# United States Patent

**Goralnick**

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[54] **MULTI-TONE PUSH BUTTON CONTROLLED ELECTRONIC HORN**


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[52] **U.S. Cl.** ............................**340/384 E**, 340/384 R

[51] **Int. Cl.** ...............................................**G08b 3/10**

[58] **Field of Search**........................340/384 E, 384 R



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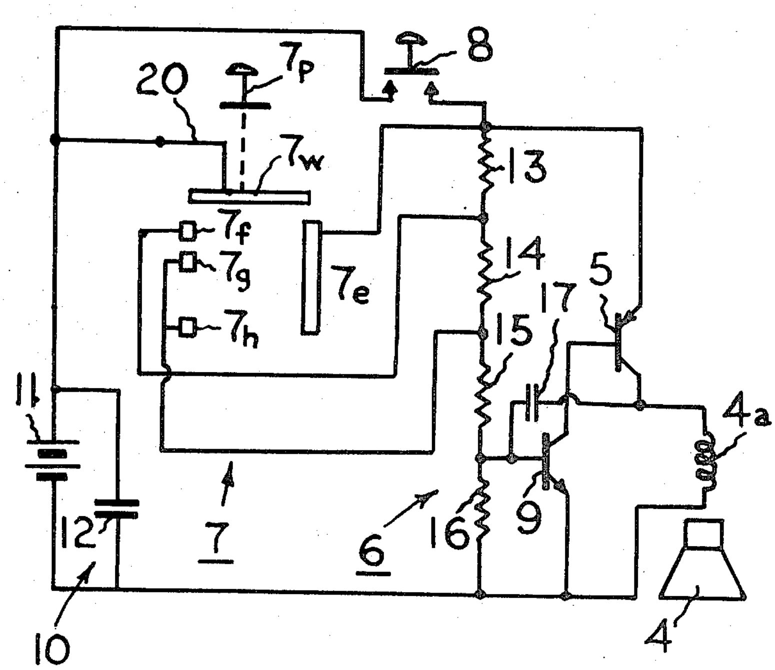
[57] **ABSTRACT**

Transistorized electronic circuitry for producing audio-frequency output signals is manually switched to vary circuit constants and effect controlled multi-tone outputs in desired automatic dequence. Battery voltage variations are avoided and tone control is simplified by way of special capacitor connections.


**3 Claims, 3 Drawing Figures**



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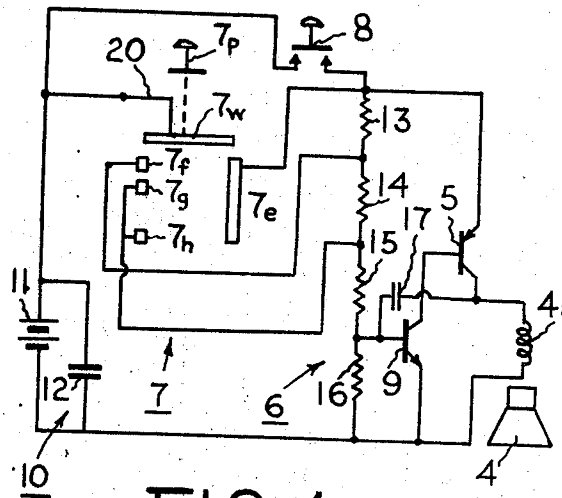


FIG. 1

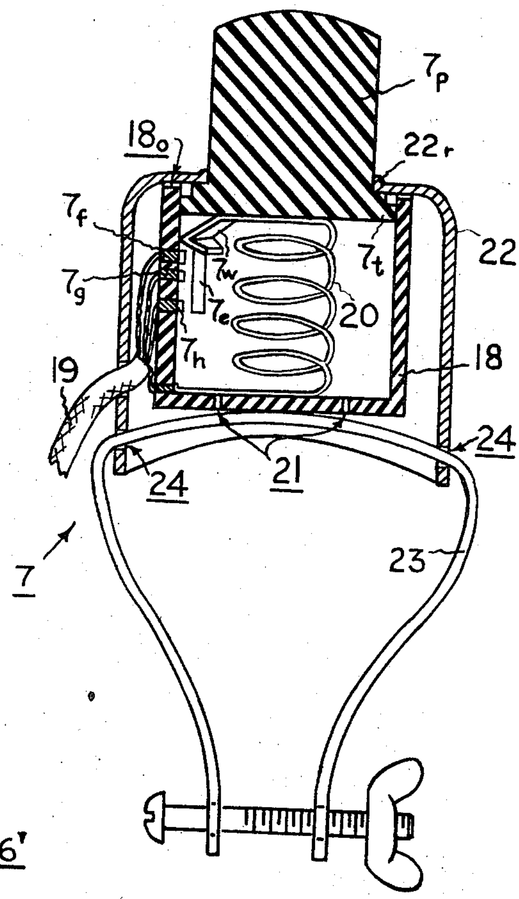


FIG. 2

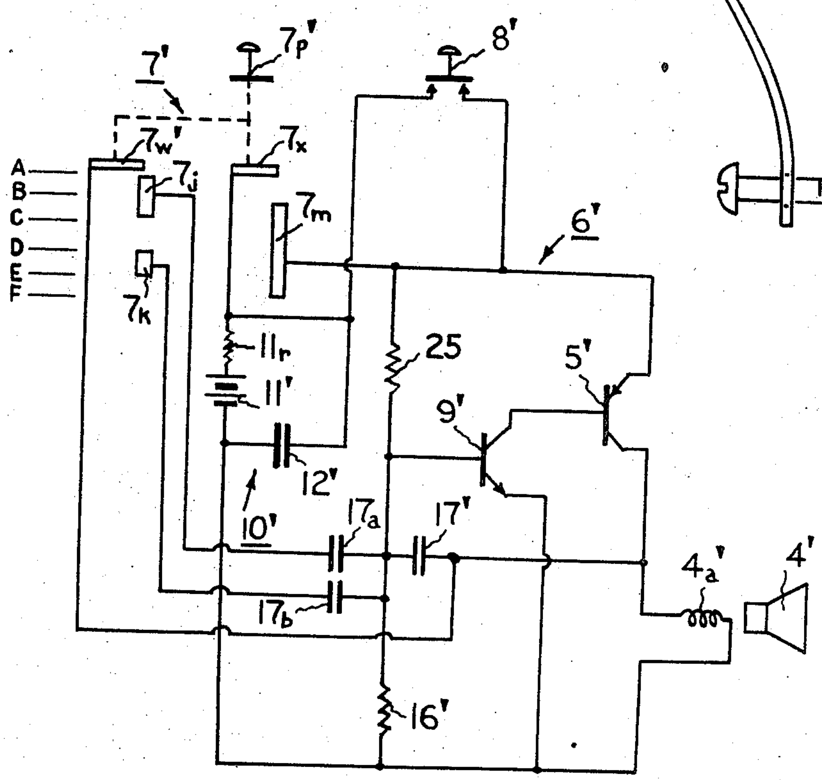


FIG. 3

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ATTORNEYS

# MULTI-TONE PUSH BUTTON CONTROLLED ELECTRONIC HORN

## BACKGROUND OF THE INVENTION

The present invention relates to improvements in electronic generation of audio tones of various frequencies, and, in one particular aspect, to novel and improved miniature transistorized sound generators in which power utilization is optimized, different-frequency tones are automatically produced in predetermined sequence by way of a manually-operated switch, and tone-switiching is uniquely controlled, and which utilize but few non-critical low-cost mechanical and electronic components.

Numerous electromechanical and electronic versions of sound-producing horns, sirens and the like have been devised in the past in efforts to take advantage of the versatile simulating capabilities of electrical equipment. Examples are found in U.S. Pat. Nos. 2,910,688 and 2,910,689 and 3,137,846 and 3,160,877. In many instances, such devices are called upon to operate from miniature inexpensive battery supplies, which are likely to be severely loaded and tend to allow generation of irregular poor-quality sounds, and, where more than one frequency of output is intended, the related electronic control circuitry tends to become undesirably complex and expensive. In the latter connection, significant economies, efficiencies and simplifications are realized through practice of certain of the present teachings having to do with mechanically-induced control of time constants in a two-transistor audio oscillator, such that multiple sustained tones are developed in sequence, preferably by way of an air-damped multi-contact push-button switch of simple low-cost construction. Further in relation to these practices, the normally-expected voltage degradations of a switched battery supply are avoided through utilization of an auxiliary capacitor as a source companion, and further simplification and improved-quality musical tone sequences may be assured through capacitor rather than resistor switching in the frequency-controlling networks.

## SUMMARY

The present invention is aimed at creating an improved and reliable mechanically-actuated electronic network which develops high-quality tones automatically in sequence and which is of economical construction involving relatively few and non-critical components. A preferred embodiment utilizes two inexpensive transistors which are connected in an oscillator configuration wherein frequency is determined by resistance and capacitance values, the network being capable of operating at more than one repetition rate, or frequency, depending upon the condition of associated mechanical switching which connects different resistance or capacitance components into the network. The low-impedance voice coil of a speaker is coupled serially in the current-flow path through one of the transistors where it responds efficiently to audio-repetition-rate pulses by producing highly acceptable qualities of tones rich in harmonics. Multi-tone horn and chime-like sequences are induced by an associated push-button switch designed as part of a piston-cylinder unit, the movable spring-biased push-button causing a movable contact to engage stationary contacts in sequence as it is depressed and then restored to its original position; the piston-cylinder unit regulates the speed of movement of the movable contact, and thereby provides for dwell on the stationary contacts and for related sustained output tones, when the flow of air into and out of the unit is sufficiently restricted to form an air-damped assembly. Preferably, the switching sequenced by the push-button unit is of capacitance in the oscillator circuit, such that one of sequenced tones can be produced without providing a separate stationary contact for it. In addition, the voltage of oscillator operation, and hence the resulting sonic power output, is maintained at a high and substantially steady level during each short pulse of the system oscillations, despite contrary effects of high internal battery resistance, by way of a charging-discharging capacitor functioning as a source.

Accordingly, it is one of the objects of the present invention to provide novel and improved electronic sound-generating equipment of uncomplicated and inexpensive construction wherein simple mechanical switching automatically sequences production of different tones from a transistorized oscillator.

A further object is to provide a transistorized electronic generator of harmonically-rich tones which develops optimum sonic power by way of a capacitor source charged via an inexpensive battery during off-duty periods in pulsing cycles of the transistorized generator.

Still further, it is an object to provide a multi-tone electronic sound generator sequenced by an associated air-damped mechanical switch and varied in tone through capacitor switching in pitch-controlling circuitry.

## BRIEF DESCRIPTION OF THE DRAWINGS

Although the aspects and features of this invention which are believed to be novel are expressed in the appended claims, additional details as to preferred practices and embodiments, and as to the further advantages, objects and features thereof, may be most readily comprehended through reference to the following description taken in connection with the accompanying drawings, wherein:

FIG. 1 comprises a schematic diagram of an improved multi-tone mechanically-sequenced electronic horn;

FIG. 2 is a partly cross-sectional illustration of an air-damped tone-sequencing push-button switch suitable for control of a multi-toned electronic sound generator; and

FIG. 3 provides a schematic diagram of a preferred multi-tone horn network with a source circuit promoting optimum sonic output and with capacitor-switching provisions.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

The network appearing schematically in FIG. 1 produces sonic outputs via a small loudspeaker 4, which responds to discrete pulses of current periodically delivered through its voice coil 4*a* by way of the collector of a transistor 5 which forms part of a two-transistor audio oscillator 6. Depending upon the control voltage established for the oscillator by an associated manually-actuated multi-contact mechanical switch 7, the resulting harmonic-laden audio signals from speaker 4 may be of different predetermined tones, and may be produced in a predetermined order and for times characterizing a musical note sequence, such as that of chimes or a musical horn. In another mode of operation, a simple push-button switch 8 may be closed to cause a single steady tone to be developed.

The electrical oscillator portion of the network includes the aforesaid transistor 5 as well as its companion transistor 9, both of which may be relatively inexpensive germanium transistors such as the Types GP1237 and GA 3292, respectively, manufactured by Texas Instruments, Inc. The emitter of transistor 9 is "-grounded" at the negative supply potential of an electrical power source, 10, including a battery 11 and an associated capacitor 12 in parallel with it, while its collector is connected to the base of the other transistor, 5. Voltage level at the base of input transistor 9 is governed by the split of voltage from source 10 by the set of four resistances 13 – 16, between resistances 15 and 16 of which the base connection is tapped. Output transistor 5 has its emitter connected to the positive side of the source 10 whenever either switch 8 or 7 is actuated, and its collector is "grounded" through the loading impedance posed by voice coil 4*a* of loudspeaker 4. A conventional low-impedance (such as 8 ohms) voice coil provides a highly satisfactory direct loading "match" in the illustrated circuit relationship, and need for the usual output transformer is advantageously obviated. Transistors 9 and 5 are arranged as inverting amplifiers, and the capacitor 17 coupling the collector of output transistor 5 with the base of input transistor 9 occasions the positive feedback which gives rise to the desired "oscillatory" effects. Capacitor 17 is typically a common 0.01 mfd. capacitance for purposes of promoting oscillatory effects in the range of about 200–800 cycles, and, in association with the two inverting transistors, effectuates the needed phase shift which achieves regeneration. The currents witnessed by voice coil 4*a* are in "pulse" form, rather than sinusoidal, and the resulting speaker tones are thus harmonically enriched and agreeable.

Circuit 6 comprises a voltage-controlled oscillator, and, when switch 8 is first closed, a positive voltage is applied to the emitter of transistor 5 while the base of input transistor 9 is first maintained effectively at the "-ground" potential of the circuit through the low impedance of the speaker voice coil 4*a*. Capacitor 17, which initially has no voltage across it, then commences charging and raising the voltage at the base of input transistor 9, the charging rate being determined by the values of the impedances of coil 4*a* and by the source voltage and by the resistances 13 – 16. Capacitor 17 continues to charge until the potential at the base of transistor 9 causes that transistor to conduct, whereupon the potential at the collector of transistor 9 and at the base of transistor 5 is reduced and causes transistor 5 to start to turn on. The resulting positive-going potential at the collector of transistor 5 is A-C coupled to the base of transistor 9 through capacitor 17, and this positive-feedback action continues rapidly until both transistors are on "hard". At that time, the collector of transistor 5 is clamped at essentially the full source potential level, and capacitor 17 charges through the low base to emitter saturation resistance of transistor 9, with the result that the potential at the base of transistor 9 begins to fall. Ultimately, the latter potential becomes low enough to start turn-off of transistor 9, whereupon the potential at the collector of transistor 9 and the base of transistor 5 increases and starts turn-off of transistor 5. A negative-going potential then appears at the collector of transistor 5, and is A-C coupled through capacitor 17 to the base of transistor 9, such that both transistors are ultimately full off. The negative potential resulting at the base of transistor 9 then begins to charge positively, at a rate determined by the impedance of voice coil 4*a*, capacitor 17, resistances 13 – 16, and by the source voltage, whereupon the cycle repeats. In the course of this cycling, the related loading of source 10 by the electronic circuitry is at alternate times being switched on and off, and this bears importantly upon the use of capacitor 12 as an active part of the power source, as is discussed in detail later herein.

The uses of NPN transistor 9 and PNP transistor 5 promotes the double inversion which is needed to establish the positive feedback condition through capacitor 17. This has the advantage of providing two stages of voltage and power amplification. Transistor 9 may therefore be a relatively low-power unit, while the power rating of transistor 5 is high enough to permit direct coupling of the speaker voice coil 4*a* to its collector as the load, with the result that such loading improves efficiency.

The value of resistance in the path between the source and the base of transistor 9 has a controlling effect upon the charging rate of capacitor 17, such that the latter in turn controls the frequency of operation of the two-transistor oscillator. Decreased resistance in that path increases the charging rate of the capacitor and the resulting signals developed through speaker 4 are then of higher pitch. Closure of simple switch 8 causes a first resistance value to exist in the said path, and a single predetermined pitch of audio output is generated for that switching condition.

For purposes of developing a series of different musical tones in sequence, the resistance between the source 10 and the base of transistor 9 is preferably actuated manually via a sequencing switch 7. Push-button 7*p* of that switch is mechanically connected to operate a wiper to engage both an energizing contact 7*e* and, in sequence, a group of switch contacts 7*f*, 7*g* and 7*h*. As the push-button 7*p* is being depressed, wiper 7*w*, which is electrically connected to the positive side of the source, first engages both contact 7*e* and 7*f*, whereby the full source potential is applied to the emitter of transistor 5 via contact 7*e* and, at the same time, is applied to the junction of resistances 13 and 14. The value of resistance between the source 10 and the base of input transistor 9 is therefore equal to the sum of resistances 14 and 15. When the wiper next engages contact 7*g*, the full source potential appears at the junction of resistances 14 and 15, rather than 13 and 14, and the pitch-controlling resistance between the source 10 and the base of transistor 9 is then decreased, being equal to the resistance 15 alone, thereby increasing the charging rate of capacitor 17, resulting in a higher pitch of the audio output. At a third position, intermediate contacts 7*g* and 7*h*, the wiper 7*w* engages only the contact $7e$, and the resistance value between the source **10** and the base of transistor **9** is a maximum, being equal to the sum of the resistances **13**, **14** and **15**, resulting in the lowest pitch of the audio output. In the fourth position of the sequence, when wiper $7w$ engages contact $7h$, the electrical conditions are the same as for the second position, and the same pitch of output signal results. Different combinations may be implemented by changing the specific resistance-switching arrangement. On return of the push-button $7p$ to its raised position, the pitch sequence is reversed.

Unless the travel of push-button $7p$ is regulated, the tone sequence may be undesirably rapid and lacking in pleasant aesthetic effects. Preferably, such regulation is achieved in an air-damped switch assembly such as that appearing in FIG. 2, where functionally-similar parts are identified by the same reference characters as used for FIG. 1. Switch **7** is intended to require only relatively small movements of its push-button $7p$ by the operator, and the desired sustained contacting or dwell upon sequentially-switched contacts $7f$, $7g$ and $7h$ is achieved by way of air damping of the push-button movements. In this connection, electrically-insulating push-button $7p$ is formed with an integral-cylindrical piston portion $7t$ at its lower extremity, and that piston fits closely within an electrically-insulating cup-shaped cylinder **18**. Both elements $7p$ and **18** are conveniently made of plastic, for example, and the conductive electrical contacts $7f$, $7g$, $7h$ and $7e$ are embedded in and sealed with the walls of cylinder **18** for the illustrated external connections with lead wires of a cable **19** and for internal wiping engagement by electrical wiper $7w$. Wiper $7w$ is electrically energized via the associated spring **20**, which also has a lead-through electrical connection at one end through the cylinder **18**, and which resiliently biases the wiper $7w$ and push-button $7p$ in the upward direction. Small air-bleed holes **21** in the bottom of cylinder **18** govern the rate at which air may escape from and be drawn into the cylinder. An inverted cup-shaped metal housing **22** receives the aforesaid switch components and holds them in the illustrated nested relationship when a metal strap-type clamp **23** is passed below cylinder **18** through accommodating slots **24** in housing **22**. Push-button $7p$ is free to move within a circular opening at the top of housing **22**, and the housing rim $22r$ about that opening fits loosely enough with push-button $7p$ to aid in guiding its movements while at the same time allowing air to enter and escape. Where necessary, the top of cylinder **18** may have slits or other openings $18o$ allowing free entry and escape of air atop the piston portion $7t$ of the push-button.

Initially, the air pressure within cylinder **18** is the same as the ambient outside pressure, and spring **20** maintains the push-button $7p$ in the raised position where no electrical switch interconnections are established. As the operator depresses the push-button, the spring bias is overcome and air pressure is increased within cylinder **18**. Downward velocity of the push-button is related to the area of bleed holes **21** divided by the piston area and the square root of the pressure difference between the air inside and outside of the cylinder. Time for the push-button wiper $7w$ to traverse the contacts, for a particular applied push-button force, may be regulated by proper selection of the sizes of bleed holes **21**, as well as by proper selection of the related piston area and spring constant. Removal of the push-button force enables the wiper to be restored to the uppermost position by action of spring **20**, with the timing being correspondingly regulated.

In FIG. 3, the two-transistor oscillator section **6'** is generally like that of FIG. **1** and the functionally-similar components are therefore identified by the same reference characters, with distinguishing single-prime accents added. Switch **8'** may be actuated to apply source voltage of a value determined by voltage-splitting resistances **16'** and **25**, to control the pitch of a single output tone from speaker **4'**. However, switch **7**, which controls the automatic-sequencing of pitches, is slightly modified, to make electrically-separate connections between one wiper part $7w'$ and contacts $7j$ and $7k$ on the one hand, and between wiper part $7x$ and the contact $7m$ on the other hand. Both wiper parts are mechanically actuated by the push-button $7p'$, preferably in an air-damped assembly like that of FIG. **2**, and part $7w'$ is effective to govern circuit capacitance, rather than resistance, to control the sequences of pitch of tones from the speaker. Audio oscillation frequency is determined by impedance of voice coil $4a'$, the value of capacitance between the collector of transistor **5'** and the base of transistor **9'**, the resistance **16'**, the resistance **25**, and the source voltage from supply **10'**. The further capacitances, $17a$ and $17b$, are used to change the aforesaid capacitance and, therefore, the pitch of tones, without switching of resistances, and without unwanted irregularities in sound as the wiper of the switch **7'** moves from one stationary contact to another. As wipers $7w'$ and $7x$ are moved downwardly from level A to level B by push-button $7p'$, wiper $7w'$ first engages the switch contact $7j$ and thereby connects the further capacitor $17a$ in parallel with capacitor **17'**; next, as wipers $7w'$ and $7x$ both descend from level B to level C, capacitor $17a$ remains in the aforesaid parallelled connection and at the same time the source **10'** is connected across the voltage-splitting resistances **16'** and **25** by wiper part $7x$, causing a sound of a first pitch to be generated. When both wiper parts $7w'$ and $7x$ descend from level C to level D, only capacitor **17'** is in circuit, and a higher-pitched sound is developed. When the two wiper parts next descend from level D to level E, capacitance $17b$ is parallelled with **17'**, causing a still different pitch to be produced. Below level E, only wiper part $7x$ is connected, with contact $7m$, and the same pitch of tone results as for the switching condition between levels C and D. Below level F there is no switching connection, and no sonic output. In this construction, the sequential pitch shifts from one to another are not meanwhile interrupted, and therefore the tone sequencing is particularly pleasing. For this type of switching, the wiper shown in FIG. **2** may readily be made in two electrically-insulated parts, each connecting separately with the different set of contacts $7j$ and $7h$ and with the potential-applying contact $7m$, the latter corresponding to contact $7e$; separate electrical connections are of course made with the different wiper parts, one of which may be via spring **20** and the other via a separate flexible lead wire.

As was explained earlier herein, loadings of the power source **10**, and also **10'**, are essentially "-

switched" on and off by the electronic oscillation circuitry, at extremely high ratio of speed such as will result in output current pulsations at audio-frequency repetition rates. Ordinarily, high battery loadings tend to degrade performance of electronic devices, and, in the case of tone-generating circuitry, this can result in undesirable wavering tones, changes in pitch, and low-power sonic outputs. A major difficulty attending use of a battery supply for such circuitry is associated with voltage drop across internal battery resistance, symbolized by the resistance **11**$r$ in FIG. **3**. In the circuitry of FIG. **3**, for example, the battery **11** may be considered to be in series with its internal resistance **11**$r$, typically about 8 ohms in a common inexpensive 9-volt battery used for operation of low-power transistor circuits, and with a transistor as a switch, and with a load impedance represented by the 8-ohm impedance of the speaker voice coil **4**$a'$. When the transistor "switch" opens and closes at a 500 c.p.s. rate for the illustrated circuitry, it is alternately "on" for about 0.0002 second and "off" for about 0.0018 second, and, with a speaker voice coil impedance essentially constant at about 8 ohms, the resulting voltage drops are about 4.5 volts across the voice coil and about 4.5 volts across the internal battery resistance **11**$r$. It is evident that the loudness of the 500 c.p.s. tone is limited by the voltage drop across **11**$r$. When the source capacitor **12**$'$ of about 500 microfarads is next considered, in a shunting relation to the battery **11**$'$ and its internal resistance **11**$r$, it is found that this capacitor will dramatically improve the supply of voltage and power. Taking the same conditions last considered, the energy E required by the voice coil load, Z, during the "on" time $\Delta t$ of 0.0002 second, for a battery voltage $E_b$ of 9 volts is as follows:

$$E = E_b^2/Z\, \Delta t = 0.0081/4 \text{ watt-second.}$$

Energy $E_c$ stored in capacitance C of capacitor **12**$'$ charged to voltage $E_b$, where $E_b$ is 9 volts, is as follows:

$$E_c = \tfrac{1}{2} C E_b^2 = 81/2\, C.$$

Setting the energy stored in the capacitor equal to 10 times that required by the load,

$$10E = E_c \text{ or } 0.081/4 = 81/2\, C$$

and

$$C = 500 \text{ microfarads.}$$

For this value of capacitance, the voltage across the load, namely the voice coil **4**$a$, remains nearly at 9 volts during the transistor "switch" on-time of 0.0002 second. When the "switch" first closes, as the result of initial closing of switch **7**$'$ for example, the voltage $V_Z$ across the voice coil "load" Z, in the presence of an internal battery resistance $R_b$, is:

$$V_Z = \frac{Z}{R_b + Z} E_b \left\{ 1 - \left[ 1 - \frac{R_b + Z}{Z} \right] e^{-\frac{(R_b+Z)t}{R_b Z C}} \right\}$$

And, with $R_b = Z = 8$ ohms, and $E_b = 9$ volts, and $C =$ 500 microfarads:

$$V_Z = 4.5\left(1 + e^{-\frac{t}{0.002}}\right)$$

For the "on" time of 0.0002 second,

$$V_Z = 4.5\,(1 + 0.905) = 8.57 \text{ volt.}$$

This is the lowest voltage that will appear across the load during the first cycle of the 500 c.p.s. signal. During the "off" time of 0.0018 second, the capacitor **12**$'$ recharges to a voltage $e_C$ through the internal battery resistance $R_b$ in accordance with the expression:

$$e_C = (9 - 8.57)\left(1 - e^{-\frac{t}{0.001}}\right) + 8.57$$

and, at $t = 0.0018$ second:

$$e_C = 8.726 \text{ volts.}$$

The fact that the capacitor does not charge fully to 9 volts is an indication that the voltage drop across the load will drop towards 4.5 volts if the 500 c.p.s. signal is sustained for a long time. However, for normal operations of the character under consideration here, where the operation at 500 c.p.s. is for a relatively short period of time and is then followed by an off period during which the capacitor may re-charge back to full voltage, the source voltage drop is not troublesome. The value of capacitor **12** and **12**$'$ is selected consistent with the operational duty cycle, to obtain the desired sonic output power and steadiness. In general, its value is such that substantially full battery voltage is charged in it during "off" times of an audio-frequency switching rate. Because the load witnesses and is powered according to capacitor-stored energy which is at substantially the maximum battery voltage, the effective electrical power is a maximum and the sonic output is much increased over what it would otherwise be.

It should be understood that the specific preferred embodiments and practices described herein have been presented by way of disclosure rather than limitation, and that those skilled in the art will appreciate that various modifications, combinations and substitutions may be effected without departure from the spirit and scope of this invention in its broader aspects and as set forth in the accompanying claims.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. Electronic tone-producing apparatus comprising an audio-frequency oscillator having a plurality of frequency-controlling elements arranged for connection into said oscillator to occasion different frequencies of oscillations thereby, multi-contact mechanical switch means including manually-operated movable electrical contact means and stationary electrical contacts disposed for connection with said movable contact means in sequence as the latter moves along a path of travel, and means for connecting different ones of said frequency-connecting elements into said oscillator through said movable contact means and different ones of said stationary contacts, said switch including spring means urging said movable contact means to a position out of connection with said stationary contacts, whereby upon manual actuation of said movable contact means against action of said spring means said stationary contacts are first connected in a predetermined sequence and then in reverse sequence when said manual actuation stops, to cause a predetermined sequence of tones to be generated by said oscillator.

2. Electronic tone-producing apparatus as set forth in claim 1 wherein said switch further comprises cooperating relatively movable piston and cylinder members, said members having a substantially air-tight relation with one another and forming an air chamber therebetween, and relatively small air-bleed passage means between said chamber and the external atmosphere, said movable contact means being movable with and damped in movement by said piston member.

3. Electronic tone-producing apparatus as set forth in claim 2 wherein said piston and cylinder members are of electrically-insulating material, wherein said spring means and said movable contact means are disposed within said chamber, and wherein said stationary contacts form parts of the inner walls of said cylinder member and are disposed for sequential connection by said movable contact in response to manual actuation thereof.

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