

Aug. 30, 1966

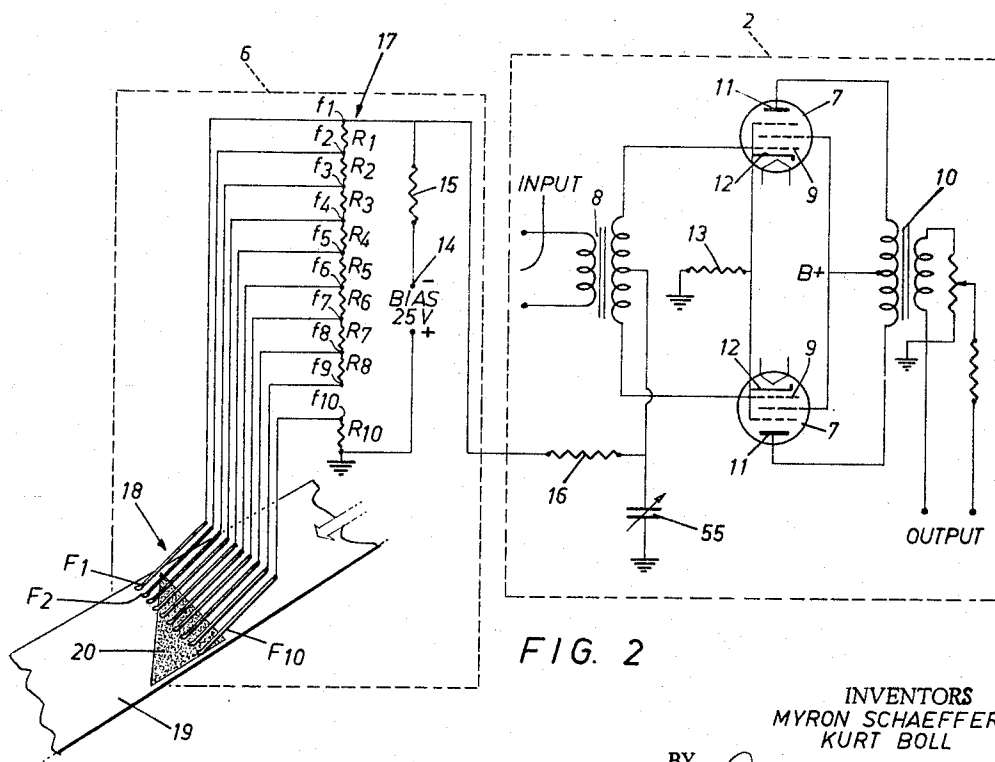
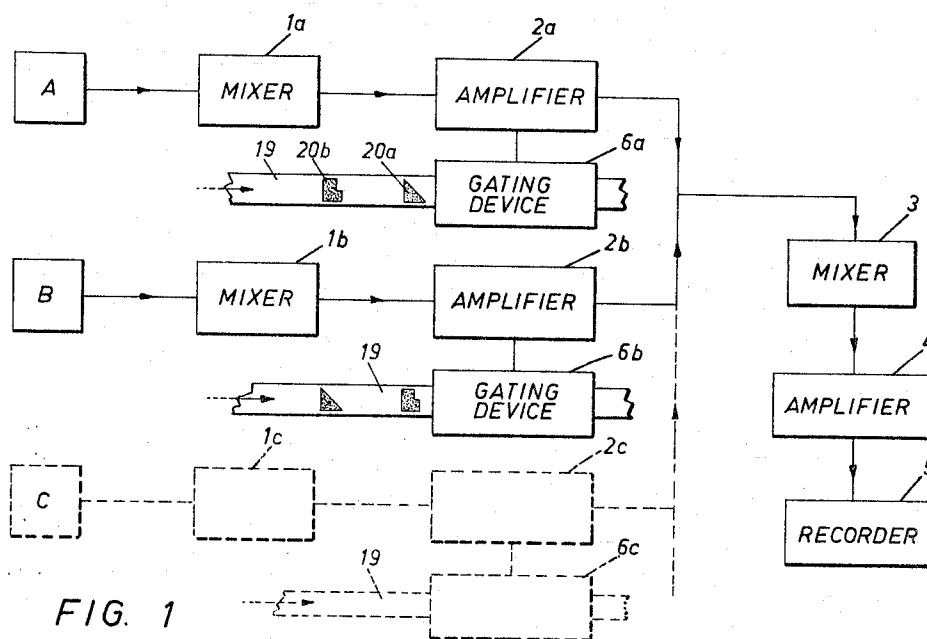
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CONTROL MEANS FOR CONTROLLING ELECTRO MECHANICAL PHENOMENA

Filed June 21, 1962

4 Sheets-Sheet 1



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CONTROL MEANS FOR CONTROLLING ELECTRO MECHANICAL PHENOMENA

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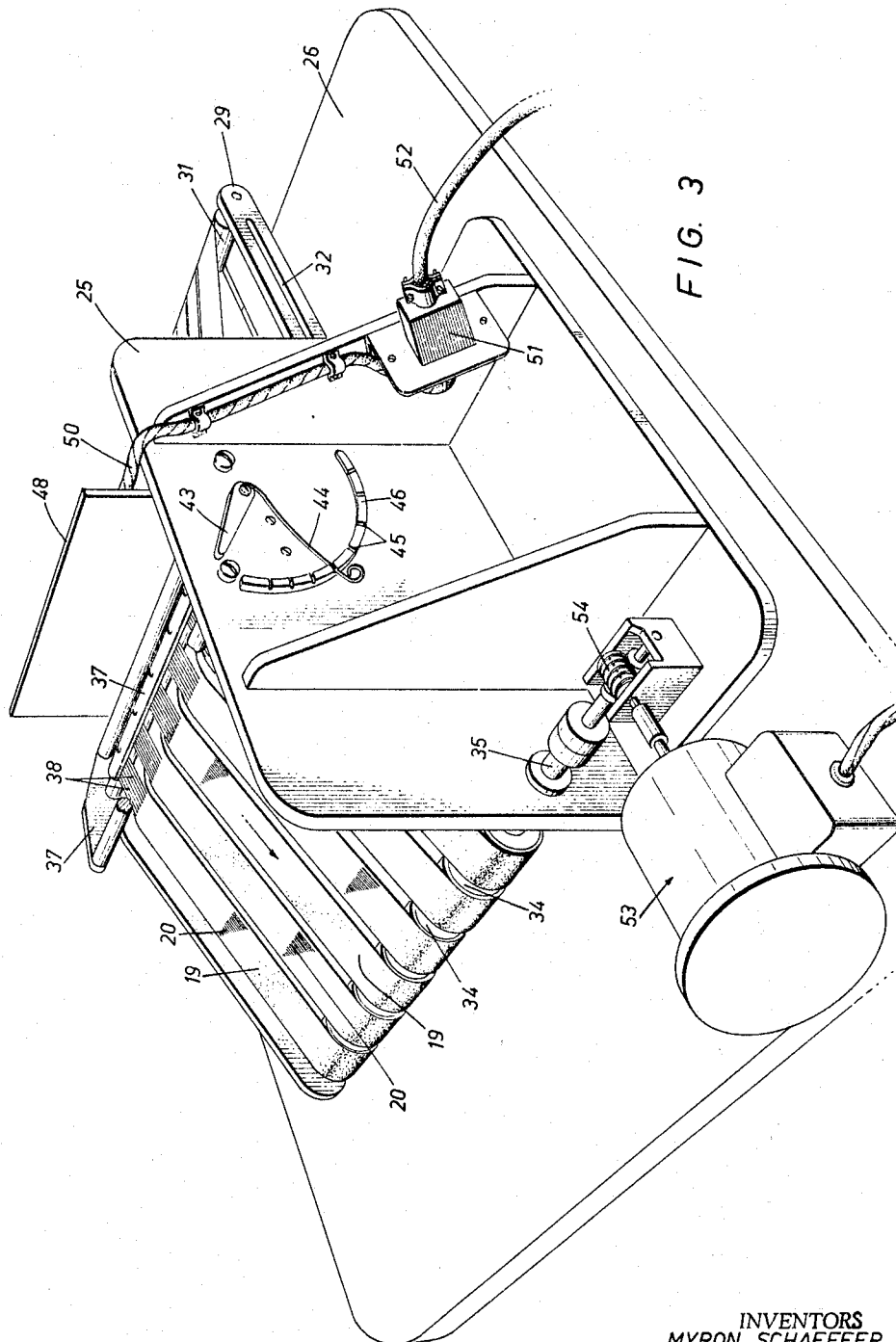


FIG. 3

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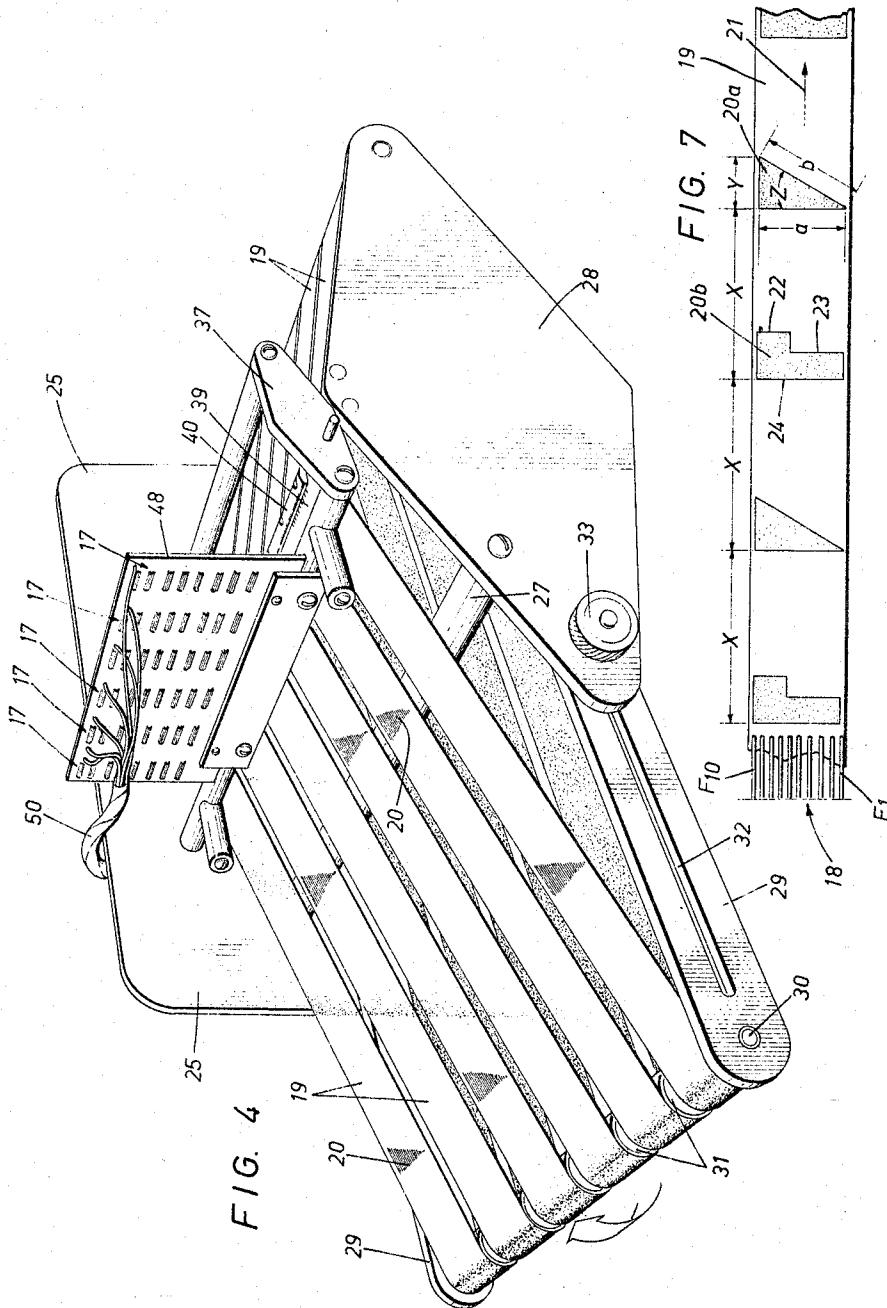
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CONTROL MEANS FOR CONTROLLING ELECTRO MECHANICAL PHENOMENA

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4 Sheets-Sheet 3



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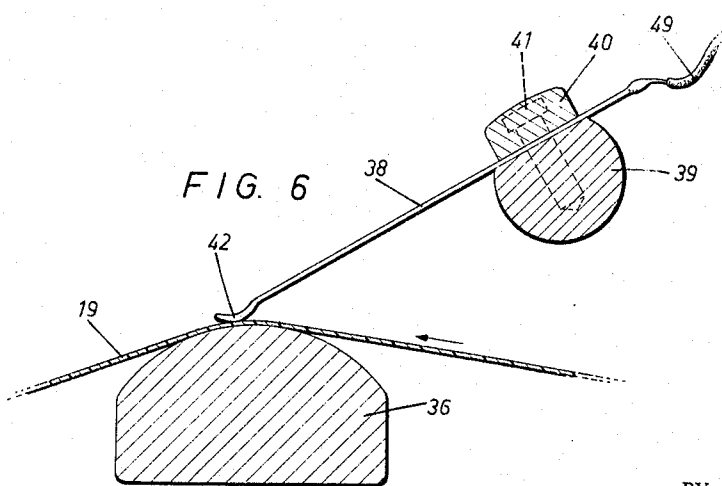
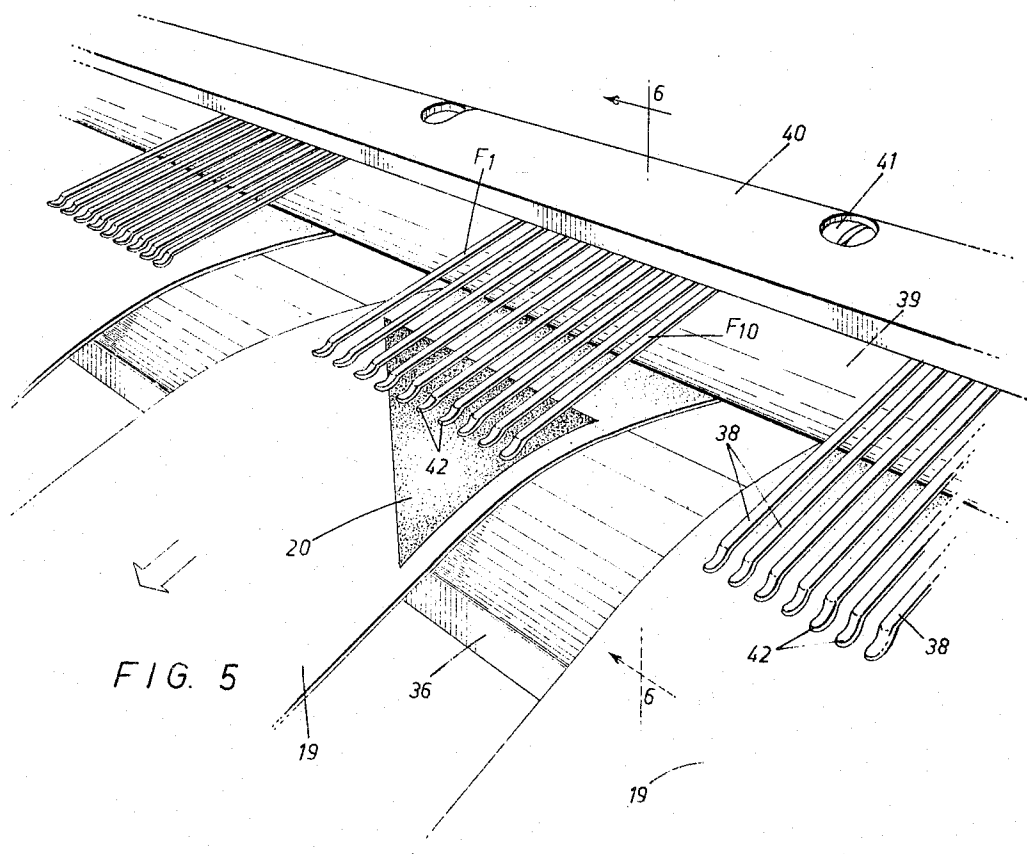
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CONTROL MEANS FOR CONTROLLING ELECTRO MECHANICAL PHENOMENA

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4 Sheets-Sheet 4



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CONTROL MEANS FOR CONTROLLING ELECTRO-MECHANICAL PHENOMENA

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This invention relates to improvements in control means for controlling electro-mechanical phenomena useful wherever control of a single responsive operation is desired. A particular application of the invention is in the art of production of electronic music and, for example, in this application the invention provides an improved method and means which will greatly facilitate and simplify the creation of electronic musical compositions.

In this specific application of the invention it is to be pointed out that with the development of the magnetic tape recorder there has been widespread interest and use of synthesized or electronic music created through the use of electronic and mechanical devices. Such synthetic or electronic music is created by using a wide range of sounds of traditional as well as new timbres obtained through a microphone or from electronic sound generators. These sounds may further be filtered, or otherwise altered or manipulated and stored in the resulting form on a magnetic tape.

To produce the final synthetic musical product according to the usual procedures the stored sounds are combined by cutting and splicing portions of the various tapes on which the stored sounds have been recorded in such a way that an organized musical composition results.

However, in producing such organized synthetic musical compositions many different problems arise. For example, it is very difficult in the cutting and splicing steps to ensure the synchronization of melodic units into a contrapuntal texture, or to ensure the organization of sounds into complex rhythmic continuities.

Again, the shaping of individual sounds in relation to their attack, continuum and decay patterns is very difficult, according to present practices. Moreover, with the present tape assemblage method, it is virtually impossible to reproduce the exact rhythmic patterns with varying timbres while, at the same time, increasing or decreasing the tempo without altering the pitch of the constituent sounds.

It will be appreciated that in attempting to obtain even the exact repetition of rhythmic patterns, perhaps with the assistance of a metronome for example, involves many hours of splicing, listening, revising and re-splicing and during the course of the efforts to provide the organized musical composition there will be required repeated transfers from one tape to another with the resulting increase of noise level and unwanted distortions.

While very elaborate, complicated and expensive equipment has been developed in an effort to eliminate the limitations inherent in the present method of splicing together pieces of separate tapes, even the best of such equipment requires an excessive amount of time to implement the composer's musical intentions. It is therefore an object of this invention to enable sounds to be easily and quickly combined into organized repeatable sound or musical compositions having any desired rhythmic patterns of any complexity without the need for tape cutting and splicing or metronomic control. In this connection, it is a further important object to enable sounds to be easily and quickly organized into even the most complex rhythmic continuities with precisely accurate synchronization.

Another important object is to enable numerous and distinct rhythmic patterns of any complexity to be combined and repeated without the need for re-recording and synchronizing spliced tape montages.

Again, it is an important object to enable the technician to produce an exact repetition of any chosen growth and decay envelope pattern for the same or different individual tone timbre and further the repetition of a calculated proportionate distribution of sound objects, melodic units of individual sounds with varying timbres.

Still another and very important object is to enable the technician to produce the exact repetition of rhythmic patterns with varying timbres while varying the tempo and without altering the pitch of the constituent sounds.

Again, it is an important object to enable the technician or composer to easily and quickly modify or alter individual sounds in portions of the composition without reconstructing other parts of the composition.

While the invention has particular application to producing organized musical sounds, the invention also has other wide applications. For example, in its broadest aspects the invention has for its object to provide a predetermined but readily alterable control programme providing a predetermined rhythmic or sequential order in the occurrences or happenings in any controllable electro-mechanical phenomena.

Another and important object is to provide a means, instrumentality, or apparatus for effecting the above objects which means, instrumentality or apparatus will, in itself, be of relatively simple and inexpensive construction.

In its broadest aspects the invention involves the utilization of a gating device which is actuated or energized in accordance with the predetermined but alterable stored control programme. The programme will, of course, be determined in accordance with the planner's desired gating pattern appropriate for the particular electro-mechanical phenomena to be controlled.

In the particular application of the invention herein-after described in detail for producing organized sound, sounds or audio frequency signals are extracted from a plurality of sources and combined into the desired sound or musical organization through the use of such gating or interrupting means which control the delivery of the sound or audio signal from each of the sources to the mixing or combining point in accordance with previously determined but variable stored opening and closing instructions compiled by the composer. Further, according to this aspect of the invention, the gating or interrupting means is arranged not only to control the time or frequency of sound delivery from any particular source but also the amplitude characteristics of the sound in accordance with the previously determined and stored gate operating instructions.

Further, in accordance with the invention, the gating or interrupting means is constructed and arranged to store predetermined gate operating instructions or data so that the gating operation can be precisely repeated as frequently as desired. Moreover, the gating action can be reversed in sequential order and where differences of pitch, for example, is controlled a mirror image control as well as a retrograde control is possible.

According to the preferred form of the invention, the gating or interrupting means comprises a detecting or sensing device and a storing element or member movable relative thereto and on which gate operation control data detectable by the detecting or sensing device can be stored. More particularly such storing element is adapted to have applied thereto or provided thereon areas distinguishable or detectable by the detecting or sensing device and governing gate performance by virtue of their configuration and location. Further, according to the invention, means are provided for controlling the rate of

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relative movement between the detecting device and storing element to control the tempo of the final frequency of attacks without altering the timbre or pitch of the sounds being combined.

It will be understood that various sensing and storing arrangements may be used. For example, the detectable areas may comprise areas of electrical conductivity or light sensitivity, or light transmissibility differing from the remainder of the storing element and the detecting device will comprise the appropriate device for sensing such differences. In the form of the invention herein particularly illustrated, the gating or interrupting device is arranged to control the cathode bias of an amplifier through which sound emanating from each particular source is fed for mixing for the final composition, such cathode bias providing for complete sound cut off and sound volume control at will.

In this connection, according to the invention as herein illustrated, the area shapes or envelopes provided on the storing element are arranged to control the cathode bias value to determine the sound amplitude envelope or attack characteristics while the positions of the areas comprise gating instruction which control the point at which the sound is introduced providing the rhythmic organization of the elements used in the resulting montage.

While it will be understood that the invention is not to be limited to a specific storing element for storing predetermined but alterable gate operating control data or information and sensing device therefor, according to the preferred form of the invention, the storing element comprises a tape to which is adapted to be applied areas of different electrical conductivities or light transmissibility, such areas being laid out with precision through simple drafting board techniques. For example, the gate operating control data may simply be applied as areas of conducting material temporarily adhered to a non-conducting tape with a pressure-sensitive adhesive so that such areas may be easily and quickly attached and as easily and quickly removed or shifted according to the planner's desires. In such a case, the sensing device may comprise a resistance network controlling the amplifier tube bias and a series of fingers or the like are employed to detect the conducting area as the tape moves therebeneath to selectively shunt out resistor components of the resistor bridge and so control bias voltage. With such an arrangement it will be readily apparent that individual sounds may be altered by changing the individual area shapes, and the rhythm may be altered by changing the point of attachment of the areas to the tape. Such changes can be made at a single point in the tape, or throughout portions of the tape without altering the arrangement of the other areas, that is, without requiring total reconstruction of the tape or storing element.

These and other objects and features of the invention will become apparent from the following detailed description in which:

FIGURE 1 is a diagrammatic showing in block form of the manner in which an electronic sound organization may be composed in accordance with the invention;

FIGURE 2 is a wiring diagram illustrating a specific gating arrangement for controlling the transmission of sound from one of the sources to the point of collection in accordance with the invention;

FIGURE 3 is a perspective view of a gating device embodying the invention;

FIGURE 4 is a perspective view of the device of FIGURE 3 as seen from the opposite side;

FIGURE 5 is an enlarged perspective view broken away illustrating the manner in which information stored on the storing elements of the gating device of FIGURES 3 and 4 is detected by the sensing device;

FIGURE 6 is an enlarged vertical sectional detail taken on the line 6-6 of FIGURE 5, and

FIGURE 7 is a view of one of the storing elements illustrating the manner of applying the predetermined gating control patterns by drafting board techniques.

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Referring first to FIGURE 1, one embodiment of the principle involved in the present invention is illustrated in block form. In accordance therewith, any number of sound sources such as A, B and C whose sounds are to be combined in the final composition are connected to deliver an audio frequency signal through their respective mixers 1a, 1b, 1c, etc., and their respective amplifiers 2a, 2b and 2c, respectively, to a mixer 3 and amplifier 4, the output of which may be monitored or may be recorded as by a tape recorder 5. Each of the sound sources A, B, and C, may in itself be a plurality of sources and may conveniently be prerecorded sounds and may, for instance, be a continuous tone, a melodic fragment, or poliphonic complex. In accordance with the invention, the signals from these sources A, B, C, etc., are combined in the final mixer 3 for amplification by the amplifier 4 in accordance with a predetermined scheme through the use of gating devices such as 6a, 6b and 6c, which control the delivery of the sound from the sources A, B and C to the mixer 3 and amplifier 4. Further, in accordance with the invention, the gating devices 6a, 6b, and 6c, determine the point in time in which the sounds are delivered from the sources A, B, and C, to the mixing stage 3, the length of time for which such sounds or audio signals are transmitted to the mixer and their growth and/or decay characteristics.

In the embodiment of the invention illustrated in FIGURE 2, each of the amplifiers 2a, 2b, and 2c, is shown as a push-pull type amplifier comprising amplifier tubes 7 having an input coupling transformer 8 connected to their control grids 9 and an output connecting transformer 10 connected to their plates 11. Their cathodes 12 are connected to ground through resistor 13 and a grid bias is applied to the control grids 9 from the gating device 6a, in the case of amplifier 2a, or 6b in the case of amplifier 2b, etc. A source of grid bias voltage 14 applied through resistor 15 and grid current limiting resistor 16 normally maintains the amplifier 7 cut-off so that no signal is transmitted through from the source to the mixer 3. Connected across the resistor 15 and grid bias voltage source 14 is a resistance network generally designated at 17 and comprising resistors R_1 to R_8 and R_{10} with the resistance value between R_8 and R_{10} being infinite or open circuit to normally block current flow through the resistor network. Associated with the resistor network is a detecting or sensing device generally designated at 18 comprising ten electrically conducting fingers F_1 to F_{10} which may conveniently be of silver. These fingers F_1 to F_{10} are connected between the various resistors as at points f_1 to f_{10} . These fingers F_1 to F_{10} are adapted to ride on a non-conducting tape 19 which may have conveniently adhered thereon areas of conducting material such as aluminum foil 20 which, when moved beneath the fingers, will short out the resistors bridged by the fingers riding thereon, thereby producing current through the resistor network 17 and resistor 15, the value of which will depend upon the number of resistors shorted out. As the current through the resistor network increases from zero, the cut-off point when fingers F_8 and F_{10} are not bridged by the conducting area 20, there will be an increasing voltage drop across the resistor 15 and the consequent decreasing negative bias applied to the control grids 9 of the amplifier tubes 8 to provide an increasing current flow through the amplifier tubes and hence increasing signal level fed through to the output transformer 10.

It will be appreciated that the point in time at which the fingers F_1 to F_{10} contact the area 20 arriving therebeneath will determine the point in time at which sound from the particular source involved is fed through to the mixer 3. The length of area 20 longitudinally of the tape will determine the length of time that the sound is applied through the amplifier to the mixer 3 and the intensity of the sound will be determined by the configuration of the area 20, that is, the number of fingers which will be bridged thereby and hence the number of resistors

R_1 to R_8 shorted out. Thus it will be seen that the area configuration transversely of the tape will determine the growth and decay characteristics of the sound transmitted from the source through the mixer 3.

Each of the non-conducting tapes 19 may be looked upon as a storing element on which is stored the control pattern for controlling sound delivery from the respective source to the mixer 3 and final amplifier 4.

FIGURE 7 illustrates the manner in which the control pattern formed by the aluminum foil areas 20 may be laid out on the tape 19 in a predetermined manner by drafting board techniques. For example, the first area at the right-hand end of the tape 19, designated at 20a, is shown as of triangular form. When this area is moved beneath the sensing device 18 as constituted by the fingers F_1 to F_{10} there will be a gradual increase in the sound volume as an increasing number of fingers are bridged by the area 20a to provide a progressively decreasing grid bias voltage on the amplifier tubes 7 which in turn provides a progressively increasing intensity in the sound from the respective source fed through to the final mixing stage. The length of the sound attack will depend upon the dimension Y of the area 20a and, of course, the relative speed of the tape and sensing device, and the rate of growth of the sound intensity will depend upon the angle Z between the sides a and b of the area 20a. Since the dimension a of the area extends the full width of the tape 19 as the tape is moved in the direction of the arrow 21 beneath the sensing fingers F_1 to F_{10} , the sound will grow at the rate determined by the tape speed past the fingers and the angle Z until maximum intensity is reached after which there will be complete cut-off as the sensing fingers F_1 to F_{10} drop off the trailing edge a of the area. Such a gradual growth from minimum to a sharply cut off maximum is, for example, characteristic of the sounds often heard produced by the brass instrument of an orchestra. If a reverse image of the triangular area 20a of FIGURE 7 were utilized, then the sound characteristic would be from a momentary maximum with a gradual decay to minimum which is characteristic of a bell or piano tone.

Spaced from the trailing edge of the area 20a on the tape 19 shown in FIGURE 7 is an area 20b of stepped form. In this case, the sound from the respective source being controlled would be delivered through to the final mixing and amplifying stage at an intermediate value of amplification as soon as the forward or leading edge 22 contacted the fingers of the sensing device 18. The volume would suddenly increase as the forward edge portion 23 subsequently contacted additional fingers of the sensing device after which the sound would remain uniform until the fingers dropped off the trailing edge 24 giving a sharp cut-off. The time interval between the sound pattern admitted through the gating device by the areas 20a and 20b will depend upon the dimension X and the rate of movement of the tape 19 past the sensing device 18.

As shown in FIGURE 7 the sound patterns are repeated in a definite rhythmic manner. It will be understood that similar gate controlling patterns can be laid out on the other tapes or storing elements of the system and with the movement of the tapes synchronized there will thus be the superimposing of these sound patterns from the various sources in the final sound organization.

Conveniently the aluminum foil areas 20 may be applied to the tape 19 as by way of a pressure-sensitive adhesive for easy application and quick removal so that the shape of the area can be quickly changed by replacement and the rhythmic control pattern can also quickly be changed by changing the dimension X.

It will be understood that all of these details can be worked out beforehand on the drafting board so that the sounds from the various sources can be precisely combined according to the composer's desires. Further, of course, since the gating control information is stored on the tapes by the temporary affixing of the areas 20a, 20b,

etc., the composition can be repeated at will, while at the same time any portion of it can be edited or changed by simply shifting or substituting conductor areas without requiring reconstruction of the tape or upsetting of the remainder of the programming of the sound composition.

FIGURES 3 to 6 illustrate a practical form of apparatus for providing the gating control of the amplifier 7 as above described. As shown, the device comprises a support bracket 25 which may be mounted on a suitable platform 26. Supported from the bracket 25 at the outer end of spacing bars 27 is a plate 28. Projecting laterally from the bracket 25 and plate 28 are a pair of arms 29 having journaled therebetween at their outer ends a shaft 30 on which are mounted a plurality of rollers or sprockets 31, the arms being slotted as at 32 for longitudinal adjustment and being secured in adjusted position by a suitable clamp 33. A similar set of rollers or sprockets 34 are journaled on a shaft 35 supported between the opposite ends of the bracket 25 and plate 28, and mounted on these rollers or sprockets 31 and 34 are a plurality of endless tapes comprising the non-conducting tapes 19. Between the rollers or sprockets 31 and 34 the tapes are led over a bar 36, seen particularly in FIGURE 6, mounted between the bracket 25 and plate 28.

Supported from the bracket 25 is a cantilever assembly 37 which carries a plurality of fingers 38 of conducting material, for example, silver, collected into groups of ten superimposed over each of the tapes 19, the fingers 38 constituting the fingers F_1 to F_{10} illustrated in FIGURE 2. As shown in FIGURE 6, these fingers are clamped on the flattened upper side of a rod 39 pivotally mounted in the cantilever assembly 37, the clamping being effected by means of a clamp bar 40 and retaining fastener or bolt 41.

The lower ends of the fingers are shaped as at 42 to ride on the tape where it is supported by the bar 36, and the rod 39 may be rotated about its axis to alter the pressure of the fingers 38 riding on the tapes 19, such rotation being effected through a lever 43, FIGURE 3, which is held in the adjusted or set position by a spring 44 resting in a selected notch 45 of an arcuate notched bar 46.

The resistor network 17 comprising the resistors R_1 to R_8 and R_{10} designated in FIGURE 2 are carried in their respective groups on a board 48 mounted on the cantilever assembly 37. As shown in FIGURE 6, leads 49 from the respective fingers 38 are provided for connection to the resistors with the points of connection (not shown in FIGURE 6) corresponding to the points of connection illustrated in FIGURE 2 at f_1 to f_{10} . The signals from these resistors are then fed by means of a cable 50 to an adaptor 51 and thence by a cable 52 to their respective amplifiers 2a, 2b, etc.

The tapes 19 which are shown endless, but may be of finite length if desired, are driven beneath the fingers 38 by means of a variable speed motor 53 which drives the shaft 30 carrying the rollers or sprockets 31 through a worm drive 54, the motor enabling the belt speeds to be changed at will.

In utilizing the apparatus of FIGURES 3 to 6, which comprises the gating devices 6a, 6b, etc., of FIGURE 1, the desired gating control pattern is applied to the individual endless belts 19 in accordance with the procedure outlined in connection with FIGURE 7. The belts are then driven by the motor 53 at a desired speed so that the fingers 38 constituting the sensing devices read the information conveyed by the envelope of the areas 20 to transmit a predetermined gate controlling signal to the respective amplifier to allow sound from the respective source through to the final mixing and amplifying stage. Thus the sounds from the various sources will be blended in accordance with the predetermined information stored on the belts 19 through the application of the areas 20 thereto.

As illustrated in FIGURE 2, there is provided in as-

sociation with each of the amplifiers 2a, 2b, etc., connected in the grid bias circuit of the amplifiers 7, a variable condenser 55 which forms a suppressor to suppress the surge voltage of the gate.

As explained in connection particularly with FIGURE 7, the desired rhythmic patterns of the sounds incorporated into the final organization are determined by the linear placement of the control areas 20 at measured intervals along the length of the tapes 19. By attaching such control areas, for example, through the use of a pressure-sensitive adhesive, such controls are provided without the need of cutting or splicing corresponding lengths of already recorded tape. Further, of course, individual envelope patterns or areas may be removed, added to, or otherwise modified by simply removing the original area design and substituting a new design.

By increasing or decreasing the speed of the motor 53, the tempo of the rhythmic patterns may be correspondingly altered without altering the pitch or timbre of the sounds. When the sounds admitted through the various amplifiers 2a, 2b, etc., by the various gating devices 6a, 6b, etc., are combined in the mixer and amplifier, they may be monitored or recorded. They may, of course, be repeated as often as desired for aural study first, and then modified and perfected and finally recorded in the desired form without the need for numerous splices or trial recordings which are difficult to edit and more difficult to reproduce a second time. All of such modification and perfecting of the components of the final organization may, of course, be carried out very simply and quickly through the removal or replacement of the conductor areas 20, or the shifting of their position as desired.

While, of course, the envelope or shape of the areas 20 will determine the intensity of the sound transmitted through from the source to the mixing stage for a given amplification factor of the amplifier, the amplifier itself may be provided with a suitable volume control to alter the amplification factor as desired.

In the embodiment of the invention particularly illustrated, the tapes 19 are of a non-conducting material on which are temporarily secured conducting areas 20, and the sensing device 18 comprises the fingers 38 which "read" the conducting areas. It will be understood, however, that the invention is not limited to such specific means. For example, the tapes 19 could be formed of a transparent material and the areas 20 could be constituted by opaque areas temporarily adhered to or formed on the tape and the sensing device 18 could be a photo cell detector. It will be understood that other forms of storing elements in place of the tapes 19 may be employed so long as a predetermined but variable gate control pattern can be stored thereon and can be sensed by the appropriate sensing device to control or gate the delivery of energy in the particular application to which the gating device is applied.

While the use of the invention has been particularly described with reference to the production of a pre-planned sound organization, it will be understood that gating apparatus according to the invention may be used to control any other electro-mechanical phenomena by providing a gating control to be introduced between a signal source and the operation to be acted upon by the signal. Thus, for example, the gating apparatus could be used to control the switching on or off of electronic filters to determine the timbre of sounds. Alternatively gating apparatus embodying the invention can be utilized to provide desired lighting or switching or further for example to control displays, motors, pumps, and other controllable devices.

It will therefore be understood that the invention is intended to cover all such variations as will appear to those skilled in the art.

What we claim is:

1. Gating means adapted to be interposed between a

signal source and an output point, said gating means comprising a gate operating data storing non-conductive planar element with response creating areas removably applied thereto, a sensing device for detecting said response creating areas and means for effecting relative movement between said storing element and said sensing device.

2. Means as claimed in claim 1 in which the shape and location of said response creating areas determine the gating characteristics.

3. Means as claimed in claim 1 in which said response creating areas are geometrically laid out on said storing element.

4. Means as claimed in claim 1 in which said mentioned response creating areas are electrically conductive and said sensing device is responsive to said electrically conductive areas.

5. Means as claimed in claim 1 in which said response creating areas are secured to said storing element by a pressure sensitive adhesive.

6. In combination with a plurality of electronic sound sources for producing audio frequency signals and amplifying means for transmitting signals from said sources to a point of collection for collecting said signals into a composite sound organization of a plurality of gating means for controlling the point in time and degree of amplification of sounds transmitted by said amplifying means according to a predetermined pattern, each of the said gating means comprising a planar storing non-conductive element with a control pattern formed of response creating areas removably applied thereto corresponding to said predetermined pattern and a sensing device responsive to said control pattern in response to relative movement of said storing element and said sensing device and arranged to govern sound transmitted through the respective amplifying means and means to effect relative movement of said storing element and sensing device.

7. A device as claimed in claim 6 in which said sensing device is a variable voltage device producing a voltage variable in accordance with the configuration of said areas.

8. A device as claimed in claim 6 in which said areas comprise conductive material.

9. A device as claimed in claim 6 in which said areas are conductive and said sensing device comprises a plurality of fingers adapted to run on said planar element and sense said areas of conductive material and a resistor network connected across said fingers to produce a voltage across said resistor network variable according to the shapes of said conductive areas.

10. A device as claimed in claim 9 in which each of said amplifying means comprises a grid bias controlled amplifier and the variable voltage produced across said resistor network is applied to control the grid bias of said amplifier.

11. A device as claimed in claim 6 in which said means to effect relative movement of said storing element and said sensing device comprises a variable speed means.

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