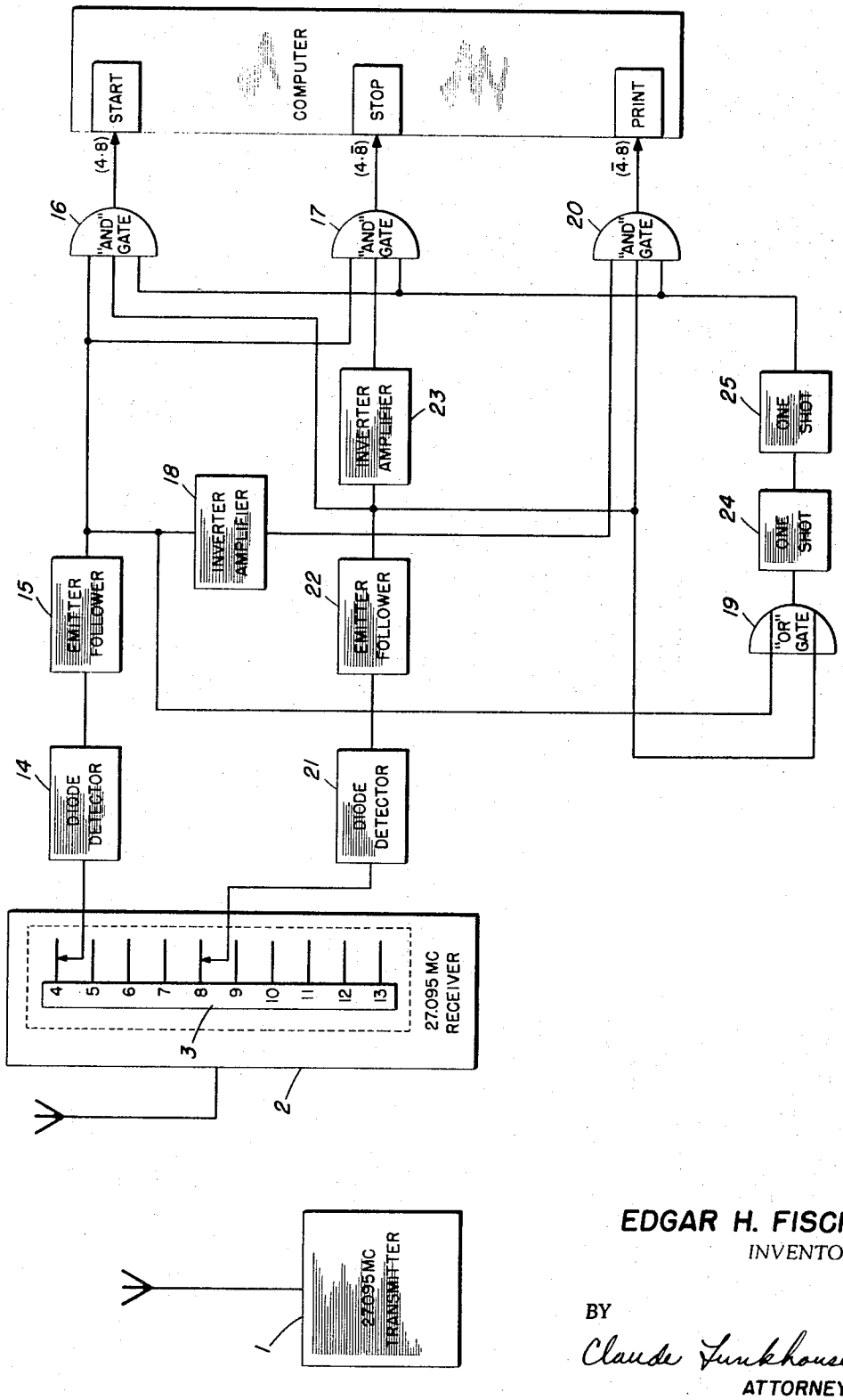
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AUTOMATION COMMAND CIRCUIT

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EDGAR H. FISCHER
INVENTOR.

BY
Claude Funkhouser
ATTORNEY

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AUTOMATON COMMAND CIRCUIT

Edgar H. Fischer, Silver Spring, Md., assignor to the United States of America as represented by the Secretary of the Navy

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ABSTRACT OF THE DISCLOSURE

A command system utilizing resonant reeds, which is capable of combining signal impulses emergent from said reeds into a plurality of commands greater in number than the number of input signals to the reeds and greater in number than the number of reeds. A transmitter sends out tone modulated signals which initiate responses in resonant reeds housed in a receiver. The reed responses are communicated to particular "and" gates after interacting with detectors, emitter followers and inverter amplifiers. To insure that the system does not issue a command until all reeds have had sufficient time to respond to input signals, delay means are provided for suspending the reaction of the "and" gates for a predetermined time.

This invention relates generally to multiple command systems and more specifically to an improved command system utilizing resonant reeds.

Many developments in radio control have taken place in recent years. Along with these developments has come the inception of the use of resonant reeds in conjunction with multiple command radio control systems. Most resonant reed control systems essentially include a transmitter and a receiver. The resonant reed bank is contained within the receiver and one or more tone modulators are contained within the transmitter. Each tone modulator is capable of providing a plurality of discrete frequencies with each discrete frequency controlling one of the reeds in the reed bank. It is therefore obvious that in the heretofore available resonant reed control systems, only the same number of output functions can be obtained as there are reeds. Most existing resonant reed control systems are also limited by the inability to produce more distinct simultaneous commands than there are tone modulators in their transmitters. Another limitation on existing resonant reed control systems is their susceptibility to the relaying of false commands. Resonant reeds are high Q devices, that is, they resonate to an impressed signal only if the signal frequency is within approximately ± five cycles per second of the reeds' natural resonant frequencies. It is, nevertheless, possible that a reed may be caused to resonate by an ambient mechanical vibration near the natural resonant frequency of the reed. This vibration would result in a false command being transmitted to the controlled device.

The dangers inherently present in existing resonant reed control systems, of initiating false command signals, can be minimized to a great extent by requiring two or more reeds to resonate in order to initiate a command signal. Since each reed resonates at a discrete frequency, the probability of any surrounding vibrations being close to the natural resonant frequencies of two or more reeds is much smaller than the probability of their being close to the natural resonant frequency of just one reed. The greater the number of reeds which are necessary to initiate a command the smaller the probability of obtaining a false command.

It is an object of this invention to provide a multiple command system utilizing resonant reeds and logic functions.

It is another object of this invention to provide a versatile multiple command system.

It is a further object of this invention to provide a multiple command system utilizing resonant reeds, wherein it is possible to initiate a greater number of command signals than there are resonant reeds.

It is a still further object of this invention to provide a multiple command system utilizing resonant reeds, wherein it is possible to provide a greater number of distinct simultaneous commands than there are tone modulators.

And a still further object of this invention is to provide means whereby the probability of initiating a false command is greatly reduced.

The attendant advantages of this invention will be better appreciated and said invention will become clearly understood by reference to the following detailed description when considered in conjunction with the accompanying drawing, wherein the figure is a functional block diagram of one embodiment of the instant invention.

Referring to the drawing in more detail, a 27.095 mc. transmitter, such as the "Hercules" manufactured by the F & M Electronics Co., is shown at **1**. Said transmitter feeds tone modulated radio frequency signals to a 27.095 mc. receiver **2**, suc has the "Midas-4" manufactured by the F & M Electronics Co. Said receiver includes a comb **3** comprising a plurality of resonant reeds **4** through **13**. The resonant reeds **4** through **13** are each secured at one end to a common support (in a well-known manner) and project perpendicularly therefrom so as to be free to resonate. Indeed, the resonant reeds **4** through **13** resemble the teeth of a comb thereby giving the name of "comb" to the entire resonant reed structure.

The tone modulators (not shown) within the transmitter **1** are merely audio oscillators capable of issuing signals of frequencies corresponding to the natural resonant frequencies of said reeds **4** through **13**. The audio signals from the tone modulators are used to modulate an RF carrier in order to increase the transmission range. A tone modulated RF signal is received by the receiver **2**, and the tone modulation is detected in a well-known manner. The detected tone signal is fed to a coil (not shown) the direction of whose field is perpendicular to all of the resonant reeds **4** through **13**. The detected tone signal causes the field of the coil to vary at the same frequency as that of the detected tone signal, thereby inducing resonance in that reed whose natural resonant frequency corresponds to that of the detected tone signal.

It should be emphasized at this point that the "Hercules" transmitter contains two tone modulators. One of the tone modulators controls reeds **4** through **7**, and the other controls reeds **8** through **13**.

In the particular embodiment of the invention herein described, either two tones, or one tone and a missing tone are necessary to complete a command. One of the tone modulators sends out a signal to one of the reeds under its control, and at the same time the other tone modulator may or may not send out a signal to one of the reeds which it controls. For illustrative purposes, the two reeds which are being activated are the reeds **4** and **8**. Said reeds **4** and **8** receive their respective signals and both start to resonate.

As the reed **4** resonates it closes a circuit to a diode detector **14** for supplying a signal thereto, and said diode detector then feeds the signals to an emitter follower **15**. The signal at the output of said emitter follower is approximately the same as at the detector output but at a lower impedance level. The output signal of the emitter follower **15** is fed to an "and" gate **16**, an "and" gate **17**, an inverter amplifier **18** and to an "or" gate **19**, all of which are electrically connected in parallel. The output

signal of the inverter amplifier **18** is fed to an "and" gate **20**.

In a like manner, the resonating reed **8** sends a signal to a diode detector **21** which sends a signal to an emitter follower **22**. The output signal of said emitter follower is fed to the "and" gates **16** and **20**, an inverter amplifier **23** and to the "or" gate **19**, all of which are electrically connected in parallel. The output signal of the inverter amplifier **23** is fed to the "and" gate **17**.

The first signal to reach the "or" gate **19**, either the signal initiated by reed **4** or that by the reed **8**, will pass through said "or" gate and trigger a monostable multivibrator or "one-shot" **24**. Said "one-shot" **24** acts to delay the impressed signal and triggers a second "one-shot" **25**. The "one-shot" **25** must be activated to allow "and" gate **16**, **17** or **20** to pass any signals. Thus, the "one-shot" **24** acts as a delay and turns on the "one-shot" **25** at the proper time in the signal, said "one-shots" acting in combination to allow the appropriate "and" gate to sample the proper portion of the signal reaching said "and" gate and issue a command signal. The aforementioned ability of the system to sample signals minimizes the probability of passing a false command.

Before proceeding further it is advisable to clarify the terminology which will be used as follows:

$A \cdot B$—means A *and* B where A and B are any numbers
$A \cdot \overline{B}$—means A and B "not"
B "not" is the absence of B
$\overline{A} \cdot B$—means A "not" *and* B
A "not" is the absence of A.

When both the reed **4** and the reed **8** are caused to resonate only the "and" gate **16** will be activated and it will pass a command signal $4 \cdot 8$. In the particular embodiment of the invention shown in the accompanying figure, three signals are necessary to activate an "and" gate, that is, two appropriate command signals plus the signal from the "one-shot" **25** must reach an "and" gate to cause it to operate and to emit a command to the mechanism to be controlled, in the example shown in the figure, a computer. An appropriate command signal is a signal resulting from the resonance of a reed or the absence of such resonance. There must, however, be at least one reed resonating in order to initiate a command. When the reed **4** is activated and there is no tone signal activating the reed **8**, the "and" gate **17** will receive the appropriate command signals and will emit the command $4 \cdot \overline{8}$. In like manner, when the reed **8** is activated and the reed **4** does not receive an activating tone signal, the "and" gate **20** will receive the appropriate command signals and will emit command $\overline{4} \cdot 8$.

Without the presence of the previously mentioned monostable multivibrator sampling mechanism, a group of signals might activate the wrong "and" gate and result in the issuance of a false command to the computer. For example, if the transmitter **1** were to send tone modulated signals to the reeds **4** and **8**, and if these signals were to reach the "and" gates at such a time as to appear to be originating from the reed **4** with the absence of the reed **8**, then the "and" gate **17** could emit the signal $4 \cdot \overline{8}$ to the computer. It is now evident that it can be very important for the "and" gates to "see" the incoming signals at the proper time.

In the embodiment of the present invention illustrated herein it is seen that the command $4 \cdot 8$ actuates the computer "start" switch, the command $4 \cdot \overline{8}$ actuates the computer "stop" switch, and the command $\overline{4} \cdot 8$ actuates the computer "print" switch. Many other types of control switches may be activated in addition to turning the computer on and off, and causing it to print. The control switches can be any of the well-known signal responsive types.

From the above teachings it is evident that similar circuitry can be connected to the other reeds in the comb **3** to provide a far larger plurality of commands than the relatively simple system, described above, for use with only two of the reeds in said comb.

Commands resulting from the resonance of a number of reeds equal to the number of signals, excluding "or" gate signals, necessary to initiate a command are called primary commands. Where a command results from the failure of one or more reeds to resonate it is called a secondary command. For example, command $4 \cdot 8$ is a primary command, and commands $4 \cdot \overline{8}$ and $\overline{4} \cdot 8$ are seconary commands.

In a basic system such as previously described, more than one primary command can be initiated at one time if more than two tone modulators are available in the transmitter. For instance, if three tone modulators are available and it is desired to require two tones to initiate a command, then the third tone could combine with either of the first two tones and constitute the signal necessary to activate another set of reeds and hence another primary command.

A theoretical total of 64 primary commands can be obtained from a 12-reed system which has three tone modulators in the transmitter if each modulator controls four reeds, with three tones or three resonating reeds at a time being required to provide a command. A commercially available transmitter, the Kraft Co. "Triple Ten," contains three tone modulators.

Additional tuned circuits can be added to this transmitter to provide 12-channel capability. Receivers with 12 reeds are available such as the "Min-X-12" superheterodyne receiver.

The successful utilization of the capabilities of the larger transmitters and receivers mentioned above, requires only the provision of additional circuitry of the type shown in the accompanying figure for a system with two tone modulators and requiring two signals to initiate a command.

The secondary commands of a system that requires two tone signals for the initiation of a command are subject to being false because of possible resonance of the one reed necessary to initiate a secondary command with absence of resonance of another reed, due to ambient vibration. It is readily noted, however, that this limitation does not apply to secondary commands where two or more tone signals plus the absence of one or more are required to initiate a secondary command.

In such systems three or more tone signals are necessary to initiate primary commands. Thus, whether the command function is of a primary or secondary nature, there will always be at least two tone signals and hence two resonating reeds in the initiation of any command.

It is important to realize that any system utilizing the teachings of this invention need not comprise all of the basic elements described previously. In the case where the system might be required to operate in an area exposed to severe shock there can be 5 or more signals necessary to initiate a command.

It might be desired not to make use of the extra number of commands which can be obtained as secondary commands. In such a case the inverter amplifiers and corresponding secondary command "and" gates could be eliminated. The elimination of the secondary commands will not affect the versatility of the system but merely reduce the number of functions which can be controlled by it.

It is possible to utilize the basic principles of the invention to provide a virtually unlimited number of commands either of a primary nature, a secondary nature or both. In the same system it can be required that some commands be initiated by a certain number of tone modulated signals and that other commands be initiated by a different number of tone modulated signals.

In general, where M equals the number of tone modulators in the transmitter and N_i equals the number of

reeds controlled by modulator (*i*) it follows that the number of possible primary commands equals

$$[N_1 \cdot N_2 \cdot N_3 \cdot N_4 \cdot \ldots N_M]$$

The total number of possible secondary commands is given generally by the equation

$$[N_1 \cdot N_2 \cdot N_3 \cdot N_4 \cdot \ldots N_M][2^M - 2] = P_s$$

Where P_s equals the total possible number of secondary commands.

Theoretically, the combination of primary and secondary commands might be thought to yield a total number of possible commands given by the equation

$$[N_1 \cdot N_2 \cdot N_3 \cdot \ldots N_M][2^M - 1] = P_c$$

Where P_c equals the total number of possible commands, i.e., both primary and secondary commands. It is to be noted, however, that many of the theoretically derived secondary commands overlap or coincide with primary commands and hence are not useful. The aforementioned teachings appear at first glance to limit the total number of practical command outputs to a number not much greater than the number of available primary commands.

For example, the command 1·3·5 from the reeds **1, 3,** and **5** respectively, in a three tone modulator 6 reed system requiring three tones to initiate a command, coincides with the command 1·3·6. This disadvantage can be overcome by using commands resulting from tone signals, where a number of possible tone signals equal to A are present and all possible tone signals other than those present in a particular group of size A are absent.

It follows that $1 \leqq A < T$, where T=number of possible tones=numberof reeds in the comb.

The use of the above principle enables the combining of primary and secondary outputs to yield a larger number of output commands than can be obtained in either a pure primary or secondary command system. It is obvious that use of the above principle requires that "and" gates requiring up to $T+1$ inputs be used.

A system of resonant reeds and logic can be used in a command receiver or in direct control operations where a false command would be catastrophic, by requiring the simultaneous operation of two or more reeds before presenting a command. The greater the number of reeds involved for simultaneous operation, the less the probability of receiving a false command.

Some applications for this invention are as follows:

(1) To detonate explosions from remote locations.

(2) To command various operations in a satellite. In the satellite application the system could be used during the severe vibration environment occurring with launch, as well as after this critical period, to provide control commands to the satellite system.

(3) For remote or direct control of industrial machinery or processes. In direct control the transmitter and receiver would be eliminated.

(4) To operate mechanical relays or switches.

(5) To provide electrical commands to many types of electronic circuits.

(6) To operate model airplanes, boats, cars, etc.

(7) To program instructions to a computer or memory system.

It can readily be seen that many variations and modifications of the present invention are possible in the light of the aforementioned teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced in a manner otherwise than is specifically described herein.

What is claimed is:

1. In apparatus for transmitting multiple command signals to remote locations the combination, including:

a transmitter for providing tone modulated radio frequency command signals,

a receiver for receiving said command signals,

a plurality of resonant reeds within said receiver connected together so as to form a comb, each said reed resonantly responding to a discrete tone modulated command signal received by said receiver,

a plurality of diodes each connected in electrical series with one of said resonant reeds for detecting signals therefrom,

a plurality of emitter followers each connected to one of said diodes for receiving signals therefrom and acting as a buffer amplifier,

a plurality of inverter amplifiers each connected to one of said emitter followers for preventing the passage of undesired control signals,

an "or" gate connected to said emitter followers for receiving signals therefrom and passing signals reaching said "or" gate,

multivibrator means connected in electrical series with said "or" gate for receiving and delaying signals from said "or" gate, and

a plurality of "and" gates each connected to at least one said emitter follower and said multivibrator means, for providing a plurality of output command signals.

2. The combination as set forth in claim **1,** wherein each "and" gate is operatively connected to at least one resonant reed, and at least one "and" gate is operatively connected to at least two resonant reeds, whereby a greater number of distinct command signals than there are resonant reeds may be initiated.

3. The invention as recited in claim **1,** wherein each "and" gate is operatively connected to at least two resonant reeds, requiring the simultaneous resonance of at least two of said reeds to activate each said "and" gate, whereby the probability of the issuance of false commands is reduced.

4. In apparatus for supplying multiple command signals, a wireless remote control system including

a radio transmitter for supplying tone modulated signals,

a radio receiver for receiving signals from said transmitter, said receiver having a plurality of reeds resonating in response to tone modulated signals emanating from said transmitter, and

logic circuitry operatively connected to said resonant reeds and including

a plurality of "and" gates,

a plurality of detectors each connected to one of said reeds and operatively connected to at least one of said "and" gates, and

a plurality of inverter means each associated with one of said detectors for operatively connecting its associated detector to a further "and" gate, said logic circuitry combining signal outputs from said resonant reeds into a plurality of discrete simultaneous commands greater than the number of discrete simultaneous signals from said transmitter and into a greater number of distinct commands than there are resonant reeds in said receiver.

5. The invention as set forth in claim **4** further comprising

an "or" gate operatively connected to each of said detectors for receiving signals therefrom and passing signals reaching said "or" gate, and

delay means connected in electrical series with said "or" gate for receiving and delaying signals from said "or" gate and for transmitting delayed signals to each of said "and" gates.

6. The invention as recited in claim **4** further comprising

a plurality of emitter followers, each having an input terminal and an output terminal, wherein

the input terminal of each of said emitter followers is connected to one of said detectors, and wherein

the output terminal of each of said emitter followers is connected to at least one of said "and" gates and

is further connected to at least one of said inverter amplifiers.

7. In a multiple command system, apparatus for providing command signals to remote locations, including

means for transmitting a plurality of discrete signals,

means for receiving said transmitted discrete signals,

responder means for each discrete signal and providing discrete output signals,

means for detecting signals from said responder means,

means for inverting signals from said detecting means to prevent passage of undesired signals,

means connected to said detecting means for passing signals therefrom,

means connected to said inverting means for passing signals therefrom,

a first series of output means for receiving signals from at least two of said responder means, and

a second series of output means for receiving signals from at least one of said inverting means and from at least one of said responder means,

said first and second series of output means reacting to signals from said responder means and from said inverting means for providing a plurality of discrete output control signals greater than the number of responder means.

8. The invention as recited in claim 7, wherein said first and second series of output means require at least two simultaneous discrete signals from said transmitting means to initiate an output command signal, whereby the probability of the issuance of false output command signals is reduced.

9. In a multiple command system, apparatus for providing command signals to remote locations, including:

means for transmitting a plurality of discrete signals,

means for receiving said transmitted discrete signals,

responder means for each discrete signal,

means for detecting signals from said responder means,

means for inverting signals from said detecting means,

first transmission means connected to said detecting means for passing signals therefrom,

second transmission means connected to said inverting means for passing signals therefrom, and

output means for receiving signals from said first and second transmission means and for issuing a response thereto, said output means having the capability of issuing a response only upon the receipt of two or more signals from said first and second transmission means, and thereby providing a plurality of discrete output control signals greater than the number of responder means.

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NEIL C. READ, *Primary Examiner.*

A. J. KASPER, *Assistant Examiner.*