

June 10, 1930.

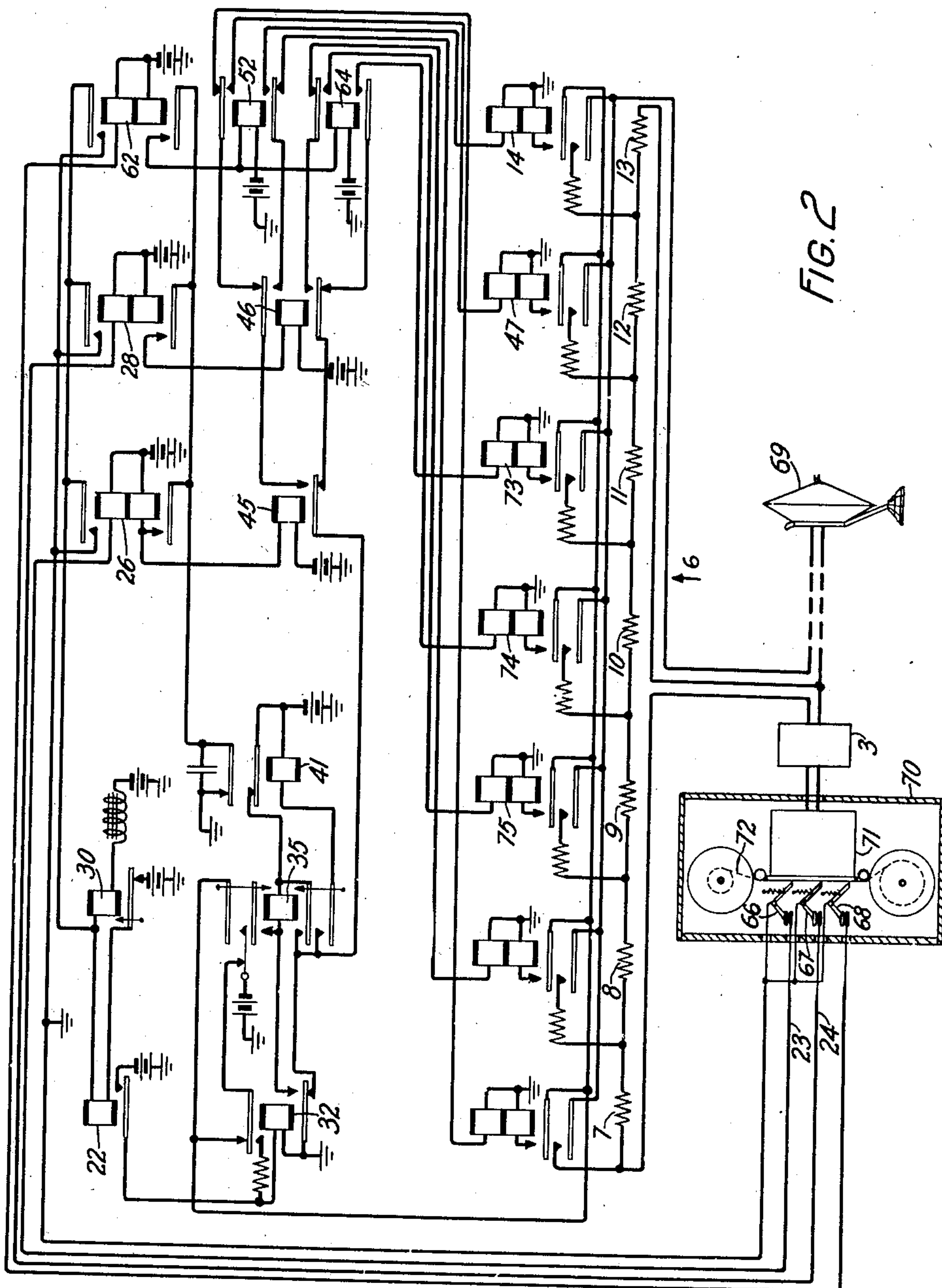
J. C. BURKHOLDER, JR

1,762,759

VOLUME CONTROL SYSTEM

Filed Dec. 15, 1927

2 Sheets-Sheet 2



INVENTOR
JOHN C. BURKHOLDER, JR.
BY *G. M. Campbell*
ATTORNEY

UNITED STATES PATENT OFFICE

JOHN C. BURKHOLDER, JR., OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

VOLUME-CONTROL SYSTEM

Application filed December 15, 1927. Serial No. 240,118.

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

5 The object of the invention in general is to provide means for overcoming the volume range limitations of sound film.

In accordance with the general features of this invention a number of relays under the
10 control of corresponding keys at the recording point vary the setting of a potentiometer to thereby keep the sound currents within the range limits of the recording material. Each change in the potentiometer setting flashes
15 a different combination of lights to mark the sound record. In reproducing, when sound films are used for instance, the reproducing film is perforated where markings occur and contacts closing through these perforations
20 actuate relays controlling a reproducing potentiometer to restore the sound level to its original value at all times.

Referring now to the drawings,

Fig. 1 illustrates in diagrammatic form an
25 embodiment of the invention as used for sound recording and compressing the volume range when necessary, and

Fig. 2 shows the arrangement of Fig. 1 modified to adapt it to reproducing the sound
30 recorded and expanding the volume range to its original value at all times.

It has been found that due to limitations of the film emulsion and of the recording device the maximum volume range which it is
35 practical to record on film is about 40 TU. Satisfactory recording of music, however, demands a volume range of approximately 100 TU. Accordingly the present invention provides for volume compression and expansion
40 in six steps of 10 TU each.

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
45 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
50 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
55 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
60 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 prepar-
65 ing 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
70 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
75 ground through contact 29, through the relay windings in parallel to grounded bat- tery. Relay 30, however, is slow acting and does not operate at this time. The operation
80 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
85 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
90 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
95 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
100 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 entire 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. In a sound film recording and reproducing system, a source of sound, a film, recording and reproducing means including a recording and a reproducing volume control device each comprising a potentiometer and a plurality of relays, selectively operable means for operating said recording control device and for marking said film to correspond to each operation, and means selectively operated by said markings for operating said reproducing control device to compensate for changes in volume level introduced by said recording control device.

2. In a sound recording system, a source of sound waves, a film, means for translating said waves into electrical currents, a potentiometer for maintaining said currents within the capacity of said system, recording means for recording said currents on said film, and a plurality of lamps arranged to mark said film in accordance with the setting of said potentiometer.

3. In a sound reproducing system, a sound record in which the amplitude of some of the sounds recorded has been arbitrarily modified during recording to adapt it to the limitations of the record and having code control markings at intervals only representing the modifications in amplitude, means including a loud speaking device for reproducing said record, a potentiometer arranged to adjust the volume level of said device, and means operated by said markings for operating said potentiometer.

4. In a sound recording system, a source of sound waves, a film, means for translating the waves into electric currents, a recording device for recording the currents on the film, a potentiometer composed of a number of sections interposed between the translating means and the recorder, a key and relay means associated with each of the sections for varying the attenuation of the currents in the recorder circuit, and means arranged to mark the film at intervals in accordance with changes of setting of the potentiometer.

5. In a sound reproducing system, a sound record having control perforations, means including, a loud speaking device, for reproducing the record, a potentiometer composed of a number of sections for controlling the volume level of the device, a plurality of relays associated with the potentiometer, and a plurality of contacts controlled by the perforations for selectively operating the potentiometer relays.

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

JOHN C. BURKHOLDER, JR.