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METHOD AND SYSTEM FOR DETERMINING WHETHER A SWITCH IS OPEN OR CLOSED

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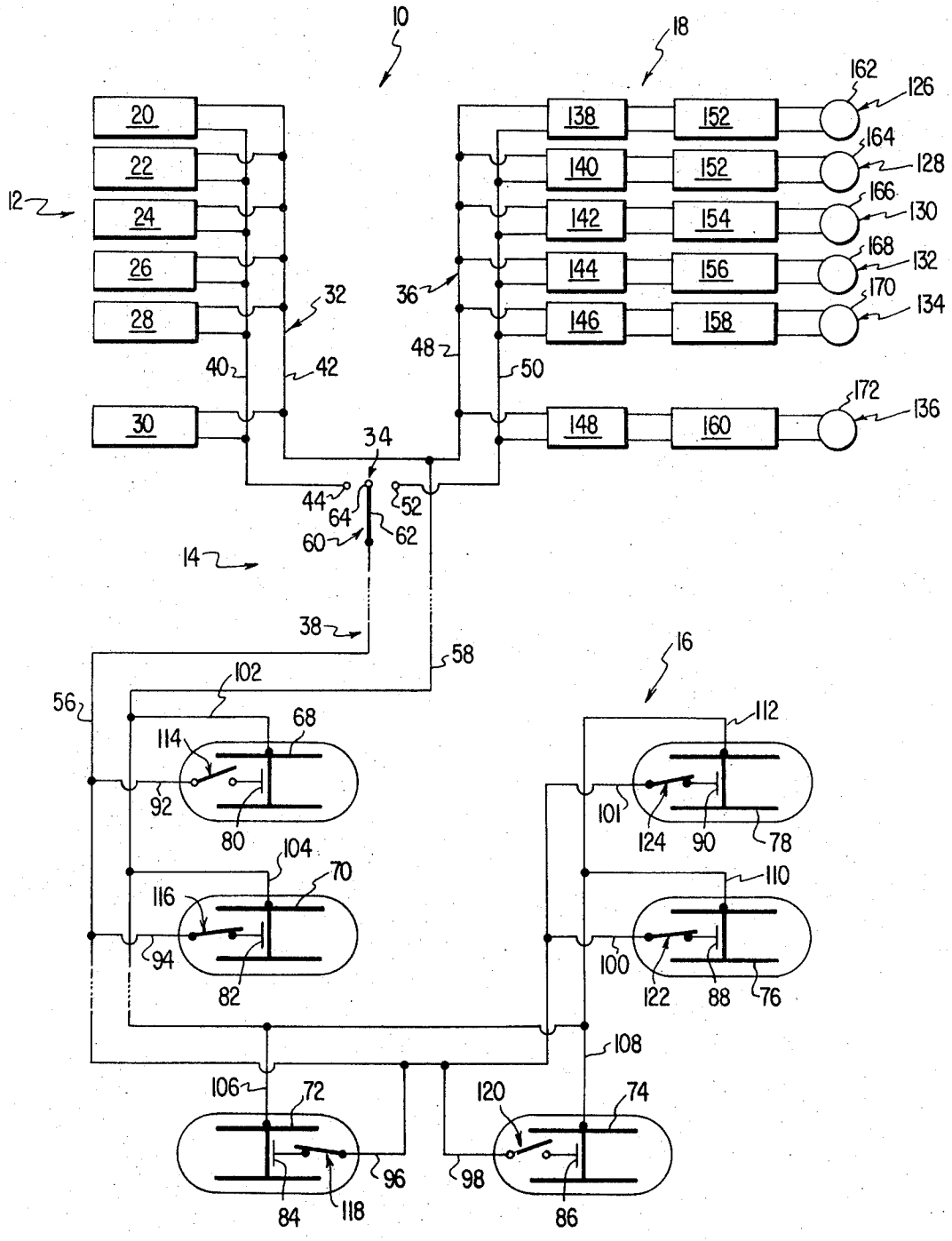



FIG. 1

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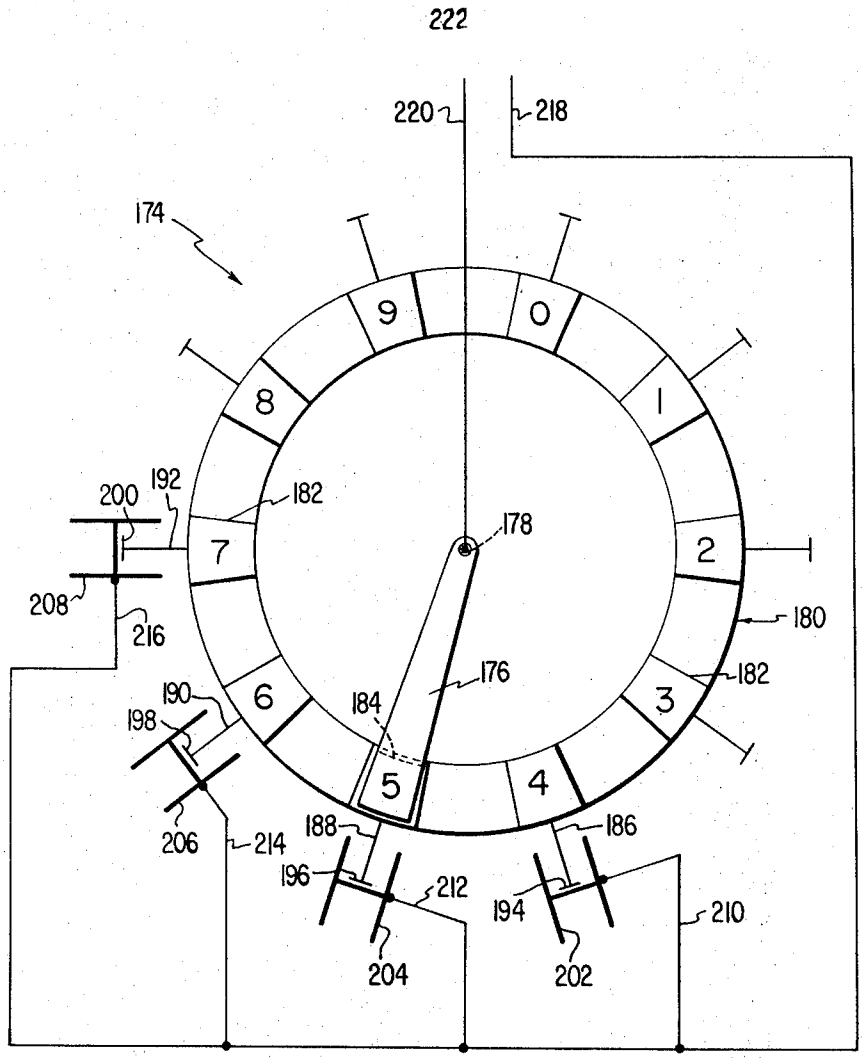



FIG. 2

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3,550,090

# METHOD AND SYSTEM FOR DETERMINING WHETHER A SWITCH IS OPEN OR CLOSED

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## ABSTRACT OF THE DISCLOSURE

This disclosure describes a system for determining whether a remotely disposed switch is open or closed. The system includes means for transmitting a signal including a predetermined frequency to energize a resonator at a remote location. The resonator is a passive resonator which produces an output signal after the energizing signal is terminated, the output signal being transmitted to an indicator unit. Means controlled by a condition being monitored selectively permits or prevents the provision of the energizing signal to the resonator. Also, a switching circuit first connects the energizing signal to the condition controlled means and then disconnects the energizing signal while connecting the output signal from the resonator to the indicator unit.

## BACKGROUND OF THE INVENTION

This invention relates to means for determining whether a remotely disposed switch is open or closed. As will be explained more fully hereinafter, the invention has application wherever a condition is capable of being sensed by the capability of a switch to pass current. For example, the invention may be used in security systems wherein it is desirable to determine whether a door or window is open or closed, in industrial applications where it is advantageous to ascertain whether an engine is running or not, in industrial applications where it is desirable to ascertain whether a valve is open or closed, and in other situations wherein it is desirable to determine whether two electrically conductive members are in contact or whether a solid state switch is capable of passing current.

There are numerous situations wherein it is desirable to ascertain whether a switch is open or closed as previously mentioned and as evidenced by U.S. Pat. 3,009,134. Many difficulties reside in prior art devices of the type exemplified by the aforementioned patent. One of the biggest disadvantages is that both the central station and the remote location require an external energy source thereby limiting the use of the device to situations where an external source of power is readily available.

Another disadvantage of systems exemplified by the aforementioned patent is the necessity for numerous electrical and mechanical components rendered unnecessary by this invention. Both of these disadvantages contribute to the high cost of communication systems of this type thereby limiting the practicable areas of application.

## SUMMARY OF THE INVENTION

To the end that the aforementioned difficulties and disadvantages of the prior art are obviated and avoided, the system of this invention utilizes means to generate a signal comprised of a predetermined frequency and means to transmit the signal to a remote location. There is provided resonator means in circuit with switch means, the condition of which is desired to be ascertained. If the switch means is closed, the resonator means is energized and then passively transmits to indicator means typically located at a central station wherein the transmitted signal may be used to activate an alarm or the like. In the event



that the switch means is open or incapable of passing current, the resonator means is not energized and accordingly cannot transmit to the indicator means.

Since the resonator means of this invention does not require an external power source to transmit this resonant frequency, the invention may be used to ascertain conditions at remote or inaccessible locations. Furthermore, the capability of passive transmission greatly simplifies the overall system and minimizes construction and maintenance expense. Since the resonator means of the invention may be of relatively small size, little or no difficulty is experienced in locating the sensing and transmitting means.

It is accordingly an object of this invention to provide a system for determining whether a remotely located switch is open or closed.

Still another object of this invention is to provide an intelligence communication system wherein the condition of a remotely disposed switch may be ascertained by passive transmission from the remote station.

Still another object of this invention is to provide a system of the type described wherein a signal is transmitted to a remote location to energize a resonator in circuit with a switch so that if a switch is closed, the resonator transmits to a central station wherein the transmitted signal is utilized to indicate the condition of the switch.

Another object of this invention is to provide a system for ascertaining the condition of a remotely disposed switch which is characterized by minimal construction and operation costs and which is considerably simpler than the devices of the prior art.

Other objects, advantages, and important features will be apparent from a study of the specification following, taken with the drawing, which together describe, disclose, illustrate and show preferred embodiments of this invention and what is now considered and believed to be the best mode of practicing the principles thereof. Still other embodiments, modifications, procedures or equivalents may be apparent to those having the benefit of the teachings herein, and such other embodiments, modifications, procedures or equivalents are intended to be reserved especially as they fall within the scope and breadth of the subjoined claims.

## BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic showing of a system made in accordance with the principles of this invention; and

FIG. 2 is a partial schematic showing of another system made in accordance with the principles of this invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Attention is now directed to FIG. 1 of the drawing wherein there is shown a system **10** for ascertaining intelligence. The system **10** comprises as major components signal generating means **12**, communication means **14**, energizable means **16** and indicating means **18**.

As illustrated, the signal generating means **12** comprises a plurality of signal generators **20, 22, 24, 26, 28, 30**, each of which produces a signal of predetermined frequency different from that of the remainder. For example, the signal generator **20** may be constructed and arranged to produce a frequency of 1,000 cycles per second, the signal generator **22** being arranged to deliver a frequency of 1,010 cycles per second with each additional signal generator producing a frequency of 10 cycles per second higher than the preceding generator. It is to be noted that the change in frequency produced by the different signal generators is dependent upon the selectivity of the energizable means **16** and the mention of a 10-cycle per second difference is for purposes of illustration only.

It is to be understood that each of the signal generators **20, 22, 24, 26, 28, 30** may be of any suitable mechanical,

electrical, magnetic or hybrid type of oscillator, vibrator, resonator or the like. It should also be understood that the signal generating means **12** may comprise a noise generator producing a signal having substantially all frequencies within a predetermined range with the energizable means **16** responding to different ones of the frequencies or the frequency with which each is tuned to resonate.

The signal generating means **12** may also comprise a comb frequency generator of the type that produces a multiplicity of frequencies spaced apart a predetermined number of cycles. A type of comb generator operates to produce a pulse comprised of frequency harmonics at a given repetition rate. This type of comb generator is typically called a comb frequency generator since the frequency spectrum produced thereby is a comb shaped pattern having a multitude of discrete harmonically related frequencies each displaced from its adjacent frequency by the number of cycles per second corresponding to the repetition frequency of the pulse generator.

The communication means **14** comprises a first wire transmission link **32** connecting each of the signal generators **20, 22, 24, 26, 28, 30** to a switching position **34**. A second wire transmission link **36** connects the switching position **34** to the indicating means **18** and a third transmission link **38** connects the switching position **34** to the energizable means **16**. The third transmission link **38** is deemed preferably wire for most applications of the invention although the use of a duplex radio transmission link between the switching position **34** and the energizable means **16** is within the scope of the invention.

The first wire transmission link **32** comprises first and second wires **40, 42** leading to each of the signal generators **20, 22, 24, 26, 28, 30** with the wire **40** terminating in a terminal **44**. The second wire transmission link **36** is similarly illustrated and comprises a first and second wire **48, 50** leading to the indicating means **18** with the wire **50** terminating in a terminal **52**. The third wire transmission link **38** is a conventional two-wire system and comprises a first and second wire **56, 58** leading to the energizable means **16** and terminating at the switching position **34**.

A switching mechanism **60** is disposed at the switching position **34** and is illustrated as a chopper type switch functioning as a transmit-receive switch although other suitable switching means are satisfactory. The switching mechanism **60** is oscillated at a synchronous repetition rate selected to be compatible with the frequencies produced by the signal generating means **12** and the decay time of the energizable means **16** which is largely a function of Q or quality of the resonator used.

Although the switching mechanism **60** may be of the electronic type, the same is illustrated as of the electromechanical variety. The wires **42, 48** are joined together in any suitable fashion and together form a common wire for the signal generating means **12** and the indicating means **18**. The switching mechanism **60** comprises a vibrative stem **62** electrically connected to the first wire **56** of the third wire communication link with the second wire **58** thereof being connected to the common wire **48**. The stem **62** comprises a contact **64** arranged to engage one of the terminals **44, 52** with suitable means (not shown) being provided to oscillate the stem **62** at a suitable rate to alternatively engage the terminals **44, 52**.

It is to be noted that the communication means **14** performs functions which may be viewed in various manners. First, the communication means **14** provides a transmission link between the signal generating means **12** and the energizable means **16** when the switching mechanism **60** is in contact with the terminal **44**. Second, the communication means **14** provides a second transmission link between the energizable means **16** and the indicating means **18** when the switching mechanism **60** is in contact with the terminals **52**. Furthermore, the switching mechanism **60** constitutes means for precluding energization of the indicating means **18** directly by the signal generating means **12** and constitutes a break-before-make type of switch.

The energizable means **16** comprises a plurality of resonators **68, 70, 72, 74, 76, 78** which may be of any suitable type but which are illustrated as resonators of the type disclosed in application S.N. 545,430 filed July 15, 1966, to which reference may be had for a more complete description of the resonator structure. It is sufficient for present purposes to state that the resonators **68, 70, 72, 74, 76, 78** may be of a generally H-shaped configuration with a piezoelectrical element **80, 82, 84, 86, 88, 90** secured in any suitable manner to the cross bar of the H-shaped structure which is typically metallic with suitable wires **92, 94, 96, 98, 100, 101** respectively connecting the piezoelectric elements **80, 82, 84, 86, 88, 90** to the first wire **56** of the third wire transmission link **38**. The circuitry necessary to energize each of the resonators **68, 70, 72, 74, 76, 78** is completed by a branch wire **102, 104, 106, 108, 110, 112** leading to the second wire **58**.

For reasons which will become more fully apparent hereinafter, the resonator structure of the aforementioned application is peculiarly adapted to this invention because of the high Q of the resonator structure, the inexpensive nature of the resonator and the passive transmitting characteristics thereof. By passive transmission, it is meant that the energizable means **16** are capable of storing sufficient signal energy from the signal source in order to transmit subsequently. Although a particular resonator structure is illustrated, it is to be understood that the energizable means **16** may be any form of electrical, electronic or electromechanical resonator which may be energized with signals or frequencies that can be carried to it and from it by the communications means **14**. Under certain circumstances, depending on particular characteristic impedances, coupling means and the like, resonators other than the form illustrated may be better suited. Each of the resonators **68, 70, 72, 74, 76, 78** is so constructed and arranged as to be energized by the respective frequency generated by the signal generators **20, 22, 24, 26, 28, 30**. In other words, the resonator **68** is energized by the signal produced by the signal generator **20**, the resonator **70** is energized by the signal produced by the signal generator **22**, etc. The number of frequencies and consequently the number of sensing locations that may be accommodated by the system **10** is dependent on the selectivity of the resonator structures. For example in an inexpensive installation, a low Q resonator may be used with a small number of sensing installations. On the other hand, the resonator structure of the aforementioned application may be so constructed and arranged to differentiate between the frequencies varying by tenths of a cycle per second. It will be apparent that the frequency produced by the signal generators **20, 22, 24, 26, 28, 30** may be very close together. Alternatively, it will be seen that a noise generator or a comb generator may be substituted for the plurality of signal generators illustrated as **12**.

In circuit with each of the resonators **68, 70, 72, 74, 76, 78**, and typically in the branch wire **92, 94, 96, 98, 100, 101**, leading to the first wire **56** in switch means **114, 116, 118, 120, 122, 124**. Using the resonator **70** as an example, it will be seen that when the switch means **116** is closed, and the switching mechanism **60** is in contact with the terminal **44** and accordingly is in the transmit interval of the switching mechanism **68**, the resonator **70** is energized by the signal produced from the signal generator **22**. When the switching mechanism **60** is vibrated or oscillated into contact with terminal **52** and accordingly is in the receive interval of the switching mechanism **68**, the resonator **70** transmits through the communication means **14** to actuate the indicating means **18** corresponding to the resonator **70**. When the switch means **116** is open, it will be evident that a resonator **70** is not energized so that the respective indi-

cator means **18** is not actuated, thereby indicating that the switch mcans **116** is open.

The switch means **114, 116, 118, 120, 122, 124** may be of any desirable type to indicate any condition desired to be sensed. For example, in the event that the system **10** is utilized in a security network for a building or the like, the switch means **114, 116, 118, 120, 122, 124** may comprise the metallic latch on a door, a metallic connection between a window and a window frame or the like. Another type of switch means that may be used in this invention is in conjunction with an engine exhaust pipe and a flapper valve thereon acting against a microswitch to indicate whether the flapper valve is spaced from the exhaust pipe thereby determining whether the engine is operating or not. Of course, the system **10** may be used in conjunction with solid state switching means since the only requirement of the switch means **114, 116, 118, 120, 122, 124** is the capability of passing and refusing to pass current in response to a condition desired to be sensed.

The indicating means **18** comprises a plurality of indicators **126, 128, 130, 132, 134, 136.** Each of the indicators **126, 128, 130, 132, 134, 136** is so constructed and arranged as to be responsive to the frequency transmitted by the respective resonators **68, 70, 72, 74, 76, 78.** To this end, each of the indicators **126, 128, 130, 130, 132, 134, 136** comprises frequency distinguishing means **138, 140, 142, 144, 146, 148** for differentiating between the respective frequencies transmitted by the resonators **68, 70, 72, 74, 76, 78.**

The frequency distinguishing means **138, 140, 142, 144, 146, 148** may be of any suitable type, for example, a filter which is an electromechanical resonator, an inductor-capacitor circuit of the like. Since the signal transmitted through the frequency distinguishing means **138, 140, 142, 144, 146, 148** is at a relatively low power level, accentuating means **150, 152, 154, 156, 158, 160** are respectively placed in circuit with the frequency distinguishing means **138, 140, 142, 144, 146, 148** in order to increase the power level sufficient to actuate the alarm means **162, 164, 166, 168, 170, 172,** which may comprise a signal light, gong, bell or the like. It should be apparent to those skilled in the art that the accentuating means **152, 154, 156, 158, 160** may be of any suitable type, such as amplifiers, relays connected to an independent power source, or the like. Alternatively, a preamplifier may be located in the second wire transmission link **36** between the switching mechanism **60** and the frequency distinguishing means **138, 140, 142, 144, 146, 148.** In such event, the accentuating means **150, 152, 154, 156, 158, 160** may or may not be needed depending upon the characteristics of the frequency distinguishing means **138, 140, 142, 144, 146, 148,** the energy which can be coupled therethrough and the energy required to actuate the indicating means and the like.

It should be readily apparent that the indicating means may be so constructed and arranged as to actuate the alarm means **162, 164, 166, 168, 170, 172** upon the failure of the respective resonators **68, 70, 72, 74, 76, 78** to transmit. This may be done by providing a normally closed circuit in the accentuating means **150, 152, 154, 156, 158, 160** held closed by the signal from the respective resonator so that the alarm means **162, 164, 166, 168, 170, 172** are normally continuously actuated, such as in the case of a signal light. In the event that the respective resonator fails to transmit, the normally closed circuit in the accentuating means **150, 152, 154, 156, 158, 160** opens thereby deactivating the respective alarm means **162, 164, 166, 168, 170, 172.**

It is intended to be covered in the scope of the invention, and such is included in the definition of the term indicating means, that the signal transmitted from the resonators **68, 70, 72, 74, 76, 78** may be used to correct the condition sensed. For example, in the event that the system **10** is utilized to determine whether a valve is open or closed wherein it is desired to maintain the valve open, and the signal transmitted from the energizable means **16** indicates otherwise, such signal may be used to actuate a remotely controllable operator for the valve.

In the operation of the system **10,** the signal generating means **12** may be continuously operated or periodically operated as desired. When the signal generating means **12** is actuated and the switching mechanism **60** is in contact with the terminal **44** a signal comprised of the frequency produced by each of the signal generators **20, 22, 24, 26, 28, 30** passes through the first wire transmission link **32,** the switching mechanism **60** and the third wire transmission link **36.** As illustrated, the switch means **116, 118, 122, 124,** are closed whereby the resonators **70, 72, 76, 78** are energized. Conversely, the switch means **114, 120** are open to sense the desired condition whereby the resonators **68, 74** are not energized.

As the switching mechanism **60** oscillates to the position where the contact **64** is in communication with the terminals **52,** and thereby in the receive interval of the switching mechanism **60,** the energized resonators **70, 72, 76, 78** transmit through the third wire transmission link **38,** the switching mechanism **60** and the second wire transmission link **36** to actuate the indicators **128, 130, 134, 136** thereby activating the alarm means **164, 166, 170, 172.** Since the resonators **68, 74** are not energized and thereby are not capableof transmitting, the indicators **126, 132,** are not actuated, so that the alarm means **166, 168** do not activate.

It will accordingly be seen that in accordance with the illustrated embodiment, an individual positioned at a central station whereat the indicating means **18** is positioned may be apprised that the switch means **114, 120** are open and the switch means **116, 118, 122, 124** are closed.

Another application of the invention is partially schematically shown in FIG. 2 wherein the invention is modified to obtain data from an installation **174** in the form of numbers. The installation **174** is illustrated as a comminutor switch of suitable configuration having a rotatable brush **176** mounted on a spindle **178** for engagement with a ring **180** having a plurality of spaced electrically conductive contacts **182** thereon. The contacts **182** are electrically insulated from each other in any suitable manner. The brush **176** comprises an electrically conductive contact **184** on the outer end thereof in electrical communication with the spindle **178.**

The spindle **178** is operatively connected to the shaft of a rotary mechanism (not shown) of the type used to measure the quantity of gas, water or electricity passing a given point. The digits illustrated on each of the contacts **182** represent the reading of the measuring mechanism. Leading from each of the contacts **182** are wires **186, 188, 190, 192** leading respectively to an energizable or piezoelectric element **194, 196, 198, 200** on a plurality of resonators **202, 204, 206, 208.** Another branch wire **210, 212, 214, 216** leads from each of the resonators **202, 204, 206, 208** to a wire **218.**

Leading from the spindle **178** is a wire **220** which taken with the wire **218** comprise a third wire transmission link **222** analogous to the third wire transmission link **38.** The third wire transmission link **222** is connected to the signal generating means **12,** the switch mechanism **60** and the indicating means **18** in much the same manner as is shown in FIG. 1. It will accordingly be seen that when the brush **176** overlies the contact **182** representing the digit 5, a circuit comprising the signal generating means **12,** the switch mechanism **60,** the third wire transmission link **222,** the spindle **178,** the brush **176,** the contacts **184, 182,** the wire **188,** the piezoelectric element **196,** the resonator **204,** and the wire **212** is completed. Thus the resonator **204** transmits to the indicating means

18 so that the indicator corresponding to the digit 5 is energized. Since none of the remaining resonators **202, 206, 208** are in circuit with the signal generating means, the reading of the measuring mechanism may be read from a location remote from the resonators **202, 204, 206, 208**. Accordingly, it will be seen that the invention may be used to remotely read a meter or other mechanism wherein the condition of a switch registers numerical data.

It should be noted that the signal generating means **12** and the indicating means **18** may comprise common components. For example, the resonator that provides the signal transmitted toward the energizable means **16** may be used as a part of the indicating means **18** to read the signal transmitted from the energizable means **16**.

While the invention has been described and disclosed in terms of an embodiment which it has assumed in practice, the scope of the invention should not be deemed to be limited by the precise embodiment herein shown, illustrated, described and disclosed, and it is to be understood that such other embodiments are intended to be reserved, especially as they fall within the scope of the subjoined claims.

What is claimed is:

**1.** A system for ascertaining from a central location a condition at a remote location without requiring the provision of a local power source at said remote location comprising a signal generating means at said central location for generating an energizing signal including at least one predetermined frequency, passive resonator means at a remote location energizable by the predetermined frequency, said passive resonator means operating when energized to provide a resonator output signal of a specific frequency which continues after the removal of said energizing signal from said resonator means, indicating means operable in response to the resonator output signal to provide an output indication, a first communication link connected to receive the energizing signal from said signal generating means, a second communication link connected to said indicating means, an input circuit connected to said passive resonator means, said input circuit including means to selectively permit or prevent an energizing signal of said predetermined frequency from reaching said resonator means over said input circuit, and transmit receive switching means to preclude energization of the indicating means by said signal generating means, said transmit-receive switching means operating to alternately connect said first communication link to said input circuit while breaking said second communication link and to connect said second communication link to transmit said resonator output signal to said indicating means while disconnecting said first communication link from said input circuit.

**2.** The system of claim **1** wherein said first and second communication links include a common transmission line connected between said signal generating means and said indicating means, a first transmission line connected from said signal generating means to a first switch terminal, a second transmission line connected between said indicating means and a second switch terminal, and a third transmission line connected between the output of said resonator means and said common transmission line.

**3.** The system of claim **2** wherein said transmit-receive switching means includes a switch arm movable between contact positions with said first and second switch terminals, said switch arm being connected to said input circuit for said passive resonator means.

**4.** The system of claim **3** wherein said signal generating means is operative to generate an energizing signal composed of a plurality of predetermined frequencies, said indicating means including a plurality of indicators, each indicator being responsive to a resonator output signal of a frequency different from those adapted to cause operation of the remaining indicators, and said passive resonator means including a plurality of passive resonators, each energizable by a different one of said predetermined energizing signal frequencies, each said passive resonator providing a resonator output signal of a frequency adapted to operate an indicator.

**5.** The system of claim **4** wherein said input circuit is connected to each of said passive resonators, said means to selectively permit or prevent an energizing signal from reaching said resonator means includes switch means in the input circuit to each of said passive resonators for allowing and precluding energization thereof by the different ones of the predetermined frequencies of said energizing signal.

**6.** The system of claim **5** wherein said switch means includes a plurality of spaced, first contacts arranged in a predetermined pattern, each of the first contacts being connected to one of said passive resonators, a movable second contact connected to the movable switch arm of said transmit-receive switch, and means for moving said second contact into successive electrical contact with said first contacts.

**7.** The system of claim **4** wherein said indicators each include frequency selecting means for passing only a selected resonator signal of a specific frequency, amplifier means connected to said frequency selector means, and alarm means connected to said amplifier means.

**8.** The system of claim **3** wherein said transmit-receive switching means includes means to oscillate said switch arm between said first and second switch terminals at a synchronous repetition rate compatible with the frequencies of said energizing signal and the decay time of said resonator means.

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