

June 10, 1930.

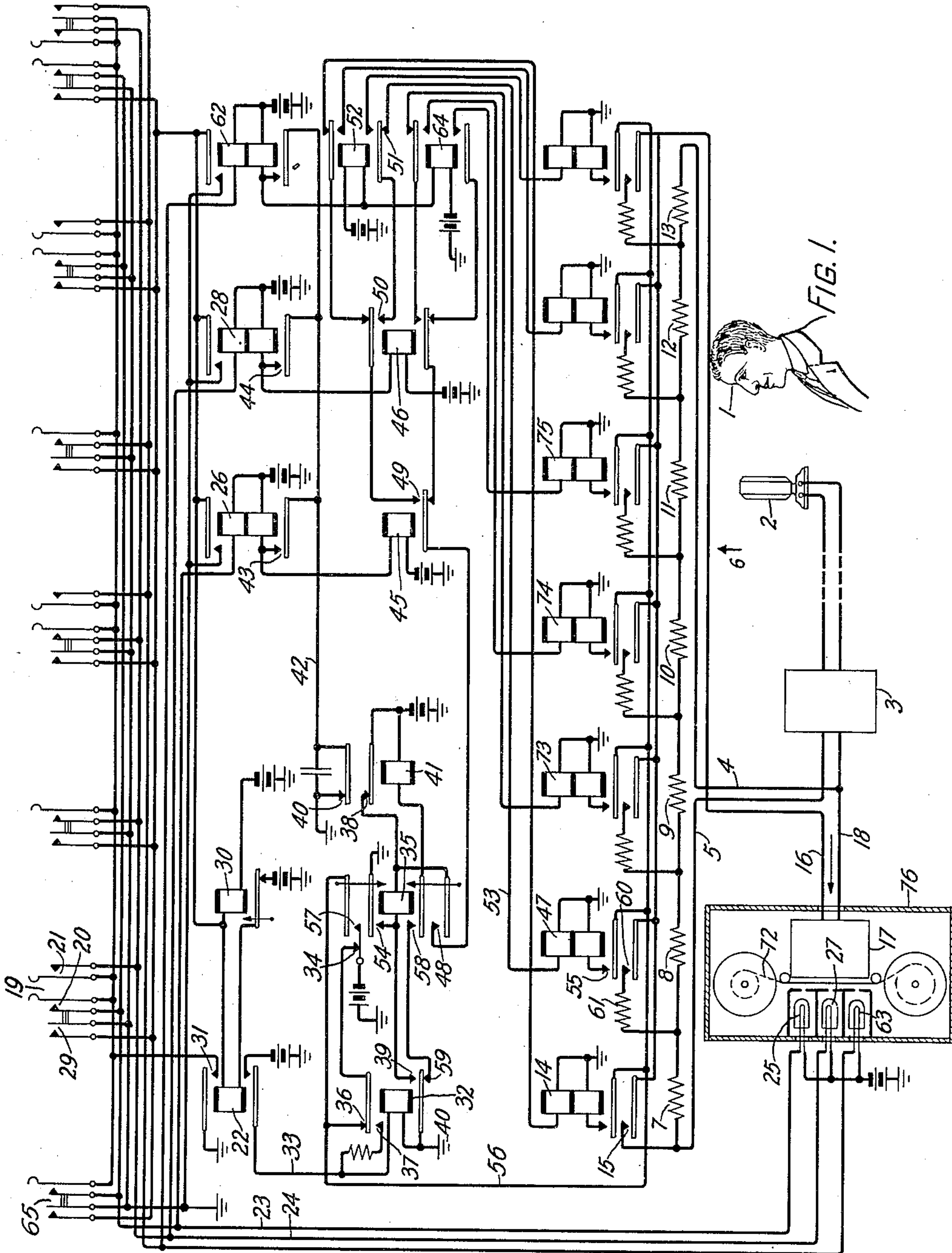
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1,762,727

VOLUME CONTROL SYSTEM

Filed Dec. 15, 1927

2 Sheets-Sheet 1



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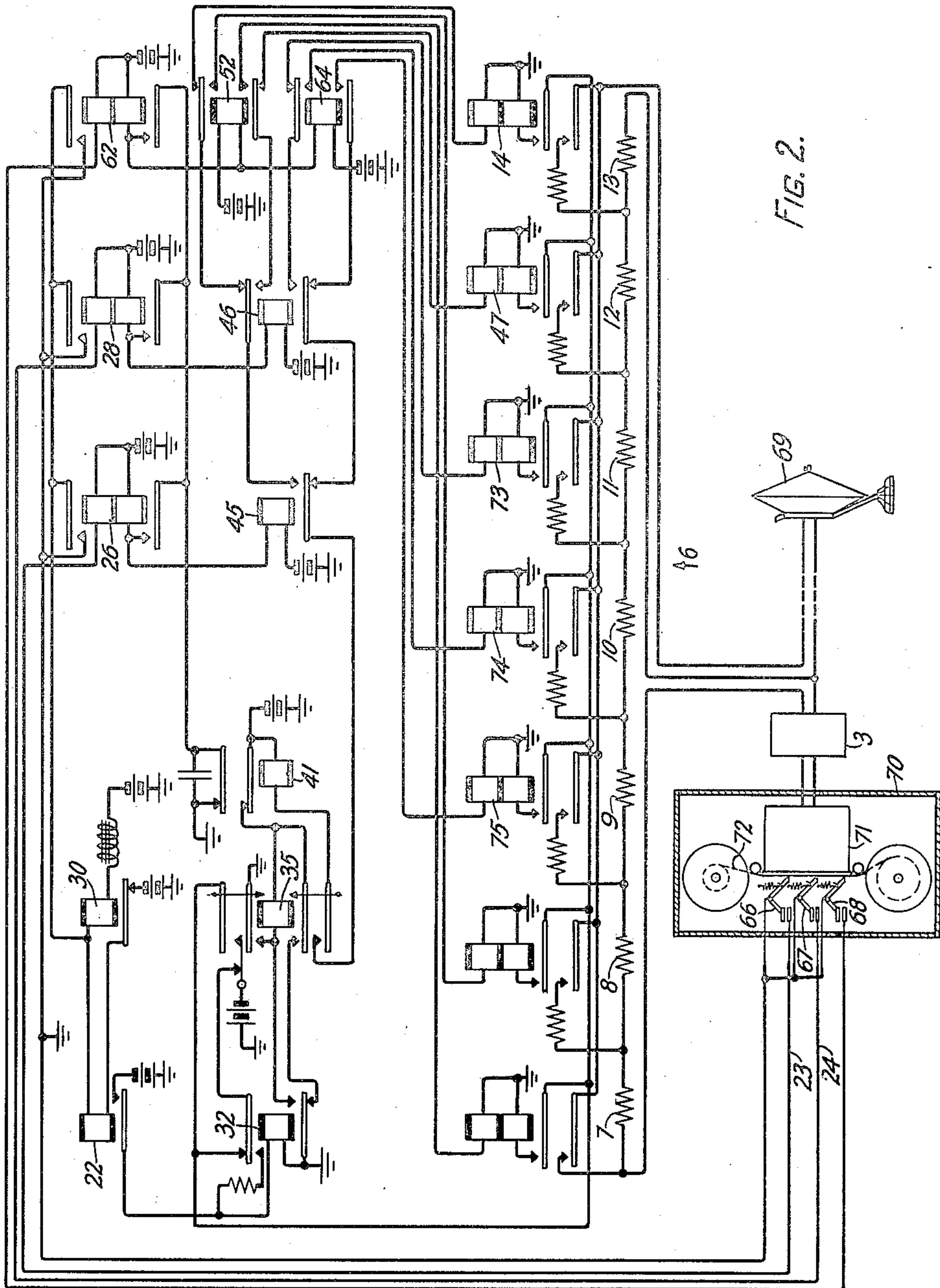


FIG. 2.

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VOLUME-CONTROL SYSTEM

Application filed December 15, 1927. Serial No. 240,105.

This invention relates to sound recording and reproducing systems and more particularly to volume control for such systems.

The object of the invention is to provide novel methods of extending the effective range of sound recording and reproducing systems.

Due to the limitations inherent in recording material and apparatus, it is impractical to record a volume range much in excess of 40 TU without employing some form of volume compression. Heretofore, it has been proposed to increase the volume range of recording and reproducing systems by recording a uniform intensity and making a second record of the variations necessary to obtain uniform intensity. The second record then serves as a volume control during reproduction and restores the level of each part of the first record to its proper relative level. In accordance with this invention only one record is made but the loss in the recording circuit is varied from time to time to keep the sound level within the recording limits. When such changes are made the record is marked accordingly, and these markings serve to effect compensating changes of sound level in the reproducing circuit.

The method of marking the sound record may take any one of various forms, that is to say, changes in the amount of compression used may be represented in various ways such as by different intensities, different frequencies or different lateral locations.

While the general features of this invention have been stated above, the invention will be more easily understood by referring to the following detailed description of one of its particular embodiments as illustrated in the accompanying drawings. These drawings are based on that method of recording wherein different lateral locations of the indicative marks are used to represent various amounts of volume compression. Fig. 1 illustrates in diagrammatical form the arrangement of the apparatus used in recording and Fig. 2 shows a somewhat similar disposition of the apparatus adapted for reproducing.

The operation of the invention during the recording process will now be described.

Sound vibrations emanating from the sound source 1 are picked up and translated into electric currents by the microphone 2. These currents are amplified by amplifier 3, conducted over wires 4 and 5 and impressed upon that part of potentiometer 6, consisting of resistances 7 to 13 in series. During normal operation, that is, when no compression is required, relay 14 is in its actuated position. A circuit including contact 15 of relay 14 and conductors 4, 16 and 18 is then complete from the potentiometer resistances already enumerated to recording device 17, and it is evident that the full voltage impressed upon the potentiometer is also applied to the recording device in projection machine 76.

The recording operator who follows the musical score may observe that a sound peak is about to be reached and that it will be necessary to insert say a 10 TU loss in the recording circuit. He thereupon actuates key 19. The operation of this key first closes contacts 20 and 21, thereby preparing a path from the upper contact 31 of relay 22 through contacts 20 and 21 to wires 23 and 24 which lead to recording lamp 25 and the winding of relay 26, and the recording lamp 27 and the winding of relay 28 respectively. After these circuits have been prepared contact 29 of key 19 closes, completing the operating circuit of relays 22 and 30 from ground through contact 29, through the relay windings in parallel to grounded battery. Relay 30, however, is slow acting and does not operate at this time. The operation of relay 22 completes the circuits prepared above by grounding its upper contact 31. The recording lamps 25 and 27 will then be flashed simultaneously to record on the film two spots in the positions chosen to indicate that a 10 TU loss is being inserted in the recording circuit. Relays 26 and 28 will also be operated upon the grounding of contact 31 since they are in parallel with lamps 25 and 27 respectively. The operation of relay 22 also completes a circuit for relay 32 extending from grounded battery through conductor 33 and winding of relay 32 to ground.

The operation of relay 32 opens the circuit extending from battery through the upper

make contact 34 of relay 35, through upper break contact 36 of relay 32, through the upper make contact of relay 14, to ground through the winding of that relay causing it to release. The upper contact 37 in closing locks relay 32 in its operated position over an obvious circuit. Relay 32 also completes the operating circuit of relay 35 from grounded battery, through contact 38, relay winding and contact 39 of relay 32 to ground. Relay 35, however, is slow acting and does not operate at this time.

The relays 26 and 28 having been operated, a locking circuit from ground through contact 40 of relay 41, conductor 42, contacts 43 and 44, and relay windings to grounded battery is now complete and relays 26 and 28 are locked up. The upper contacts of these relays are in parallel with key contacts 29 and serve no useful purpose during recording. Operating circuits are also complete for relays 45 and 46 from contacts 43 and 44 through relay windings to grounded battery. Slow acting relay 30, which has already been energized, is so timed that it operates a short time after relays 26 and 28. The operation of this relay deenergizes relay 22 by disconnecting the battery at its lower contact and relay 22 in its turn opens the operating circuits previously made, namely, those of relays 26, 28, and 32 and those of recording lamps 25 and 27. It should be remembered, however, that while the lamps are extinguished after only a momentary flash, the relays are held operated by their locking circuits.

Slow acting relay 35 is arranged to close its contacts and lock up through contact 54 about .02 second after its operating circuit which has already been traced, is made. In closing, this relay opens contact 34, thereby releasing relay 32 which has already been held operated a sufficient time to insure the release of relay 14. The operating circuit for the potentiometer relay 47 is now complete and is traced from grounded battery through contact 38 of relay 41, contact 48 of relay 35, contacts 49 and 50 of relays 45 and 46, which have already been operated, contact 51 of relay 52, conductor 53, and winding of relay 47 to ground.

The operation of relay 47 restores the recording circuit opened by relay 14 and completes a locking circuit for itself prepared by the operation of relay 35 and extending from ground through contact 55, conductor 56, contact 57 of relay 35 to grounded battery. The release of relay 32 by relay 35 closes contact 36 to prepare, for the next operation, a path for the holding circuit of the potentiometer relays and completes a circuit for relay 41, from the battery through winding of relay 41, contact 58 and contact 59, to ground. The operation of relay 41 opens the holding circuit of relays 26 and 28 and the operating circuits

of relays 45 and 46 at contact 40, causing these relays to release. By opening contact 38 relay 41 also releases relay 35 which opens the operating circuit of relay 47 at contact 48, thereby preventing the false operation of another potentiometer relay before relays 45 and 46 have fully released. The release of relay 35 releases relay 41 by opening its operating circuit at contact 58 and transfers the potentiometer relay holding battery from contact 57 to contact 34 of that relay. The reclosing of contact 34 places the potentiometer relay holding circuit again under the control of relay 32 preparatory to the operation of another key.

It should be noted that the circuit is now restored to its original condition except that potentiometer relay 47 is operated instead of potentiometer relay 14. It will be remembered that the recording circuit was opened by relay 14 which was released when key 19 was first actuated. At its lower contact 60, relay 47 recloses a circuit through resistance 61 for the recording device 17. The full volume of the output of amplifier 3 is, however, no longer impressed upon the recorder since resistance 7 no longer forms a part of the recording circuit. This circuit now extends from recording device 17, through conductor 18, resistances 13 to 7, 61, contact 60, conductor 16, to recording device 17.

The operation of the recording mechanism thus far described consists then in actuating the proper key to introduce the desired loss in a recording circuit. This is accomplished by first releasing the last previously operated potentiometer relay to momentarily open the recording circuit, and then closing the circuit again at the proper point along the potentiometer winding to give the desired change in volume level.

When it becomes necessary to again modify the volume level another key will be actuated and another cycle of operations will occur in a manner similar to that already described. A different combination of the relays 26, 28 and 62 will be energized and a different combination of lamps 25, 27 and 63 will be flashed, depending, of course, upon which key is chosen. This combination of relays will then determine what combination of relays 45, 46, 64 and 52 is to be energized. The position of the contacts of these latter relays will in turn determine which potentiometer relay is to be operated. The operation of any key, however, will release the potentiometer relay which is then energized, close the relay corresponding to the key operated and flash the proper combination of lamps to mark the film accordingly. In this way, a complete record of a musical selection is recorded upon the film. By properly adjusting the volume level from time to time during reproduction from this record the en-

tire composition is reproduced at its original volume throughout.

The reproducing apparatus for making these adjustments automatically is substantially a duplicate of that shown in Fig. 1 except that the keys 65, 19, etc. are omitted, the recording lamps are replaced by contact fingers 66, 67 and 68 and the microphone 2 is replaced by a loud speaker 69. A copy of the sound record is perforated according to the markings made on it during recording before being inserted in the projection machine 70, wherein a source of light, (not shown) actuates a photoelectric cell 71, through the film 72, in the well-known manner. Current variations are then amplified and impressed upon the loud speaker in the usual way.

As in the recording process, the output of the amplifier 3 is impressed upon the series of resistances 7 to 13 of potentiometer 6. For normal operation in reproducing, however, the loud speaker is not connected directly in parallel with the amplifier. Instead it is connected across only resistance 13 by means of relay 14. Accordingly when the projection machine is reproducing those parts of the record in which there is no compression, there is a 60 TU loss in the loud speaker circuit. When that part of the film in which was a 10 TU loss reaches the contact fingers, fingers 66 and 67 which correspond to the recording lamps 25 and 27 in the recording apparatus, will move into the perforations in the film and close their contacts. Circuits are then complete for operating relays 26 and 28 from common ground over wires 23 and 24 to relay windings and grounded battery. These relays complete the operating circuits of relays 22 and 30, 45 and 46, and their own locking circuits as in recording. The operation of relay 22 operates relay 32 and by the same sequence of operations as described in recording, relay 14 is released and relay 47 operated. It should be noted, however, that in the reproducing potentiometer the leads to the relays are reversed so that relay 47 in this case adds resistance 12 to resistance 13 in the loud speaker circuit. This introduces a 10 TU gain in that circuit which compensates for the 10 TU loss inserted during the recording process.

In a similar manner markings corresponding to a 20, 30, or 40 TU loss in the recording circuit will actuate potentiometer relay 73, 74, or 75, to raise the volume level in the reproducing circuit a corresponding amount.

By making the contact fingers adjustable with respect to the sound record and arranging them in the proper relative location with respect to the reproducer, any slight differences in the time required for the operation of the compression and expansion systems can be readily counteracted so that changes in

the volume level in the reproducer circuit will be made at exactly the proper moments.

It is evident then, that each loss inserted in the recording circuit is properly compensated by a corresponding gain in the reproducer circuit and that the several parts of the composition are reproduced with the same relative volume levels as were impressed upon the recording potentiometer.

What is claimed is:

1. A method of recording and reproducing a wider range of sounds than recording material will ordinarily permit which consists of varying the loss in the recording circuit according to the limitations of the recording material, making a single record of the sounds, marking the record at intervals only with code markings in accordance with the loss inserted, reproducing the record and varying the gain in the reproducing circuit according to the markings.

2. In a recording and reproducing system a source of sound waves, a film, means for translating said waves into electric currents, means for modifying said currents in accordance with the limitations of said system, recording means for making a single record of said modified currents upon said film and marking said film at intervals only with code markings representing the modifications of said currents, reproducing means for reproducing and remodifying said currents to their original values in accordance with said markings, and retranslating means for translating said currents again into sound waves.

3. A method of recording a wide range of sound intensities which consists in translating the sounds to be recorded into corresponding electric currents, amplifying the currents so that the sounds in the pianissimo range are represented by currents well above the lower limit of the recording medium, arbitrarily inserting when necessary sufficient loss in the recorder circuit to prevent the currents from exceeding the upper limit of the medium, making a single record of the currents, and marking the record at intervals only with code markings representing the loss inserted.

In witness whereof, I hereunto subscribe my name this 13th day of December, A. D. 1927.

ROBERT C. MATHES.