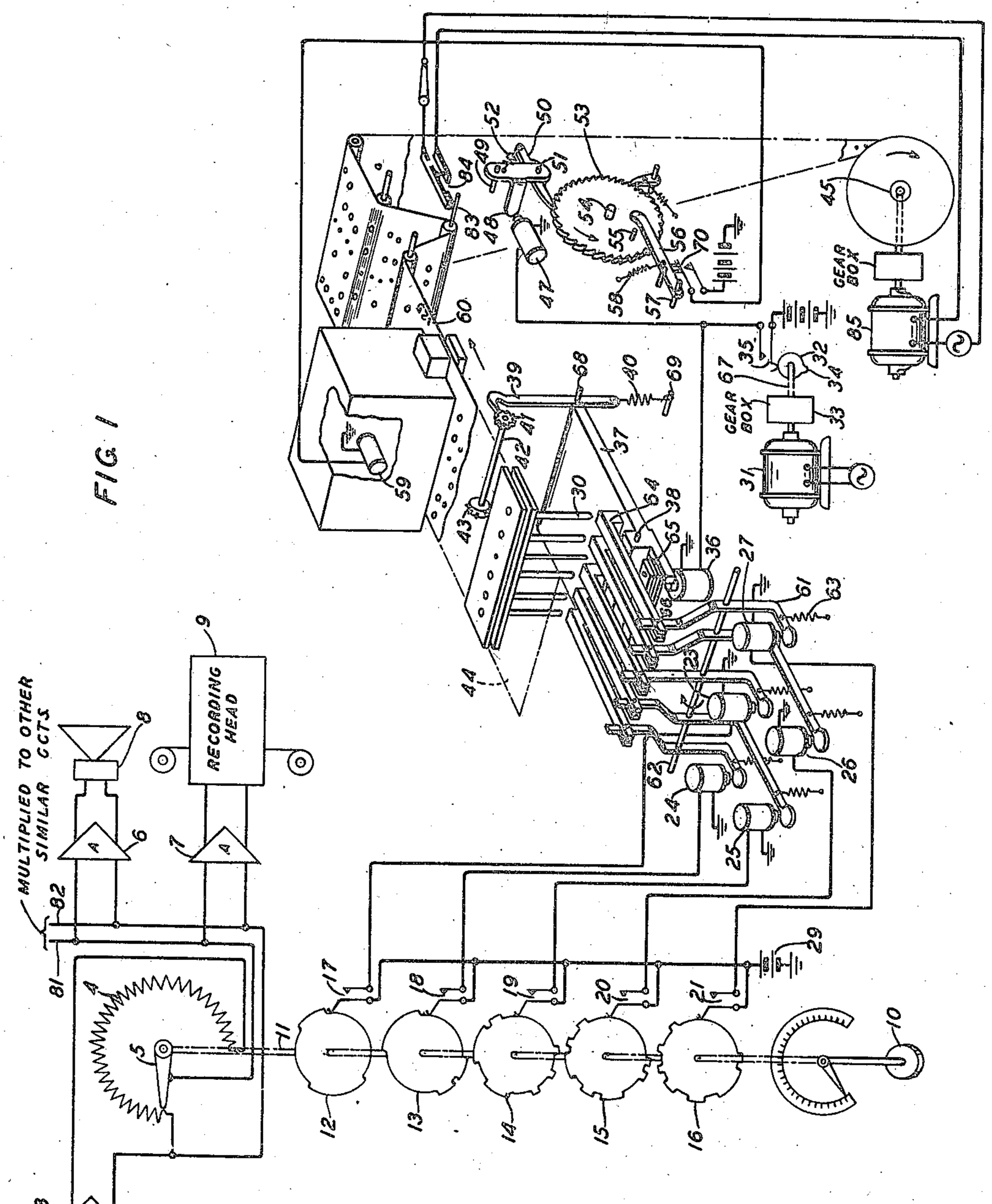

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FIG 2

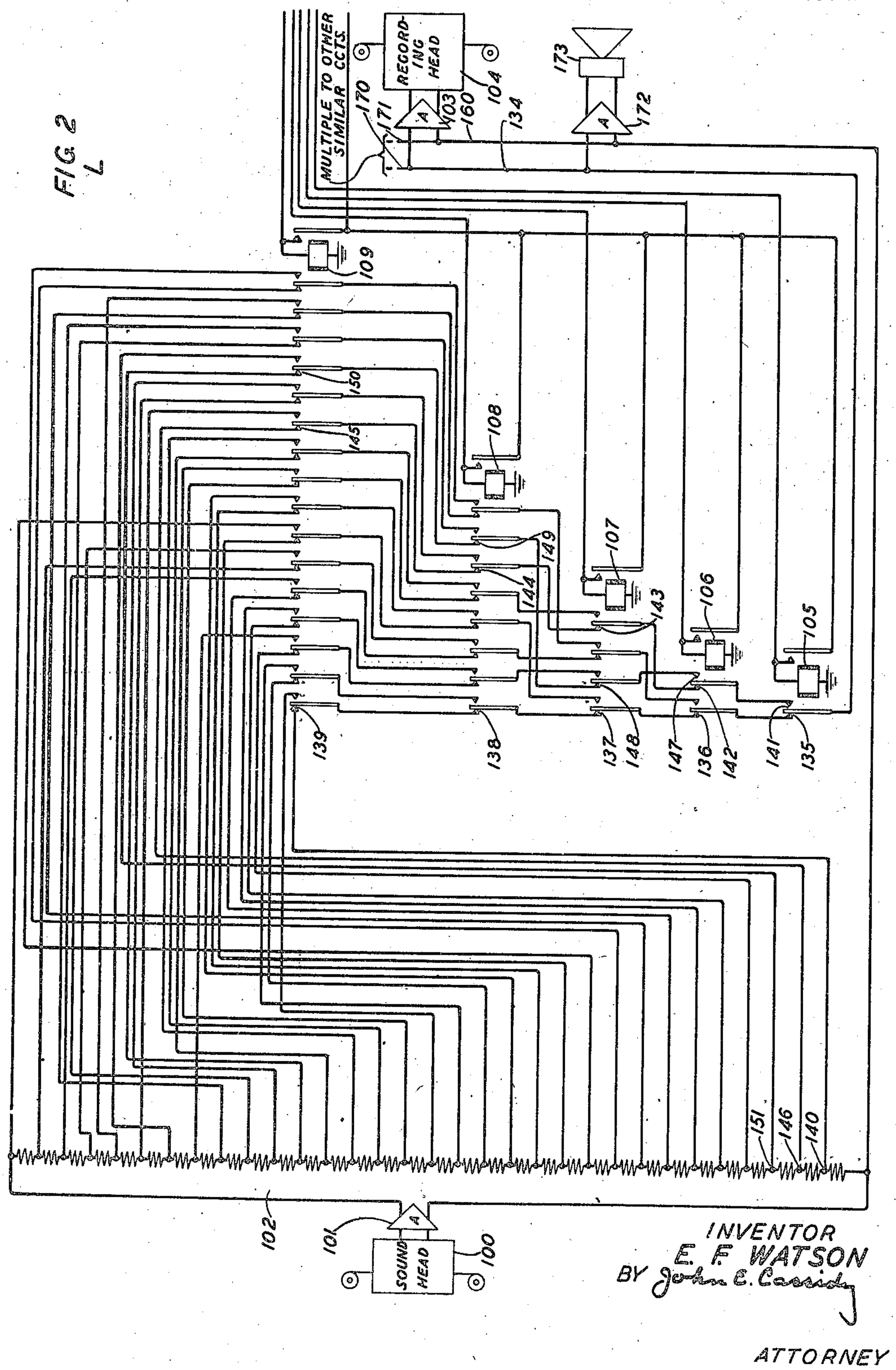

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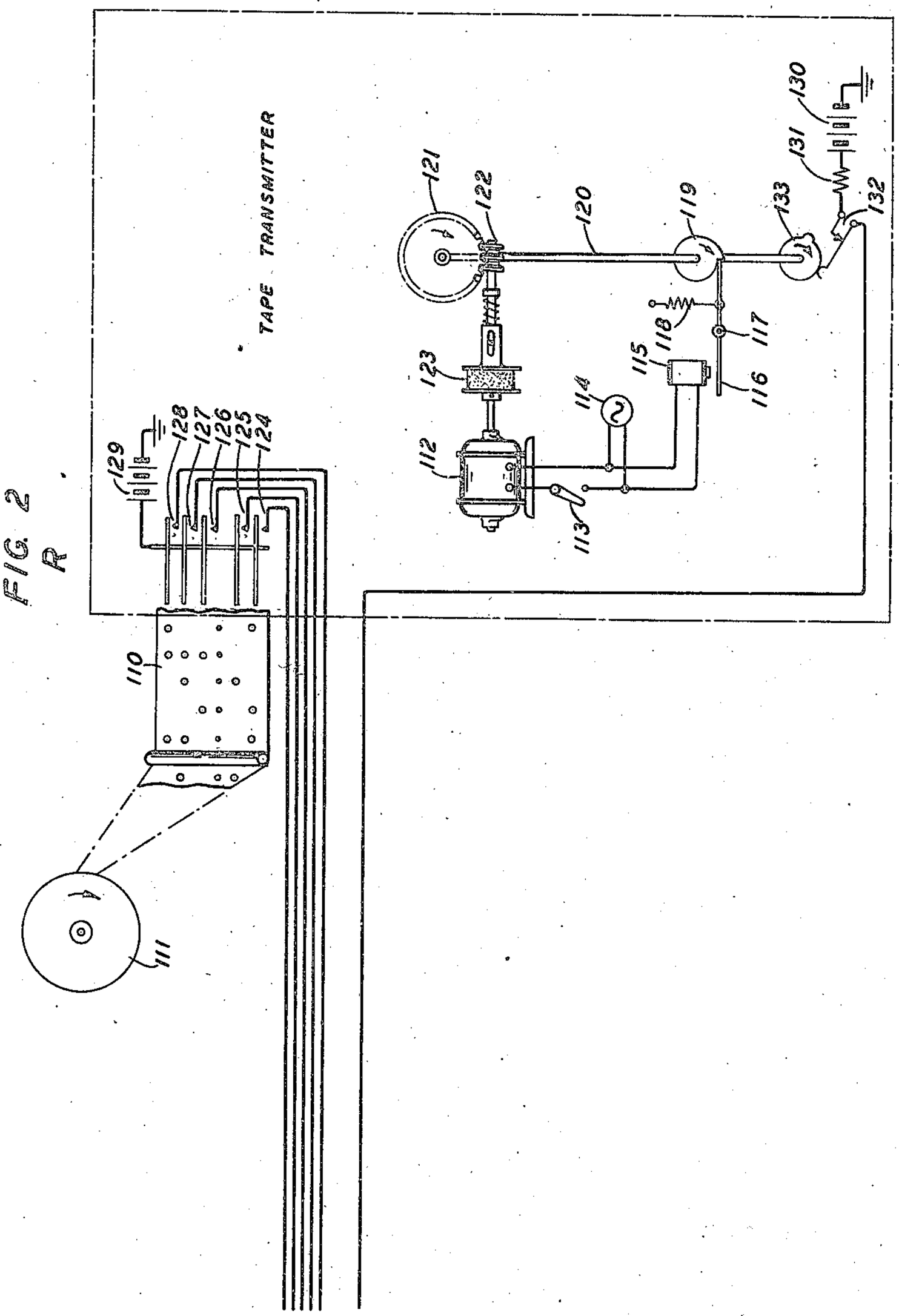
FIG. 2



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2,405,246

SOUND RECORDING SYSTEM

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Application May 21, 1943, Serial No. 487,890

8 Claims. (Cl. 179—100.3)

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This invention pertains to the recording of sound and more particularly to the recording of sound on film for use in conjunction with motion picture film. More specifically the invention pertains to the production of a control corresponding to the volume variations of sound as said sound is varied in the production of sound film.

An object of the invention is the improvement of controls employed to reproduce variations in sound volume in the manufacture of sound film.

In the sound motion picture industry at the present time it is the practice to combine the sounds produced in a number of sound sources into a single sound record. For instance, a record of the speech sounds occurring during the filming of a sequence will have added to it other sound effects such as music, etc. The picture film is projected and the various sound effects are integrated into a single sound tract at a rehearsal or a number of rehearsals. The volume of the sound from the separate sources is adjusted manually by an attendant or a number of attendants who operate controls, such as potentiometers or other volume controls, on what are known as sound mixer panels. Until recently, when it was found necessary to modify a sound track into which sound from a number of sources has been integrated, there were no means other than the memory and experience of the mixer attendants for reproducing exactly the original control settings and there was no record of such settings which might have been used as a reference for changes found necessary in the volume of the sounds from the various sources.

Recently means have been provided in the art for improving this situation. Record is made of the patent to Wolfe, 2,279,018, April 7, 1942, which provides a magnetic tape record of the control settings which is used to reproduce the settings. Experience has shown that the magnetic tape method of reproducing the settings of sound volume control apparatus is not entirely satisfactory.

The invention herein affords certain advantages over presently known arrangements, among the most important of which are its accuracy, its stability, and its economy and even more important, its ease of operation and its simplicity, as compared with presently known devices for performing the same function.

A feature of the invention is apparatus for translating control settings into permutation code signals which are recorded as punchings in a continuous tape. The tape is thereafter used to reproduce the original settings of the control instrument.

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The invention may be understood from the following description when read with reference to the drawings in which:

Fig. 1 discloses the means for translating each of thirty-two settings of a potentiometer or volume control into a different one of thirty-two different code combinations of contact settings in accordance with a five-element permutation code. It includes a circuit by means of which the permutation code signals are impressed on a set of five magnets which set in turn controls a set of five punches in a tape perforating device. Permutation code signals corresponding to the setting of the control instrument are thus punched in a continuous tape.

Fig. 2 is an arrangement for retranslating the permutation code signals punched in the tape produced in the apparatus per Fig. 1 into settings of a sound volume control device.

Refer now to Fig. 1. A sound head 1 comprising a sound track 2 and an electro-optical system, not shown but well known, is shown at the upper left of the figure. Electric currents corresponding to the variations in the sound track are impressed on amplifier 3. The full voltage of the output of amplifier 3 is impressed across the full resistance of potentiometer 4. Rotatable contact arm 5 of potentiometer 4 impresses gradations of the full voltage on amplifiers 6 and 7 in parallel, the outputs of which are connected respectively to a monitoring sound reproducer 8 and a sound recording device 9. Multiple branches 81 and 82 extend from the connections to the inputs of amplifiers 6 and 7. These connect to potentiometers such as 4 in as many other sound sources as are being integrated into a single record. It is emphasized that any number of sound sources without limit may be connected to a single recorder. Arm 5 is controlled by knob 10 through shaft 11 to which shaft the knob 10 and arm 5 are rigidly secured. Rigidly secured also to the shaft 11 are five cams 12 to 16. The cams 12 to 16 are conditioned to actuate their followers to control contacts 17 to 21, respectively. Rotatable arm 5 is conditioned to be rotated through an arc of 270 degrees. The arc is divided into thirty-two equal segments. The cams 12 to 16 are cut in a manner to provide thirty-two different permutative settings of contacts 17 to 21 each corresponding to a different one of the thirty-two segments. The control knob 10 is operated manually to vary the settings of potentiometer arm 5 and thus to regulate the input into amplifiers 6 and 7 which are connected across the output of the potentiometer. The volume of the sound is re-

corded by the recorder 9 and monitored by means of sound reproducer 8.

Magnets 23 to 27 are under control of contacts 17 to 21, respectively. When combinations of contacts 17 to 21 are closed, circuits are established from battery 29 through such of contacts 17 to 21 as are closed and the windings of the corresponding magnets 23 to 27 to ground, energizing the magnets. Magnets 23 to 27 are energized in permutative sets corresponding to the codes set up on contacts 17 to 21. Each of the magnets controls an armature such as 61 which is pivoted on a fixed rod 62. The left-hand end of each of the armatures is normally maintained in its lower or unoperated position under the influence of a tensioned spring, such as 63. When a magnet, such as 27, is operated the corresponding armature, such as 61, is rotated in a clockwise direction, as indicated by the arrow, against the tension of spring 63, about fixed rod 62. The left-hand end of a bar, such as 64, is connected by means of a pin, such as 65, to the top of each armature lever, such as 61. The five horizontal bars, such as 64, are supported by lateral support 65. When the armature is rotated in a clockwise direction the bar, such as 64, is moved to the right substantially horizontally so that its right-hand end is projected into alignment with a punch, such as 30.

The armature 37 of magnet 36 is conditioned to rotate in a limited arc about pivot 38. Attached to the right-hand end of the armature 37 by means of pin 68 is pawl lever 39. Attached to the lower end of pawl lever 39 is a spring 40 which is attached at its lower extremity to fixed bar 69. The spring is tensioned to draw the pawl downwardly, rotating the armature 37 about its pivot 38 in a clockwise direction. The armature 37 therefore is normally disengaged from the depending right-hand ends of the five horizontal punch bars, such as 64.

Motor 31 is driven synchronously with the films through the sound head 1. Motor 31 drives cam 32 through gear box 33 and shaft 67. Once in each rotation of cam 32 raised surface 34 on the periphery of cam 32 closes contact 35, energizing punch magnet 36. When magnet 36 is energized it attracts the left-hand end of armature 37 which in rotating in a counter-clockwise direction about pivot 38 raises the right-hand ends of the horizontal punch bar, such as 64. Those of the horizontal punch bars, such as 64, which have been actuated to their forward or right-hand positions will each engage with a punch, such as 30, which will be urged upwardly against the tension of springs, not shown, to perforate tape 44.

The tape is thus perforated in accordance with the code set up on the cams 12 to 16 which code in turn depends upon the setting of rotatable arm 5 of potentiometer 4. After the magnet 36 is deenergized spring 40 will restore armature 37 to its original position. Pawl 39 will be actuated downwardly. A left-hand projection on the top of pawl 39 engages with ratchet 41 which turns shaft 42, rotating spur wheel 43 which engages with a row of longitudinal perforations in tape 44, advancing the tape to the next punching position. The tape is wound on reel 45 which is driven by a motor 85. The motor is controlled by a displaceable roller 83, the vertical position of which is changed as the amount of unreeled slack in the punch tape varies. When the supply of punched tape reaches the minimum permissible the roller 83 is raised to its top position

opening contact 84, stopping motor 85 and reel 45.

When contact 35 is closed, as heretofore described, magnet 47 is also energized, attracting armature 48 which is thus rotated in a clockwise direction about pivot 49. Secured to the bottom of armature 48 is a lever 50 which is conditioned to rotate in a limited arc about pivot 51. The lever 50 is tensioned to rotate in a counter-clockwise direction by means of spring 52 which is connected to the upper portion of the armature 48 and the right-hand end of the lever 50. The left-hand end of the lever 50 is thus maintained in engagement with the periphery of gear 53. Each time the magnet 47 is energized gear 53 is rotated one step in a counter-clockwise direction about shaft 54. Once in each revolution of shaft 54 a pin 55 extending laterally from the front surface of gear 53 engages the right-hand end of lever 56, the left-hand end of which is conditioned to rotate in a limited arc about fixed pin 57. Lever 56 is actuated in a clockwise direction against the tension of spring 58 to close contact 70, thus energizing magnet 59. Magnet 59 in turn controls a counting and stamping mechanism in a well-known manner to stamp the film footage on the edge of the tape as indicated at 60.

The above-described mechanism cooperates to provide a tape in which thirty-two different five-element two-condition code symbols, each corresponding to a different one of thirty-two settings of rotatable arm 5 of potentiometer 4, may be recorded. One skilled in the art may interpret the code punchings visually directly from the tape and translate them mentally in terms of potentiometer settings quite readily. One of the advantages of the present arrangement, therefore, is that it provides an easily translatable, visual record of the successive potentiometer settings corresponding to the sound volume control recorded on the sound track. If it is decided that adjustments are necessary sections of the tape may be cut out and readily replaced with new sections of equal length modified as desired. If it is preferred, the sections of the tape which are modified may be made by rerunning the original sound track and resetting the potentiometer by adjusting the control 10 as desired after reference to the codes punched in the portion of the tape which is considered unsatisfactory. Or, if it is preferred, new codes may be punched in a new section of tape, using the punchings in the old portion for reference, by means completely independent of the mechanism described, such as a key-operated tape perforator which is well known.

The tape in its original form or modified in any convenient manner may be used to control the final sound recording by means of the mechanism per Fig. 2 which will now be described.

The output of a sound head 100 is impressed on the input of an amplifier 101. A potentiometer 102 is connected across the output of amplifier 101. The potentiometer is divided by means of taps connected between successive resistance elements so that the voltage impressed on the input of amplifier 103 which is connected to recording head 104 may be varied through thirty-two gradations corresponding to the thirty-two settings of the rotatable arm 5 of potentiometer 4. Thirty-two different selecting paths are provided through the contacts of the five-relay fan circuit comprising relays 105 to 109. The relays 105 to 109 are operated in accordance with the

permutation codes punched in the tape 110 which is the tape 44 modified as desired. The tape 110 is drawn off supply reel 111 by a sprocket in the tape transmitter driven from motor 112 synchronous with motor drive for sound head 100, and wound on a take-up reel, not shown, secured by suitable gearing to shaft 120. When switch 113 is closed power is supplied from power source 114 to motor 112 and the winding of magnet 115 in parallel. Normally the transmitter feed sprocket is driven from a cam on shaft 120 and is prevented from rotation by means of the right-hand end of armature lever 116 which is interposed in the path of a projecting shoulder on cam 119 rigidly secured to shaft 120. Spur gear 121 is rigidly secured to shaft 120 and engages worm gear 122 which is connected through friction clutch 123 to motor 112.

Magnet 115 when energized attracts the left-hand end of lever magnet 116 rotating it in a clockwise direction about fixed pin 117 against the influence of spring 118. The right-hand end of lever 116 is thus disengaged from the shoulder on the periphery of cam 119, permitting shaft 120 to rotate.

Tape 110 is drawn over five sensing pins. Where any of the five lateral positions in a transverse section of tape 110 is punched a sensing pin in a corresponding position is admitted through the opening and a corresponding one of contacts 124 to 128 is closed in a well-known manner. A circuit may thereupon be traced from battery 129 through such of the contacts 124 to 128 as are closed and the windings of the corresponding relays 105 to 109 operating the corresponding relays. The contacts of relays 105 to 109 will be closed in various patterns to establish a different one of each of thirty-two paths through the relay contacts for each of the thirty-two different code combinations which may be punched in the tape 110. Whenever a relay is operated it is locked over a path which may be traced from battery 130 through resistance 131 and contact 132 which is connected in parallel to an armature on each of relays 105 to 109 which cooperates with a locking contact on each of these relays to extend the path through the relay winding to ground. Contact 132 is under control of cam 133. The cam is arranged so that once in each revolution contact 132 is opened for a short interval, thus unlocking those of relays 105 to 109 which may have been operated by the particular code combination for an interval just sufficient for them to release so that the relays may respond to the next code combination. This interval is timed to correspond with the stepping of the tape from one code combination to the next.

The bottom terminal of amplifier 101 is connected to the bottom terminal of potentiometer 102 and the bottom terminal of amplifier 103. The top terminal of amplifier 101 is connected to the top terminal of potentiometer 102. Each of the thirty-two taps connected to the junctions of the resistance elements of potentiometer 102 extends through a different path through the contacts of relays 105 to 109 to conductor 134 which connects to the top terminal of amplifier 103. When relays 105 to 109 are each in the released condition, as shown in the drawings, upper conductor 134 extends through contacts 135, 136, 137, 138 and 139 to junction point 140 of potentiometer 102. If relay 105 is operated and relays 106 to 109 are released, a circuit may be traced from conductor 134 through contacts 141, 142, 143, 144 and 145 to junction point 146. If

relays 105 and 106 are operated and relays 107 to 109 are released, a circuit may be traced from conductor 134 through contacts 141, 147, 148, 149 and 150 to junction point 151. For each one of the other taps of potentiometer 102 there is a single selecting path extending through the relay contact fan circuit which is closed through the operation of the proper combination of relays 105 to 109.

It has been pointed out above that the final sound track is ordinarily made by controlling the volume of sound from a number of sources. Any number of separate sources may be employed for this purpose.

The mechanism which has been described in detail is arranged to provide a record of the variations in the volume of one sound source only. If more than one source is employed, which will almost invariably be the case, it will be necessary to provide a separate mechanism such as has been described for the production of a record corresponding to the variations of each sound source.

Attention is particularly called to the fact that a separate tape, such as 44, is prepared to record the potentiometer or volume control settings of each potentiometer or volume control which controls the output of the sound from each sound head, such as 1, which is connected to recording head 9. The multiple leads 81 and 82 which connect to the input of the common sound reproducer 8 and common sound recorder 9 are multipled to as many separate potentiometers, such as 4, as there are separate sound heads, such as 1. Voltages corresponding to the combined sounds are impressed on the input of amplifiers 6 and 7. An individual record of the settings of each potentiometer, such as 10, is recorded simultaneously in separate tapes, such as 44, by means of an individual tape perforating mechanism controlled by an individual set of permutation cams and contacts for each separate sound source.

If it is found desirable to modify the sound recording produced by the mechanism of Fig. 1, such of the individual tapes corresponding to 44 as are unsatisfactory are modified as desired. Then the original sound tracks used in preparing the original tapes are run through their respective sound heads. This time instead of connecting each sound head through a manually adjusted potentiometer, such as 4, to the recording head, each separate sound head is connected through a potentiometer, such as 102, which is controlled by a relay fan circuit in response to the modified codes in its respective tape.

Only one sound head and its associated tape controlled potentiometer are shown in detail. Conductors 134 and 160 which interconnect potentiometer 102 associated with sound head 100 and the common recorder 104 are multipled through conductors 170 and 171 to other potentiometers, such as 102 and 100, each of which is individually controlled by its respective tape, such as 110, and its own individual fan relay circuit corresponding to relays 105 to 109.

An amplifier 172 and a sound reproducer 173 serve for monitoring the production of the final sound record.

If it is desired, a permutation code of a larger number of elements may be used to provide finer adjustment. It would also be feasible to set a single group of a larger number of contacts permutatively to integrate the settings of a number of volume controls and thus provide a punched tape in which a single code having a larger

number of elements defines the setting of all of the potentiometers simultaneously.

What is claimed is:

1. In a sound recording system, means for varying sound volume, and means controlled in accordance with successive sound varying adjustments of said first named means for providing a visible permutation code record of said sound volume so varied, said record comprising visible permutation code combinations, at successive equal intervals, each individual combination corresponding to the full amplitude of said volume so varied, to facilitate the reading interpretation and modification of said record.

2. In a sound recording system, a volume control, means for varying the settings of said volume control, and means directly responsive to the operation of said varying means for perforating permutation code signals defining said variations in a tape.

3. In a sound recording system, a sound track, a sound reproducer connected thereto, a sound volume control intermediate said track and said reproducer, means for varying the settings of said control, means for recording a continuous series of permutation code signals defining said settings, said last means comprising a continuous tape, separate from said track, said tape having code combinations corresponding to said settings visibly impressed thereon at short equally spaced intervals.

4. In a sound recording system, a sound track, a sound reproducer, means intermediate said track and said reproducer for varying the volume of sound, means responsive to said variations for permutatively controlling a plurality of contacts, and means connected to said contacts for producing a visible permutation code record having a sequence of permutation codes each representing

a volume of sound characteristic of a small portion of said track.

5. In a sound recording system, a sound track recorded upon a medium, a sound reproducer, means intermediate said track and said reproducer for varying the volume of sound, and means responsive to changes in the setting of said sound varying means for producing a visible record of said settings in a medium separate from said sound medium, said record being a succession of permutation code combinations of visible elements, each of said code combinations corresponding to a particular setting of said varying means.

6. In a sound recording system, a sound track, a sound reproducer, a sound volume control, intermediate said track and said reproducer, for varying the volume of sound, a set of cams, a set of contacts controlled by said cams, means for varying the setting of said volume control, and means for controlling said contacts so as to set up a multielement permutation code signal corresponding to settings of said volume control.

7. In a sound recording system, a sound track, a sound recording device, a volume control intermediate said track and said device, a medium, a succession of permutation code combinations of visible conditions in said medium, and means capable of assuming successive permutative conditions under control of said medium for selectively setting said volume control in accordance with said conditions.

8. An elongated flexible medium, a sound volume control, and means directly responsive to changes in the setting of said control for physically impressing said medium with successive permutation code combinations representing sound volumes.

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