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DEVICE FOR AUTOMATICALLY CONTROLLING WATER JETS OF ARTIFICIAL FOUNTAINS IN SYNCHRONISM WITH MUSICAL SOUNDS

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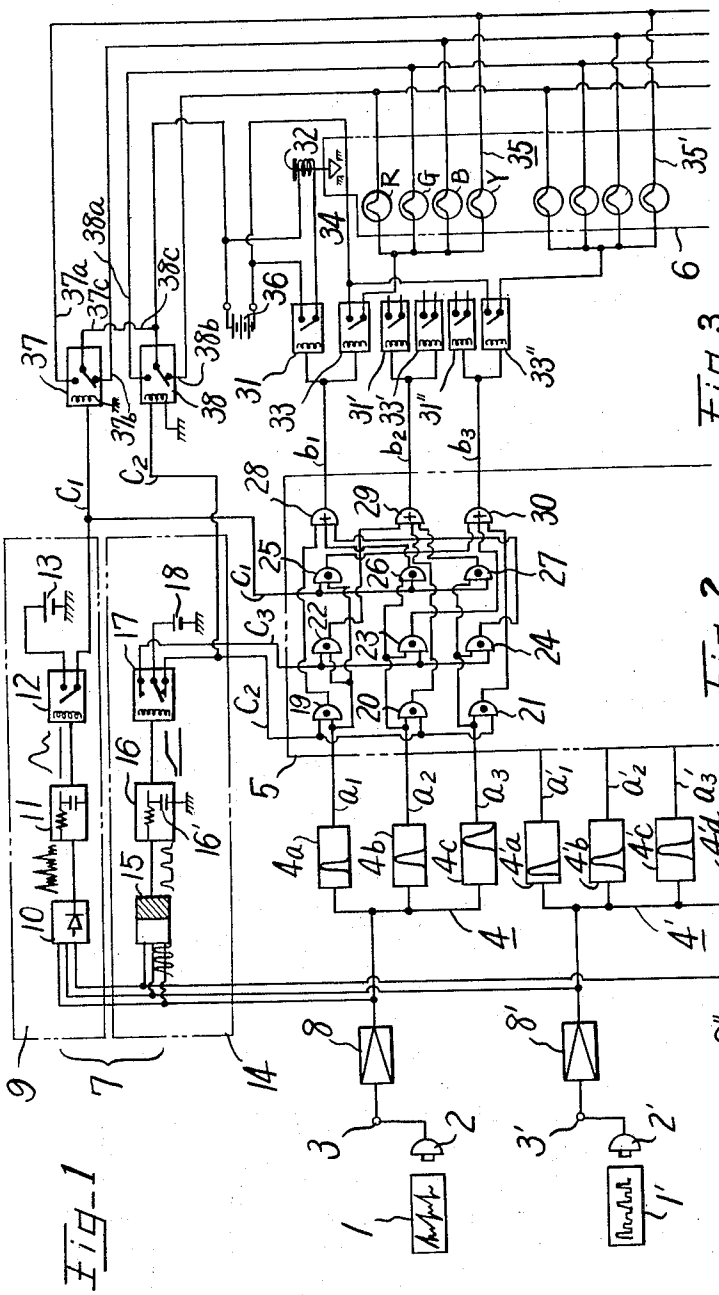


Fig-1

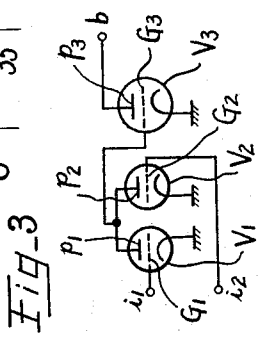


Fig-3

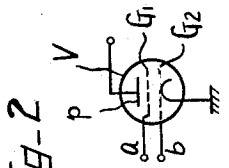


Fig-2

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DEVICE FOR AUTOMATICALLY CONTROLLING WATER JETS OF ARTIFICIAL FOUNTAINS IN SYNCHRONISM WITH MUSICAL SOUNDS

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6 Claims. (Cl. 239—17)

This invention relates to a device for automatically controlling water jets of artificial fountains in synchronism with musical sounds.

For controlling water jets of artificial fountains in synchronism with musical sounds, it has been conventional to manually control electric switches for operating magnetic valves, electric light bulbs, a power source, and other control devices, responsive to the music. However, since the number of control devices which can be operated manually by an operator is limited, it has been necessary, for effecting delicate variation in performance of water fountains, either to limit the controllable range of variation in water fountains or to increase the number of operators. In the former case, the variation of the fountain tends to be monotonous, while in the latter case, it becomes asynchronous.

If water fountains are controlled directly by an automatic device which produces electrical control signals responsive to music, the above limitations will be eliminated and water fountains of large scale will be controlled with a high fidelity for delicate variations, and a great progress in the art will be attained.

The principal object of the invention is to provide a novel control device fulfilling the above requirements, and to make an epoch-making advance in the performance of water fountains responsive to musical sounds.

A further object of the invention is to provide a device for automatically controlling water jets of fountains by means of a tape or disc on which musical sounds are recorded.

According to the invention, certain characteristics of music, such as sound volume and frequency, are analyzed to select proper nozzles to be controlled and to control automatically electric light bulbs, regulating valves, and other control devices of the water jets of fountains.

The music essentially consists of an integration of various sounds of different tones produced by various instruments and singers in audible frequencies at a wide range of intensity.

If output sounds from each instrument and singer are converted into electrical signals and applied to a filtering device, then the output signals from the filtering devices in predetermined frequency bands represent said output sounds in each frequency band at each moment. By applying the output signals of the filtering device to control devices of each water fountain, the water ejections and their illumination are varied in a predetermined manner for given frequency bands and sound volumes. Thus an automatic control of water fountains is attained.

Musical water fountains equipped with the control devices of the invention produce a novel performance which is different from conventional ones due to the direct and automatic control of the water fountains responsive to musical sounds, such as instrumental and vocal sounds.

According to the invention, the control device for performance of water fountains comprises a converting circuit, to convert the performed musical sounds into electrical signals and to amplify and filter said electrical signals into predetermined frequency bands in order to apply the filtered signals to each element of a matrix circuit as an input signal; a musical discriminator circuit, to detect a mean level of the sound volume during a

given period by rectifying and integrating said electrical signals corresponding to said output sounds of the music, to detect a rhythm of the music by converting said electrical signals into pulse signals responsive to rhythms in said music and integrating said pulse signals, and to transmit order signals to each element of said matrix circuit and to color selective relays by means of relays responsive to quantities thus detected; and a color selective relay circuit to control the color change of the illumination of the water fountains responsive to said order from the musical discriminator circuit in synchronism with the variation in the dynamic operation of water jets of the fountains. Thereby said control device automatically controls the selection and change-over of the dynamic operation and coloring of the water jets of the fountain in synchronism with the music by applying the output from said matrix circuit to control devices of each water fountain.

For a better understanding of the invention reference is made to the accompanying drawings, in which

FIG. 1 is a circuit diagram illustrating an example of control circuits embodying the automatic control device according to the invention for controlling performance of water fountains responsive to music; and

FIGS. 2 and 3 are circuit diagrams showing a multiplying circuit and a summing circuit respectively.

Referring to FIG. 1, reference numerals 1, 1′, and 1″ are musical instruments such as string instruments, drums and flutes, sound outputs from such instruments being applied, for instance, to microphones 2, 2′, and 2″ to produce electric signals corresponding to said sound outputs and provide said signals to input terminals 3, 3′, and 3″ of the control device. Reference numerals 4, 4′, and 4″ are filtering devices and 7 a musical discriminator circuit. The filtering devices 4, 4′, and 4″ separate and convert the input electrical signals from the input terminals 3, 3′, and 3″ into control signals a_1, a_2, and a_3 in a number of frequency bands. These control signals can be used directly to control the regulating valves and lighting bulbs to operate the water fountains. However, in order to obtain the automatic control for producing performance of water fountains responsive to the music and to cause coincidence of the visual impression from the water fountain with the audible impression of the music, the overall mode of the music is reflected in the operation and coloring of the water fountains by means of the matrix circuit 5 and the musical discriminator 7 which synthesize the acoustic effects of each instrument in the music. The matrix circuit takes a combination of the control signals from said filters as input and gives a number of water fountain control signals, corresponding to the number of water fountains to be controlled, by multiplying and summing up the input signals in a suitable manner.

The musical discriminator circuit 7 detects certain characteristic elements of the music. It controls the impression of the music on the listener depending on the nature and the type of the music, converts said detected elements into electrical control signals, and transmits said converted signals to the matrix circuit 5 to regulate the water fountain control signals from the matrix circuit so that the audible impression of a certain mode of the music may coincide with the visual impression of the operation of the water fountains. For instance, the musical discriminator circuit 7 consists of a rhythm discriminator circuit particularly sensitive to instruments which determine the rhythm of the music and a volume discriminator circuit particularly sensitive to the sound level of each instrument, and transmits its output order signals to the matrix circuit 5 based on the nature of the music determined by the combination of rhythm and volume. The matrix circuit 5 combines the output signals from the filter devices with the above order signals from the musical discrimina-

tor circuit and select the predetermined water fountain control signals responsive to said combination.

It is possible to combine the output sounds of each instrument and to apply a combined single signal to the filters, and thus to simplify the circuitry.

The details of the matrix circuit **5** and the musical discriminator circuit **7** will now be explained. The input signals from the input terminals **3**, **3'** and **3''** are amplified by amplifiers **8**, **8'** and **8''** and then filtered by filtering devices 4_a, 4_b, 4_c, . . . , $4_a'$, $4_b'$, $4_c'$, . . . etc. to produce the filtered signals a_1, a_2, a_3, . . . , a_1', a_2', a_3', . . . etc. applied to elements **19** to **30** of the matrix circuit **5**. For simplicity sake, descriptions will be made only on the behavior of a set of filtered signals a_1, a_2, and a_3 from the filtering devices 4_a, 4_b and 4_c, and the behavior of other filtered signals will be apparent from the descriptions of this set of signals.

The output signals from the amplifiers **8**, **8'** and **8''** are also applied to the musical discriminator circuit **7** in parallel width the filters **4**, **4'** and **4''** to produce output signals, for instance, responsive to the rhythm and sound volume of the music. A sound volume discriminator circuit **9** detects the mean level of the sound volume of the music. Said mean level of the sound volume is obtained by applying the input signal to a rectifying circuit **10** and then to an integrating circuit **11**, having a large time constant, to produce an integrated signal to operate the relay **12**. The circuit **9** is so constructed that the relay **12** is not operated by a strong but intermittent sound level, but the relay is operated by a continuous medium sound level for instance a sound from a string instrument. Accordingly, the volume discriminator circuit **9** gives a signal c_1 to the matrix circuit **5**, through the power source **13** and the relay **12**, when the integrated sound volume in a given time exceeds a predetermined level.

On the other hand, the rhythm discriminator circuit **14** discriminates the rhythm of the sound and consists of a pulse forming circuit **15**, which converts the rhythm of the sound into pulses responsive to the rhythm of the input signal to said circuit **15**, and a pulse integrating circuit **16** to integrate said pulses. A condenser **16'** in the pulse integrating circuit **16** is charged by the output from pulse forming circuit **15** to operate the relay **17**. The relay **17** has a set of stationary contacts to cooperate with a moveable contact connected to a power source **18** and arranged to selectively close the source circuit. When the relay does not operate, an order signal c_2 is generated, and when they relay is operated, order signal c_3 is generated.

If the filtering devices 4_a, 4_b, and 4_c are assigned to low, medium, and high frequency bands respectively, the filtered signals a_1, a_2, and a_3 for each frequency band are combined with the order signals c_1, c_2, and c_3 in the matrix circuit **5**, and the combination will cause a suitable automatic switch-over which will be explained below.

In the example shown in FIG. 1, the signal a_1 is applied to multiplying circuits **19**, **22** and **25** in parallel, a_2 to multiplying circuits **20**, **23** and **26**, and a_3 to multiplying circuits **21**, **24** and **27**, while the output order signals from the musical discriminator circuits c_1, c_2 and c_3 are applied to respective multiplying circuits, namely c_1 to **25**, **26** and **27**, c_2 to **19**, **20** and **21**, and c_3 to **22**, **23** and **24**. Accordingly, 9 different kinds of products of any two quantities from said 6 different signals of 2 kinds, which cover all valid combination of the 2 quantities from said signals for the purpose of the control device, are given as output signals from said multiplying circuits.

FIG. 2 illustrates as an example a vacuum tube to be used for the multiplying circuits. If each input signal a and b is applied to the terminals of a respective grid G_1 and G_2 of the vacuum tube V, then the product ab of the two signals will be taken out of the plate p as an inverted output signal.

The output signals from the multiplying circuits **19** to **27** are grouped and applied to three summing circuits **28**, **29** and **30**. In the example shown in FIG. 1, three products $a_1 \times c_2$, $a_2 \times c_1$ and $a_3 \times c_3$ are applied to the summing circuit **28**, three products $a_1 \times c_3$, $a_2 \times c_2$ and $a_3 \times c_1$ to the summing circuit **29**, and three products $a_1 \times c_1$, $a_2 \times c_3$ and $a_3 \times c_2$ to the summing circuit **30**. The output signals b_1, b_2 and b_3 from the summing circuits are applied to relays which control the regulating valves **32**, switches of the power sources of the colored illumination devices, and other control devices of the water fountains **6**.

FIG. 3 illustrates an example of summing circuits using vacuum tubes, wherein plates p_1 and p_2 of respective vacuum valves V_1 and V_2 are connected in parallel, and the inputs i_1 and i_2 are applied to respective grids G_1 and G_2, and the total current summing the output currents from plates p_1 and p_2 is applied to grid G_3 of the vacuum tube V_3. Thus the output quantity b, corresponding to the sum of the input quantities i_1 and i_2, is taken out of the vacuum tube V_3.

Accordingly, the output quantities b_1, b_2 and b_3 from the matrix circuit **5** in the above example can be given by

$$b_1 = a_1 \cdot c_2 + a_2 \cdot c_1 + a_3 \cdot c_3$$
$$b_2 = a_1 \cdot c_2 + a_2 \cdot c_2 + a_3 \cdot c_1$$
$$b_2 = a_1 \cdot c_1 + a_2 \cdot c_3 + a_3 \cdot c_2$$

which can be simplified to the following matrix expression.

$$\begin{bmatrix} b_1 \\ b_2 \\ b_3 \end{bmatrix} = \begin{bmatrix} c_2 c_1 c_3 \\ c_3 c_2 c_1 \\ c_1 c_3 c_2 \end{bmatrix} \begin{bmatrix} a_1 \\ a_2 \\ a_3 \end{bmatrix}$$

In the above example, the input signals a_1, a_2 and a_3, which correspond to low, medium, and high frequency bands, respectively, are modified in the matrix circuit **5** responsive to and in combination with the order signals from the musical discriminator circuit **7**, and the output signals b_1, b_2 and b_3, which are accentuated according to the characteristics of the music, are obtained. If no musical discriminator circuit is used, the order signals c_1, c_2 and c_3 can be replaced with output signals from other additional filtering devices. The regulating valves **32** are controlled by selectively actuating the relays **31** with the output signals b_1, b_2 and b_3 from the matrix circuit **5**, and the colored illumination of the water fountains is controlled by selectively actuating relays **33**, **33'** and **33''** with said output signals and thereby controlling the connections to the power source of the colored light bulbs.

A control device for one of the water fountains **6**, for instance, consists of a relay **31** for controlling the dynamic operation of the water columns in the water fountains and another relay **33** for controlling coloring of the illumination of the water fountain, both of which are actuated by an output signal b from the matrix circuit **5**. For simplicity sake, the description will be limited to the behavior of the control devices actuated by the output signal b of the matrix circuit **5**, and it will be understood that similar control devices, such as **31'**, **31''**, **33'**, **33''** etc. are connected to the other output signals b_2, b_3 etc. from the matrix circuit **5**, as shown in FIG. 1, and the behavior of the latter control devices will be apparent from the description of the behavior of the former control devices.

The relay **31** controls the power source switch of the circuit **34** including the solenoid of the water fountain regulating valve **32**, and actuates the solenoid to control the dynamic operating conditions of the water fountain. The relay **33** controls the power source switch of the circuit **35** including colored light bulbs for colorful illumination of the water fountains, and the coloring of the illumination is varied in such a manner as will be described later. Since the circuit **35** should actuate the light bulbs as soon as the water columns of the fountain

are established and maintain the colored illumination until the entire water column disappears, the relay **33** is equipped with a time lag device to provide a proper time delay to the illumination circuitry compared with the water fountain operation circuitry.

To give a variety to the tone of the colored illumination, the illumination circuit **35** includes a set of colored light bulbs such as a red bulb R, a green bulb G, a blue bulb B, a yellow bulb Y, etc., and corresponding terminals of said colored light bulbs are connected in parallel and the other terminals of each of said bulbs are connected individually to corresponding terminals of the color selective relays **37** and **38**, which are actuated by the order signals c_1 and c_2 from the musical discriminator circuit **7**. The terminals **37***a* and **37***b* of the color selective relay **37** are connected to colored bulbs Y and B, respectively, and terminals **38***a* and **38***b* of the color selective relay **38** to colored light bulbs G and R, respectively. The power source terminals **37***c* and **38***c* of respective relays **37** and **38** are commonly connected with each other and to one terminal of the power source device for the colored light bulbs. The other terminal of said power source device is connected to the time delaying relay **33**, and then to the common terminal of the colored light bulbs, as shown in FIG. 1. The closed circuit including the light bulb R, for instance, traces from one terminal of the power source **36** through a stationary contact and a movable contact of the time delaying relay **33**, a red light bulb R, a stationary contact **38***b* of the color selective relay **38**, and a common terminal (movable contact) **38***c* of the color selective relays **37** and **38** and back to the other terminal of the power source **36**. Accordingly, it is apparent that the set of colored light bulbs, for instance, a set in the circuit **35** consisting of R, G, B and Y, are actuated by the time delaying relay **33**, while an individual bulb, for instance a bulb R, is actuated by the color selective relay, for instance the relay **38**. Each set of bulbs in circuits **35**, **35′** and **35″** is, for instance, selected from bright colors, quiet colors, and dark colors to provide suitable tone to the illumination of the water fountains by a proper set of light bulbs.

The color selective relays **37** and **38** may be actuated by any other suitable means, for instance by the output signals from the filtering devices **4**.

If similar matrix circuits **5′**, **5″**, etc., are provided for filtering device groups **4′**, **4″**, etc., then output control signals *b′*, *b″*, etc. from such matrix circuits will increase the variety in the dynamic operation of the water jets and the coloring in the illumination. Hence more complicated visual and chromatic representations of musical motifs and expressions will be obtained in synchronized colorful and dynamic performance of the water fountains.

The coloring control of the illumination, for instance, can be done in the following manner. For quiescent music, like that expressing the impressions of moonlight, the order signal c_2 actuates the set of colored light bulbs from quiet color groups, like purplish ones, in conjunction with a calm operation of water columns, and thus production of a quiescent performance of the water fountains can be obtained. For brilliant rhythms in the music, the order signal is switched over to c_3 to actuate another set of colored light bulbs from bright color groups in conjunction with an activated operation of water columns, and thus production of a brilliant performance of the water fountain can be obtained. For voluminous passages in the music, the order signal c_1 is actuated to select the set of colored light bulbs from the color groups implying abundance in conjunction with voluminous water columns in the water fountain to imply magnificence.

According to the invention, the musical discriminator circuit can be replaced by additional filtering devices as pointed out hereinbefore. If the latter devices are used, the output signals from such additional filtering devices are applied to the matrix circuit **5** to modify the output order signals from the matrix circuit in a manner similar

to modification by the output signals from the musical discriminator circuit **7**, and thus similar automatic control, consisting of switch-over of dynamic operation of the water jets and coloring of the illumination, are also obtained.

The automatic control device of the invention contributes greatly to controlling the performance of water fountains responsive to music by enabling automatic and simultaneous control of the dynamic operation of water jets and switch-over of illumination coloring in synchronism with the back-ground music, regardless of the scale of the water fountains, through analyzing frequencies and other characteristics of the acoustic signals derived from said music, live or reproduced, and combining the analyzed signals to apply them to said automatic control devices.

What we claim is:

1. An automatic control device for controlling performance of water fountains responsive to musical selections, said device comprising, in combination, selectively operable water volume control means controlling the dynamic operation of a fountain; selectively operable colored illumination means for the fountain; transducer means operable to convert musical sounds into corresponding electrical signals; filter circuit means connected to said transducer means and operable to separate said electrical signals into respective frequency bands to provide plural respective band frequency signals; discriminator circuit means connected to said transducer means and operable to provide respective sound volume signals and sound rhythm signals corresponding to said electrical signals; combining means connected to said filtering circuit means and to said discriminator circuit means and operable to combine each band frequency signal with a sound volume signal and a rhythm signal to provide plural respective combined control signals each corresponding to a respective combination of band frequency, sound volume and rhythm; and means, including circuit connections, connecting said combining means to said water volume control means and said colored illumination to control the same to vary the dynamic operation and colored illumination of the fountain in accordance with variations in the sound frequency, sound volume and rhythm of the musical selection.

2. An automatic control device for controlling performance of water fountains, as claimed in claim **1**, in which said discriminator circuit means is connected to said transducer means in parallel with said filter circuit means.

3. An automatic control device for controlling performance of water fountains, as claimed in claim **1**, in which said discriminator circuit means comprises a sound volume discriminator circuit and a rhythm discriminator circuit, said sound volume discriminator circuit and said rhythm discriminator circuit being connected in parallel to said transducer means.

4. An automatic control device of controlling performance of water fountains, as claimed in claim **1**, including further means connecting the output of said discriminator circuit means to said water volume control means and said colored illumination means.

5. An automatic control device for controlling performance of water fountains, as claimed in claim **1**, in which said combining means comprises a matrix including a plurality of multipliers equal in number to the product of the number of respective band frequency signals times the number of respective output signals of said discriminator circuit means; and plural summing circuits equal in number to the number of respective band frequency signals and each having its input connected to a number of multipliers equal in number to the number of respective band frequency signals, each summing circuit being connected to a different respective set of said multipliers.

6. An automatic control device for controlling performance of water fountains, as claimed in claim 3, in which said sound volume circuit provides a sound volume output signal responsive to a continuous medium musical sound level and is ineffective to provide a sound volume signal responsive to a strong and intermittent sound volume level.

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EVERETT W. KIRBY, *Primary Examiner.*