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Faber et al.

[11] **3,732,562**

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[54] **SURVEILLANCE SYSTEM**

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[52] **U.S. Cl.** **340/408,** 324/52, 340/150, 340/170, 340/181, 340/207, 340/216, 340/288

[51] **Int. Cl.** **G08b 5/22**

[58] **Field of Search** ....340/408, 150, 258 R, 340/258 C, 203, 312, 181, 215, 170, 216, 416, 207 R, 207 P, 183; 324/52; 179/175.3, 5 R

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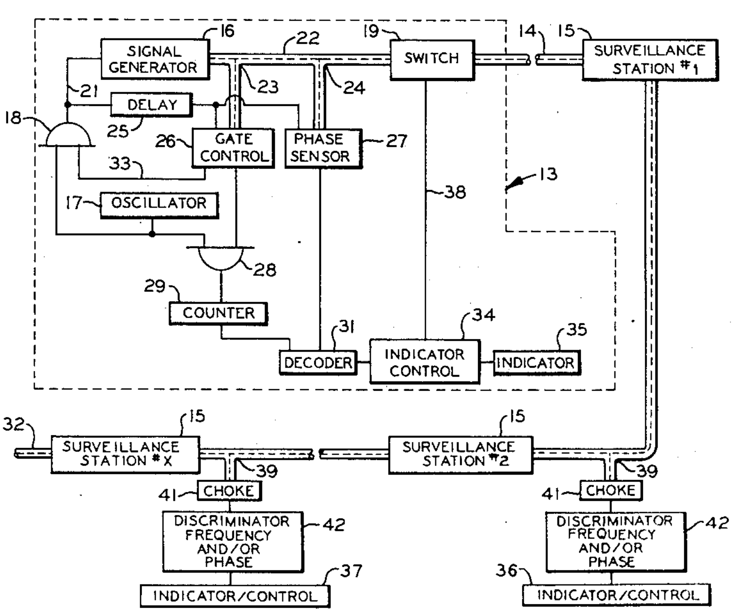
[57] **ABSTRACT**

A surveillance system having a primary station from which signals are issued upon a coaxial cable to one or more surveillance stations. Each surveillance station selectively can impose an impedance discontinuity upon the cable which gives rise to a characteristic signal reflection and a measurable interval from the signal issuance to its reflected return to the primary station. This interval is indicative of the separation of the primary and surveillance stations. Various forms of surveillance station actuatory are contemplated for introducing the impedance discontinuities at the station in response to various actuating conditions. The system also locates breaks or other impedance discontinuities in the cable at other than surveillance stations. Where discontinuities are controllable, as by surveillance station means, they can be varied from time to time to convey supplemental information to the primary station and they can be imposed for brief intervals to enable the continued monitoring of other surveillance stations beyond the activated station during the periods that activated station is not imposing a discontinuity.

17 Claims, 5 Drawing Figures



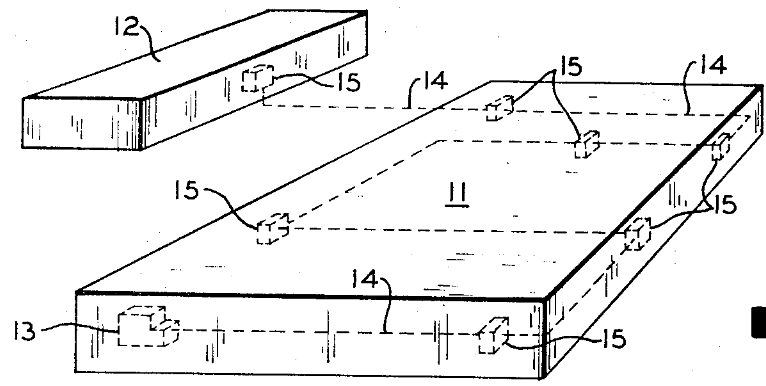


FIG. 1

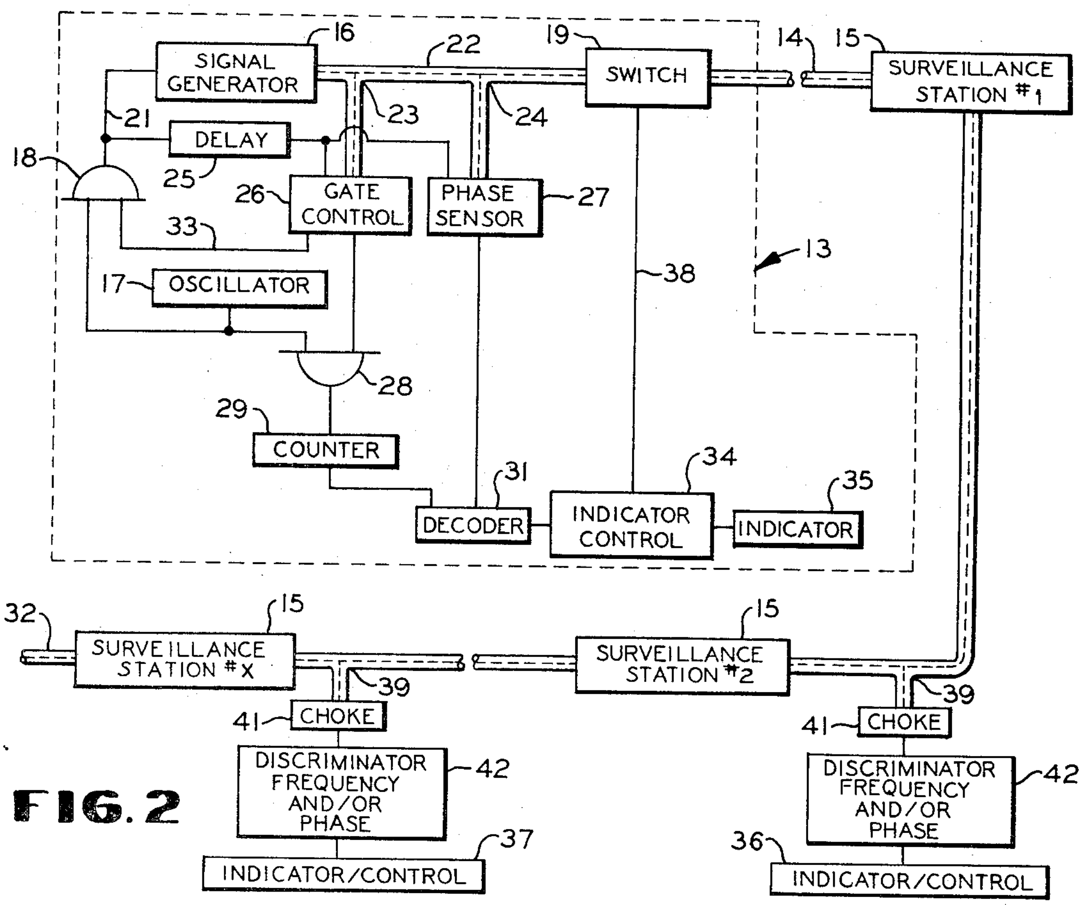


FIG. 2

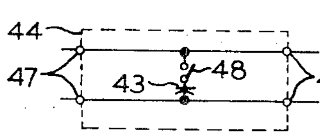


FIG. 3

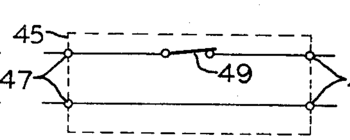


FIG. 4

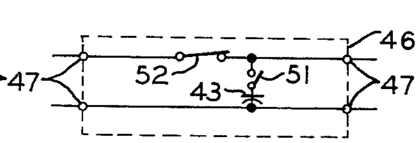


FIG. 5

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SURVEILLANCE SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to surveillance systems and more particularly to systems having a primary station which applies signals to a transmission line and senses reflections of those signals as an indication of a condition along the line and the location of that condition.

2. Description of the Prior Art

Surveillance systems of various forms have been employed for conveying information from locations in buildings, plant complexes, and municipalities. These have included coded, noncoded, supervised and nonsupervised systems wherein a coded system has surveillance stations providing a distinctive signal upon activation to identify the activated surveillance station for the supervisory or primary station, and wherein a supervised system indicates a fault which impairs the system or precludes transmission of signals. In general, these systems can be arranged in the combinations, as coded-nonsupervised, coded-supervised, noncoded-nonsupervised, and noncoded-supervised, by providing separate coding and supervising equipment. Coding frequently requires a multiplicity of conductive paths and or complex coding equipment at the surveillance station for controlling and in some instances, transmitting signals. Usually, where a plurality of surveillance stations control signals on a common transmission circuit, the operation of one station precludes the monitoring of any additional stations on that circuit. A single information transmission state, as "on" and "off," is ordinarily controlled from each surveillance station.

Surveillance systems having means for opening and closing contacts to complete or interrupt circuits are subject to contact resistance variations which can introduce marginal operation. Further, voltage drops along the conductors, where long runs are required, can degrade operation and reliability where signals are issued from the surveillance stations.

Many of the prior systems have employed direct current or low-frequency alternating current as the signal energy. They have been arranged with manually operable signaling devices at their surveillance stations, as for monitoring the rounds of a watchman, or for transmitting a "help call" from a watchman, with thermostatic detectors, for fire detection, with smoke detectors employing photoelectric and ionization sensors, and with intrusion detectors employing ultrasonic and infared sensors, to name a few. These automatic devices usually require local power at the surveillance station for operation and when coded require power for coding.

Intrusion sensing systems have been arranged with precisely and uniformly related conductors providing a transmission line having a uniform characteristic impedance. In these systems a high frequency signal is transmitted down the line and impedance perterbations caused by objects in the vicinity of the line cause a portion of the signal to be reflected back along the line to the source. The return signal is used to indicate the presence of the object and its approximate location along the line. Such lines are extremely expensive to install and maintain. They tend to have unstable characteristics and thus issue false alarms. They are sensitive to environmental changes and issue false alarms in response to changes such as rain, snow and high humidity. When employed with oscilloscope displays, these systems require a skilled operator for interpretation of signals.

SUMMARY OF THE INVENTION

The present invention is a surveillance system employing a sharp wave front signal applied to a coaxial cable system having a substantially uniform impedance along its length and a detecting means for ascertaining the phase and reflection time of the signal reflection of that sharp wave front. Surveillance stations can be serially connected into the line so that signals can be transmitted to the primary station from any of the surveillance stations. A coaxial cable has low loss and a uniform impedance characteristic along its length, its characteristic impedance, and is self-shielding so that it is unaffected by the usual environmental changes.

Switches can be located in the coaxial cable transmission line so they impose little or no impedance discontinuity on the line when they are not actuated to intentionally introduce a discontinuity. These switches are arranged for actuation by any of the usual actuating conditions effective at conventional surveillance stations including manual means, by heat, by light, by smoke or vapor, and by auxiliary detecting systems of the ultrasonic or radiant electromagnetic energy types.

The system can be effective at a station or at points spaced from a station where the transmission line is broken, crushed or otherwise disrupted. Since it responds to an open circuit disruption, with a reflected signal shifted 180° in phase, e.g. to the opposite polarity, from that of a short circuit disruption, the switches can be arranged to impose both types of discontinuity in accordance with the coding established for the condition to be indicated at the station. In the case of short circuits for the sharp wave front signal, a capacitance is employed to provide an effective open circuit where the coaxial cable is also employed as a direct current or low frequency conductor, as where power is transmitted over the conductors of the cable from the primary station to the surveillance station. Power transmission can be continuous or in response to a sensed condition as where an acknowledging signal is desired.

Advantageously, the surveillance stations are arranged to intermittently present the impedance discontinuity. In this manner the remainder of the system can be monitored when the discontinuity is removed. Such a system requires signal pulses to be coincident with the signalling discontinuity as by having a pulse frequency from the primary station which is great enough to insure at least two pulses during the interval the discontinuity is imposed.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic representation of the system employed as an alarm system for a plant complex comprising a main structure and an outbuilding in which a surveillance station is located at each of a plurality of locations;

FIG. **2** is a block diagram of one embodiment of a surveillance system according to this invention; and

FIGS. **3**, **4** and **5** are schematic representations of surveillance station switches for the coaxial cable illustrating respectively a shorting switch, a circuit opening switch, and a combined shorting switch and circuit opening switch.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A representation of a typical utilization of a surveillance system according to this invention is disclosed in FIG. 1 where the system is installed at a plant site including a main building **11** and an outbuilding **12**. A primary station **13** is located at some convenient point in the plant complex and affords the means to generate, receive and analyze signals and issue indications of the region of the plant in which an activating condition exists and, in some instances the nature of that condition. Coaxial cable **14** extends from the primary station to a plurality of surveillance stations **15** distributed as desired throughout the plant site. Activating means are provided at each surveillance station to impose selectively in response to an activating condition an impedance discontinuity on the normally constant impedance, the characteristic impedance, of the coaxial cable. Such an impedance discontinuity, when subjected to a sharp wave front signal transmitted from the primary station, produces a reflection of that signal to the primary station. The signal monitoring apparatus of the primary station **13** senses the distance of the discontinuity from the primary station and the phase of the reflection. This is employed as the means of conveying information from surveillance stations, however, such reflections are also sensed and the origin is located when the cable is damaged at other than surveillance stations as by a mechanical break, fire, or crushing between such stations.

Primary station **13** includes a signal source, means to couple signals to coaxial cable **14** and means for interpretation of the reflected signals from coaxial cable **14**. A pulse or step signal generator **16** produces a signal having a sharp front and thus a signal of an effective high frequency characteristic insofar as its relationship to the circuits and transmission line in which it is transmitted. A pulse generator **16** is controlled by an oscillator **17** through coincidence gate **18** for timing purposes.

The sharp wave front pulse issuing from generator **16** is passed by switch **19** when in the sensing condition, to coaxial line **14** and along that line until it encounters a significant impedance discontinuity from the characteristic impedance of the line to cause a significant reflection of the signal. A gated signal on lead **21** from gate **18** to generator **16** results in a sharp wave front signal on line **22**. The signal on line **22** has no immediate effect on the circuits coupled through coaxial T connectors **23** and **24** since delay **25** prevents any signal being effective on gate control **26** or phase sensor **27** for the first pulse of oscillator **17**. This prevents the transmitted sharp wavefront signal from having any effect on gate control **26** and phase sensor **27**. When the transmitted signal from generator **16** decays, the signal from delay **25** activates gate control **26** and phase sensor **27** so that gating of oscillator pulses through gate **28** is enabled by gate control **26** until a sharp wave front reflection is returned from line **14** through switch **19** to T**23** and gate control **26**. The reflected signal, when of significant magnitude causes gate control **26** to inhibit gate **28**.

In the interval gate **28** is enabled, the pulses issued by oscillator **17** are passed to counter **29** and accumulated therein as a count representative of the transit time of the sharp wave front from primary station **13** to a reflecting impedance discontinuity on the line and return. More particularly, where the velocity of propagation of the sharp wave front signal on the coaxial cable is 80 percent of the velocity of propagation of signals in free space, a resolution of the position of the reflecting discontinuity along the line of approximately 0.5 meter per oscillator pulse is achieved with an oscillator frequency of 350 megacycles. Position measurements therefore are ascertained by a pulse counter **29** cooperating with a decoder **31** which assigns specific counts or ranges of counts to surveillance stations or zones along the coaxial cable length.

The reflected signal is passed by T**24** to provide further information as to the nature of the impedance discontinuity. An open circuit termination reflects a signal which is shifted 180° in phase from a short circuit termination. Phase sensor **27** is fed signals from T**24** and identifies their phase. It issues an indication of the phase to decoder **31** whereby the coder is able to identify the position and the type of discontinuity. The utilization of such information will be discussed below.

Monitoring of the system from primary station **13** can be on a one shot basis, by actuating the signal generator **16** to issue a single sharp wave front signal. Such a signal can be issued periodically provided this is done with an interval at least as great as that necessary to complete the decoding of a signal transmitted and reflected, the maximum distance available in the system as to the open circuit termination of coaxial cable **14** at **32**. In the preferred arrangement, the system recycles itself on return of the reflected sharp wave front signal. When gate control **26** receives the reflection and issues an inhibiting signal to gate **28** to terminate the pulse count, it also issues a signal on lead **33** to enable gate **18** to pass the next pulse from oscillator **17** to lead **21** and the triggering input for signal generator **16**. Thus, generator **16** initiates a sharp wave front signal immediately following the preceding signal reflection.

Decoder **31** actuates an indicator control **34** in response to the count and phase decoding to issue several useful signals. Assume that the actuating mechanism at the surveillance stations **15** is a manually actuated fire alarm including a manual switch **44** for imposing a short circuit to the high frequency of the sharp wave front signal to indicate the presence of a fire, and a manual switch **45** for imposing an open circuit to the high frequency of the sharp wave front to indicate a "reset" or "all clear." A fire signal at surveillance station number **1** by a short circuit would result in a predetermined low count in counter **29** and a predetermined phase indication from indicator **27** to set decoder **31** and cause it, through control **34**, to actuate indicator **35**. Indicator **35** can be an annunciator (not shown) which displays as signal "Fire at station No. 1" and/or an audible signal or equivalent device for issuing an immediate alarm. Similarly, a second annunciator or a reset for the first can be incorporated in indicator **35** so that upon actuation of the "reset" switch at station No. 1 an "all clear" is indicated or the "Fire at station No. 1 annunciator is reset.

The signalling from a surveillance station subsequent to a first signal can be made effective by merely transferring the type of termination at that station. However, it is frequently desirable to continue to monitor the entire system and particularly those portions beyond the actuated surveillance station. In order to enable the primary station to transmit signals beyond the actuated surveillance station and to receive reflections from beyond that station, the surveillance station switches for transferring between the characteristic impedance of the line and a terminating impedance are arranged to introduce the terminating impedance for an interval sufficient to actuate the monitoring equipment. Advantageously, this interval should be at least two monitoring pulse cycles to insure operation of the monitoring equipment. Thereafter, the switch should return to its deactuated state to again provide a characteristic impedance beyond which signals can be transmitted. Accordingly, several or even all stations can indicate the conditions which the system is designed to supervise.

Another function of the indicator control is that of controlling indicators **36** and **37** spaced from the primary station. An elemental form of such indication is to actuate all such indicators distributed throughout the plant. More refined systems selectively actuate such indicators in any desired response pattern, as an individual indicator associated with the zone of the plant site in which the surveillance station has been actuated, or as such an indicator in conjunction with those in zones of the plant site which are related to the zone of the activated indicator.

Indicator control **34** activates remote indicators such as **36** and **37** by transmitting activating signals of low frequency or direct current along the conductors of coaxial cable. In one embodiment controlling signals are passed on **38** from indicator control **34** to switch **19** to transfer the coupling of line **14** from signal generator **16** to a low frequency or direct current source integral with **34**. This signal can be passed along the line **14** to the various indicators **36** and **37** through coaxial T connectors **39**, arranged to match the characteristic impedance of line **14** and thereby avoid undesired reflections, and chokes **41**, arranged to prevent the transmission of the high frequency signals of the sharp wave front pulses from generator **16** and to avoid introducing reflecting impedances to those signals.

Where selective actuation of remote indicators is desired, the indicator control **34** is provided with selected ringing controls wherein the indicator signals it issues are polarized, as positive or negative pulses, and are of coded frequencies, frequencies sufficiently spaced from indicator zone to indicator zone to be positively segregated and yet of a sufficiently low frequency to have transmission characteristics distinct from the sharp front wave to be reflected in the monitoring function of the system. Such selective ringing signals are well known in telephone practice.

Selective actuation of the remote indicators require discriminators **42** which can be polarity and/or frequency sensitive devices. Band pass filters having polarizing rectifiers (not shown) and vibrating reed contacts (not shown) are two forms of such discriminators for passing indicator actuating signals to indicators **36** and **37**.

When switch **19** is arranged to decouple signal generator **16** from line **14** and couple indicator control **34** to line **14**, and when it is desired to continue monitoring of the surveillance stations from the primary station, the switch is intermittently transferred between the generator **16** and control **34** by control **34**. Thus, the remote indicators can be actuated while coupled to control **34** and can be deactivated while the system is monitored.

Continuous power can be supplied on the line **14** to the surveillance stations and/or the remote indicators. Thus, where the activating means at each surveillance station requires continuous energization, the energy can be supplied over the line **14** continuously. Where such continuous energization is imposed, short circuit terminations for the reflected sharp wave front signal are provided with a capacitance **43** as shown in FIGS. **3** and **5**. FIGS. **3**, **4** and **5** represent surveillance station switches, but not the actuating means therefore, as the circuit within the dashed rectangles **44**, **45** and **46** having cable connections **47** and arranged in the condition shown to impose no discontinuity in the line. When the switch **48** of FIG. **3** is closed, switch unit **44** presents a short circuit termination of the line **14** at the surveillance station of the switch sofar as the sharp wave front signal is concerned. However, capacitance **43** maintains the high frequency short circuit as an open circuit to the low frequency signals transmitted on coaxial cable **14** as operating power for the surveillance stations or actuating signals for the remote indicators or both.

FIG. **4** represents switch unit **45** providing means to introduce an open circuit termination for cable **14** at a surveillance station by opening switch **49**. Ordinarily, the low frequency signals of the system can tolerate momentary interruptions as would be introduced where the short circuit termination was applied for only a brief interval. If the switch unit is of a nature to maintain an open circuit for substantial intervals, a low frequency shunt (not shown) can be placed around the switch **49** as a choke.

FIG. **5** shows a switch unit for a surveillance station offering means to introduce a short circuit termination to the pulses to be reflected by closing switch **51** and means to introduce an open circuit termination to those pulses by switch **52**.

The above set forth surveillance system is typical of the type contemplated according to this invention utilizing a coaxial cable transmission line on which the transmission and reflection of sharp front waves can be transmitted between a primary station and a surveillance station to convey useful information. It should be understood that many variations of the system can be introduced in that it lends itself to various forms of monitoring, even including an oscilloscope "A-scope" display of the indicated spacing of the impedance discontinuity from the primary station; recording type indicators, and controls which activate equipment such as sprinkler systems.

Further, the forms of activating means for surveillance stations can be highly refined and automatically responsive to environmental conditions. Accordingly, the present disclosure is to be read as illustrative of the invention and not in a limiting sense.

What is claimed is:

1. A surveillance system comprising a surveillance station; a primary station; a coaxial cable extending from said primary station to said surveillance station and having a characteristic impedance; a termination for said coaxial cable at its end; means for issuing a sharp wave front signal on said coaxial cable from said primary station; means at said primary station for sensing a reflection of said signal from said end termination; means at said surveillance station responsive to a predetermined actuating condition at said station for selectively imposing a predetermined impedance discontinuity to the sharp wave front signal on said coaxial cable; means at said primary station for sensing a reflection of said signal from an imposed impedance discontinuity on said coaxial cable intermediate said primary station and said termination; and an indicator actuated by the response of said last mentioned means.

2. A combination according to claim 1 wherein said sensing means includes means for ascertaining the time between the issuance of the sharp wave front signal and the reflection of said sharp wave front.

3. A combination according to claim 2 including means to translate the measured time to a region along the length of said coaxial cable.

4. A combination according to claim 1 wherein said sensing means includes means for ascertaining the phase of the reflected sharp wave front signal.

5. A combination according to claim 1 wherein said surveillance station includes means for imposing said impedance discontinuity for a brief interval in response to an activating condition at said station and thereafter removing said discontinuity even though the activating condition persists whereby signals can be reflected from beyond said activated station to said primary station.

6. A combination according to claim 1 wherein said surveillance station includes means for imposing a short circuit to said sharp wave front signal in response to an activating condition.

7. A combination according to claim 1 wherein said surveillance station includes means for imposing an open circuit to said sharp wave front signal in response to an activating condition.

8. A combination according to claim 1 wherein said coaxial cable provides a circuit for very low frequency signals between said primary station and said end termination and wherein said surveillance station includes means to prevent a discontinuity in said low frequency circuit when said actuating condition imposes an impedance discontinuity to the sharp wave front signal.

9. A combination according to claim 8 wherein said surveillance station includes means to selectively impose a short circuit as an impedance discontinuity to the sharp wave front signal and wherein a capacitance of a value to present an open circuit to said low frequency circuit and a low impedance to said sharp wave front signal is connected in series with said means to impose a short circuit.

10. A combination according to claim 1 including means at said primary station responsive to a reflection of said signal for actuating said means for issuing the sharp wave front signal to issue such a signal.

11. A combination according to claim 1 wherein said primary station includes a clocking oscillator; a gate control coupled to said coaxial cable and responsive following issuance of a signal from said signal issuing means and until a reflection of said signal is received from said cable; a gate passing clocking pluses from said oscillator when said gate control is responsive; and a clock pulse counter for counting pulses from said gate.

12. A combination according to claim 11 including means issuing an actuating signal to said means for issuing a sharp wave front signal; a delay coupled to said means issuing the actuating signal; and inhibiting means for said gate control which are rendered ineffective by a signal from said delay coupled to said delay.

13. A combination according to claim 1 wherein said primary station includes a phase sensor coupled to said coaxial cable; and means rendering said phase sensor responsive to reflections of the sharp wave front signal following the issuance of the sharp wave front signal by said issuing means.

14. A combination according to claim 3 including means for ascertaining the phase of the reflected sharp wave front signal.

15. A combination according to claim 1 wherein said indicator is coupled to said primary station by said coaxial cable and is remote from said station.

16. A combination according to claim 1 wherein said indicator is a plurality of indicating means each coupled to said primary station by said coaxial cable and spaced from said primary station and each other.

17. A combination according to claim 16 wherein said sensing means includes means for ascertaining the time between the issuance of the sharp wave front signal and the reflection of said signal; wherein said primary station includes an indicator control responsive to predetermined reflection time intervals defined by said ascertaining means to issue predetermined different coded signals according to said reflection time intervals; and wherein each of a plurality of said indicating means have a decoding actuating means responsive to given predetermined coded signals from said indicator control.

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