

[54] ALARM TRANSMISSION LINE
SECURITY SYSTEM UTILIZING
PSEUDO RANDOM ENCODING

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340/274

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[57] ABSTRACT

An alarm line security system wherein areas to be pro-
tected each include an alarm source having an intru-
sion detector and an alarm source monitoring circuit
including a code generator for generating a code com-
prised of a pseudo-random sequence of bits for trans-
mission over an alarm transmission line to alarm moni-
toring circuits at a central monitoring area, and a code
complementor circuit controlled by the intrusion de-
tector for modifying the generated code prior to trans-
mission to the central monitoring area whenever an
unauthorized entry is detected. A multiplexer circuit
interposed between the alarm source monitoring cir-
cuits for all of the protected areas and the trans-
mission line enables transmission of one or more of the
bits which comprise the pseudo-random codes
generated at each alarm source to be transmitted over
a common transmission line. The alarm monitoring
circuits at the central monitoring area include a
reference code generator which generates the same
pseudo-random code as the code generators as-
sociated with the alarm sources, and a code compar-
ator circuit which compares the code received from
each source to the reference code and provides an
alarm indication whenever codes from one or more of
the alarm sources differ with the reference code.

22 Claims, 4 Drawing Figures

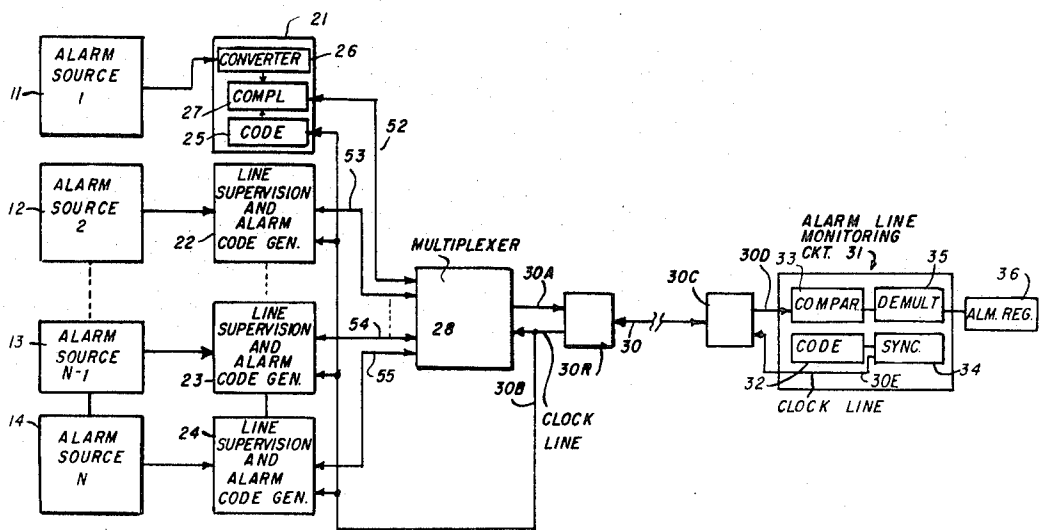
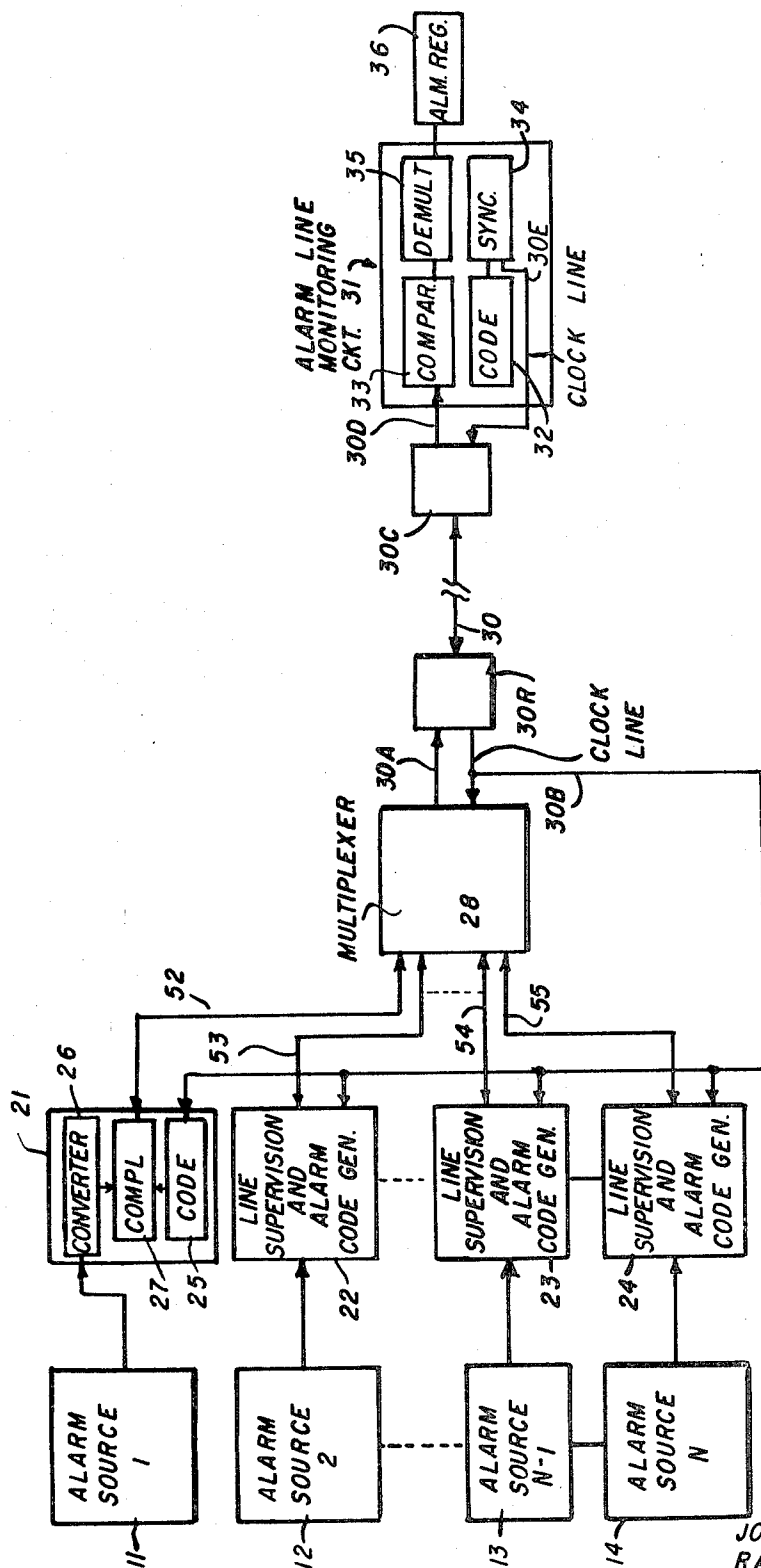


FIG. 1

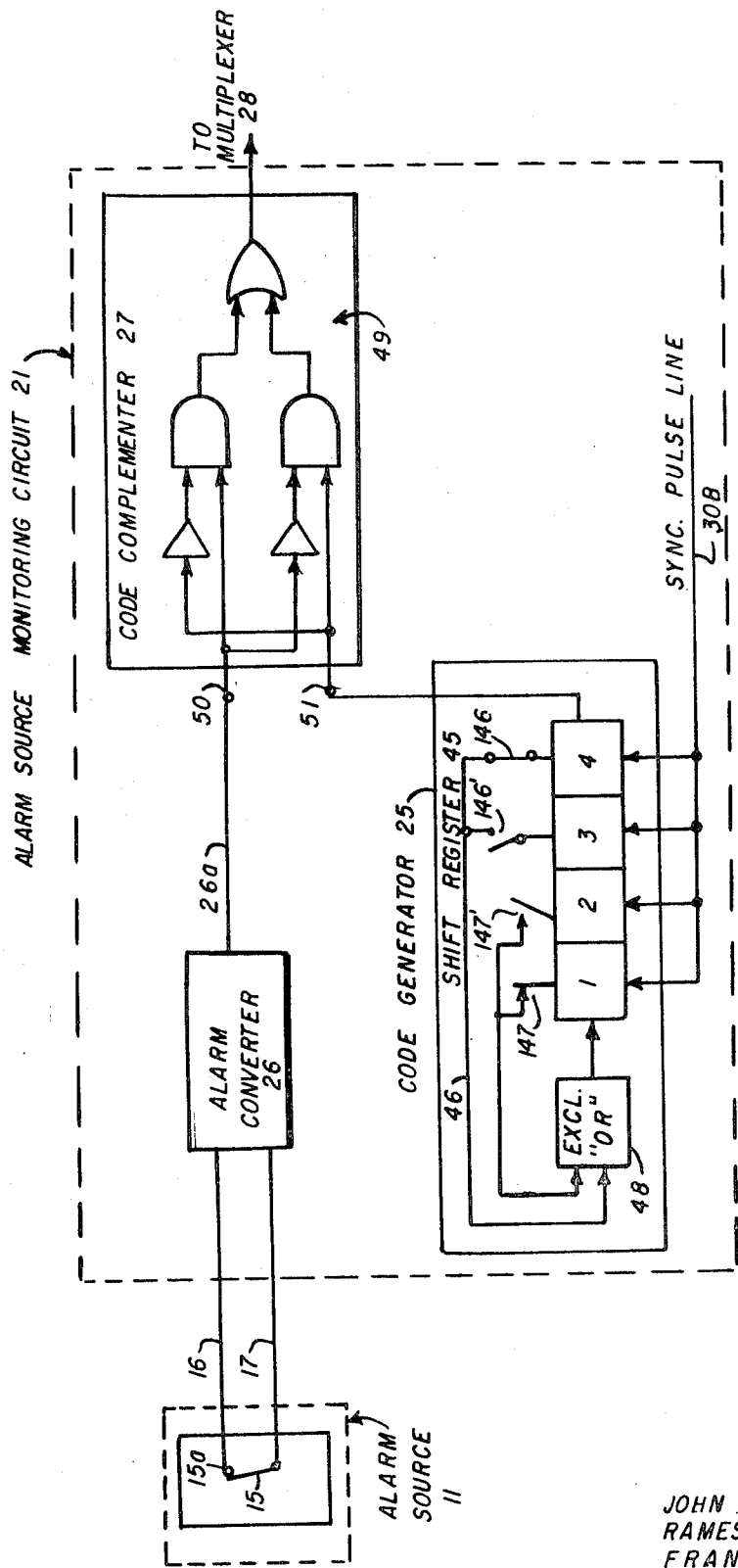


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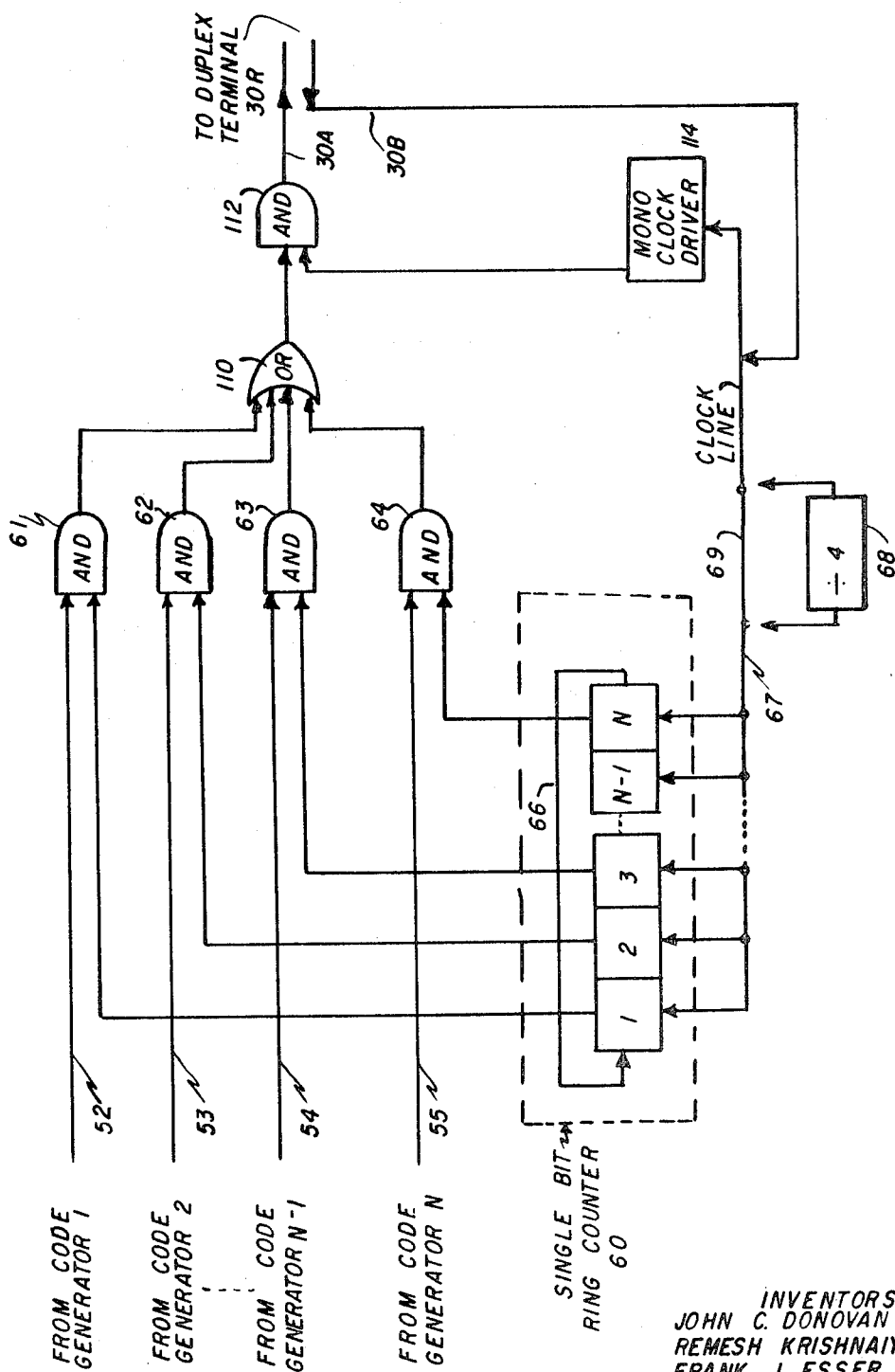
FIG. 2



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FIG. 3



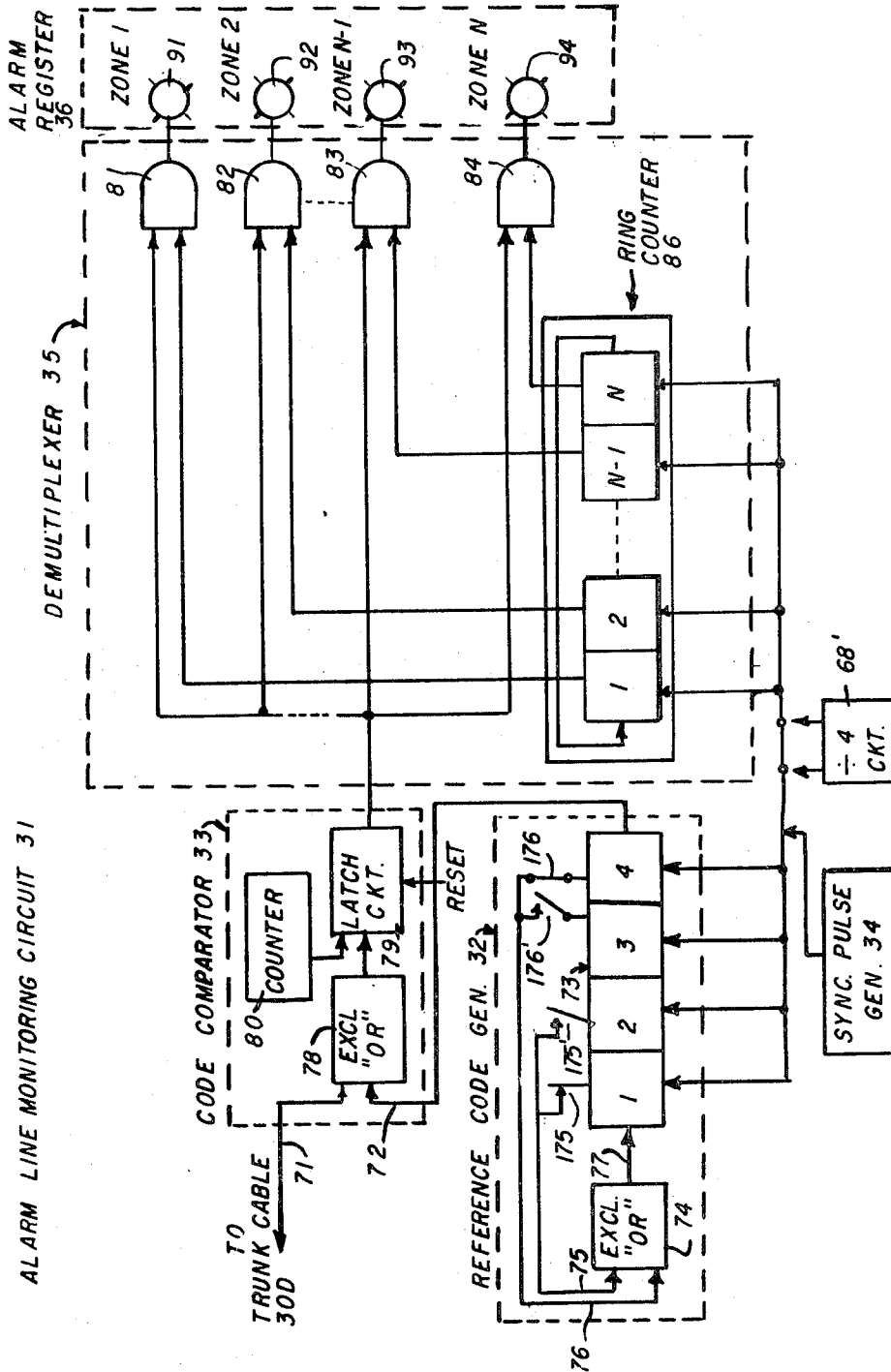
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FIG. 4
ALARM LINE MONITORING CIRCUIT 31



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ALARM TRANSMISSION LINE SECURITY SYSTEM UTILIZING PSEUDO RANDOM ENCODING

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to security systems and more particularly to a system for transmitting alarm signals from a protected area to a central monitor via a communication line.

2. Description of the Prior Art

In known security systems it has been difficult heretofore to reliably provide indications at a central location of an unauthorized entry to an area being protected. Typically, the protected area is a room containing an intrusion detection system which is capable of generating an alarm signal whenever an intrusion has been sensed. Such alarm signal, in many systems, must be transmitted via associated lines to a central monitor.

In an intrusion detection system, the transmission lines between the protected area and the monitoring area are typically the most exposed and the most accessible part of the security system. A variety of approaches have been employed in the past in an attempt to ensure that tampering with these lines has not occurred.

One type of known system relies on the presence of a DC current on the interconnecting transmission line. Until recently, closed DC loop circuits which are sensitive to changes in excess of 40 percent of line current have been used as the industry standard. Further systems that provide AC pulses superimposed on a standard UL approved closed loop DC circuit are also presently available. Although these circuits are more difficult to compromise than a circuit with a sensitivity to a 40 percent variation in signal, they likewise can be compromised by voltage as well as resistance substitution.

A more recently developed system is based on the principle of a balanced bridge circuit. In its simplest form, this system merely employs a sensitive indicator in a carefully balanced bridge circuit. The system complexity is enhanced by using multi-level DC excitation and/or multi-level, multi-frequency AC excitation together with matched terminating modules. One of these matched modules is located in the protected area while the other is located with the bridge at the monitoring end of the line. These modules are typically complex combinations of linear and nonlinear, passive and active elements. Properly applied, such balanced bridge systems provide the greatest degree of line security in commercially made line security equipment which are available at the present time. These systems can be adjusted to an extremely high level of sensitivity. At the high sensitivity setting, however, frequent false alarms are generated by variations in the monitoring signal caused by environmental changes, component aging, minor noise sources, and the like. To prevent such false alarms, the system sensitivity is reduced with an attendant reduction in the security level.

Other techniques include the use of highly complicated cryptographic techniques that tend to remain tamperproof for an extended time period. However, the complexity of operation and maintenance as well as the initial cost along with the need to operate on relatively narrow bandwidth transmission lines dictate against the use of such systems.

The problems with these various systems point to the need for a simple, inexpensive, fail-safe system for supervision of transmission lines which extend from the alarm generating apparatus in a protected area to a control monitor.

In security systems, it is common to transmit alarm signals from a plurality of remote intrusion detection systems to a central alarm monitoring area over individual wires. If the transmission distances are great, the cost of the required individual pairs of transmission wires is significant. If there are several protected areas in close proximity to one another, but relatively remote from the monitoring area, it would seem reasonable to use a system including a multiplexing arrangement to compress the several channels of alarm information into a form which can be carried on a single pair or a relatively few number of transmission wires.

The art of multiplexing, such as time division multiplexing, is well developed in other areas. Typical examples include the areas of voice and digital data communications as well as the area of industrial instrumentation and control. In time division multiplexing, the condition of one channel is sampled for a short time interval and transmitted to the central monitoring area. Then the condition of the next channel is sampled and transmitted in the next interval, etc. At the receiving end, the samples of each channel are separated, and the individual signals are reconstructed.

Despite the level of sophistication to which the art of multiplexing has risen in other application areas, it has not found much acceptance in the security area. There is a prevailing feeling that a necessary condition for maximum security requires the connection of a permanent, hard-wired transmission line between the intrusion detector in the protected area and the alarm unit in the monitoring area. Thus, any time division multiplexing system which inherently results in a brief interruption between the detector and the alarm unit to provide a time interval for interleaving of the signals of several channels has not been well accepted. A part of this disfavor results from the likelihood that a malfunction in the multiplexer switching circuitry will result in an open in the alarm line. There is also the fear that an alarm may occur on a given channel between the two instants at which a given channel is being sampled.

The present invention provides a security alarm multiplexing system which employs an alarm line supervising technique wherein the function of providing coded line security signals for indicating alarm information for each of a plurality of protected areas and the function of multiplexing of the coded signals for transmission to centralized monitoring equipment are integral with one another.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide an alarm line security system which realizes a maximum level of security for transmission lines which are used to carry alarm information from remote areas protected by intrusion detection systems to a central alarm monitoring area. This system could, of course, be employed in applications other than intrusion detection systems which require secure transmission lines between two physically separated locations.

It is another object of this invention to provide a line security system capable of protecting low grade tele-

phone lines, low grade twisted pairs or lines installed especially for security monitoring purposes.

It is a further object of the invention to provide an alarm line security system in which the alarm signal is inherent in the line monitoring signal and is indistinguishable therefrom, whereby a person who is attempting to defeat the system by monitoring an alarm transmission line would not know at which point his entry into a protected area will result in the generation of an alarm signal.

It is yet another object of the invention to provide a system for sequentially relaying the alarm signals from a plurality of remote intrusion detection systems to a central alarm monitoring area over a single pair of wires, which wire pair is secured from tampering by the transmission of a known selected sequence code bits from the remote locations to the central alarm monitoring area.

In one embodiment, the alarm line security system provided by the present invention includes a plurality of alarm sources which include intrusion detectors located in areas to be protected, each of which detectors provides an alarm indication responsive to the detection of an unauthorized entry of one of the protected areas. Each alarm source is connected to a separate alarm source monitoring circuit which includes a code generator which generates a selected sequence of code bits for transmission to alarm line monitoring circuits at a central monitoring location. The coded sequence of bits from each alarm source monitoring circuit are multiplexed for transmission to the central monitoring location over a single pair of transmission alarm lines.

Furthermore, each alarm source includes an associated alarm source monitoring circuit having a code generator and means responsive to the detection of an unauthorized entry, to modify code bits output by the code generator to indicate an alarm.

The alarm line monitoring circuits at the central monitoring area also include a reference code generator which generates a sequence of code bits which is identical to that provided by the code generators associated with each alarm source.

The alarm line monitoring circuit also includes a code comparator circuit which accepts the coded bits transmitted to the central monitoring area over the alarm line from each alarm source and compares such bits with the reference code bits generated by the reference code generator at the central monitoring location. Under normal conditions, (i.e., when all protected areas are secure), the sequence of bits received from the remote alarm sources will be identical with the sequence of bits provided by the reference code generator. However, whenever an alarm indication is provided by one or more of the alarm sources, the code transmitted from such sources will differ from the reference code. With the detection of a difference in one or more bits by the code comparator circuit, an alarm output signal is provided to enable an alarm to be registered at the central monitoring area.

A multiplexing circuit, interposed between the outputs of the alarm source monitoring circuits at each protected area and the alarm transmission line, serves to enable the transmission of one or more of the bits of the selected sequence of bits provided by each alarm source monitoring circuits to the central monitoring location. By way of example, for a given cycle the sequence of bits transmitted to the central monitoring

area may include the first bit of the code sequence provided by a code generator associated with an alarm source at a first protected area, the second bit provided by a code generator associated with an alarm source at a second protected area, etc., with the last bit being provided by a code generator associated with the alarm source at the N^{th} protected area.

In accordance with the feature of the invention, with the sequence of bits transmitted from a given number N of protected areas as described above, the resulting code received at the central monitoring location will be identical to the sequence of bits generated by code generators at each remote alarm source and also to the reference code sequence generated at the central monitoring location.

Thus, a comparison of the multiplexed code received from the remote equipment and the reference code generated in the central monitoring facility simultaneously provides for the security of the branch lines which interconnect the individual remote alarm sources with the multiplexer and the main trunk line which connects the multiplexer to the central monitoring area.

The alarm line monitoring circuits include a demultiplexer circuit which separates the time interleaved code bits transmitted from the alarm sources via the multiplexer to permit identification of the alarm source which is providing an alarm indication and to enable registration of the alarm indication at the central monitoring area.

In accordance with a further feature of the invention, the operation of the multiplexer, the demultiplexer and the code generators, including the reference code generator, are synchronized by sync pulses provided by a single sync pulse generator at the central monitoring location. In addition, means are provided for resynchronizing the code generator circuits and the multiplexer and demultiplexer circuits in the event that one of these circuits fails to receive one of the sync pulses or in the event that the circuit accepts a noise spike as a sync pulse. Such resynchronization is provided after an alarm indication is registered but before an investigation.

It is further noted that the alarm signal is inherent in the line monitoring codes generated by the code generators associated with the alarm sources, such that the alarm indication is indistinguishable from the line monitoring codes. Therefore, a person attempting unauthorized entry or tampering with the alarm transmission lines would be unaware that the code has been changed due to the random nature of the line monitoring code provided by the code generators.

Other objects and advantages of the invention will become apparent from the following detailed description of the invention which makes reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of an alarm transmission line security system provided by the present invention;

FIG. 2 is a schematic representation of an alarm source monitoring circuit of the system shown in FIG. 1;

FIG. 3 is a schematic block diagram of a multiplexer circuit of the system shown in FIG. 1; and

FIG. 4 is a schematic representation of an alarm line monitoring circuit of the system shown in FIG. 1.

DESCRIPTION OF A PREFERRED EMBODIMENT

General Description

Referring to the block diagram of an exemplary illustration of a multiplexed secure line alarm transmission system shown in FIG. 1, the system comprises a plurality of alarm sources, including alarm sources 11-14 shown in block form in FIG. 1, for providing alarm indications for transmission to alarm line monitoring equipment 31 at a central monitoring location via associated alarm source monitoring circuits 21-24, a multiplexer circuit 28 and a transmission line 30. Each alarm source, such as alarm source 11 is located in an area or zone to be protected. Typically, the protected area may be a room.

Each of the alarm sources 11-14, such as alarm source 11, controls an associated alarm source monitoring circuit such as circuit 21 associated with alarm source 11. Preferably, the alarm source monitoring circuit is located within the area protected by an associated entry device. Monitoring circuit 21 includes a code generator 25, an alarm converter 26 and a code complementor circuit 27.

The alarm source monitoring circuits 22-24 which are associated with the alarm sources 12-14 are identical to alarm monitoring circuit 21, and each include an individual alarm converter, code generator, and code complementor circuit. Under normal conditions, that is when no alarm is provided by alarm source 11, for example, the code generator 25 associated with alarm source 11 generates a predetermined series of data bits or multi-bit code words which are transmitted to the alarm line monitoring equipment via multiplexer 28 and transmission line 30. The alarm line monitoring equipment 31 includes a reference code generator 32 which is identical with each of the code generators such as the code generator 25 at the remote station 11. A code comparator 33 which comprises the alarm monitoring equipment 31 compares the reference codes provided at the central location by the reference code generator 32 with the information code being generated by each of the code generators at the remote locations 11-14. Whenever the codes are identical, the code comparator provides an output indicating that no alarm is being sent from any one of the monitoring positions. In the event of an alarm at zone 1, for example, the alarm source 11 at zone 1 enables the code complementor circuit 27 of the alarm source monitoring circuit 21 associated with alarm source 11 to complement the code being sent to the central location from remote zone 1. Consequently, when the complemented code sent from zone 1 is received the difference in the codes will be indicated by the code comparator 33 at the central monitoring station. The comparator will provide a different output which indicates an alarm condition is to be registered for zone 1. The central monitoring includes suitable alarm registers 36 which indicate which of the remote positions has registered an alarm, zone 1 in the present example.

The alarm transmitting system employs time division multiplexing which enables the line security codes generated by each of the alarm code generators associated with alarm sources 11-14 to be transmitted to the alarm monitoring equipment 31 over the same transmission line 30. Accordingly, the alarm source monitoring equipment includes a multiplexer circuit 28 at one of the alarm monitoring locations for applying the

signals provided by the code generators which comprise the alarm source monitoring circuits 21-24 to the transmission line 30 at separate time intervals or time slots, and the alarm line monitoring circuits 31 include a demultiplexer circuit 35 which separates the time interleaved signals from the time slots. As will be shown hereinafter, the output code produced as a result of multiplexing the output of all of the alarm source monitoring circuits is the same code as would be provided by a single alarm source monitoring circuit. Thus, an alarm condition from any one of the alarm sources 11-14 can be detected with each scan. Synchronization of the operation of the code generators, the multiplexer circuit 28 and the demultiplexer circuit 35 is provided by sync pulses generated by a sync pulse generator circuit 34 which comprises the alarm line monitoring circuits 31. The sync pulses provided by sync pulse generator 34 are transmitted to the remote alarm sources 11-14 over lines 30E, 30 and 30B. Transmission over line 30 is by half duplex transmission terminals 30C and 30R which is bi-directional. Sync pulse transmission is unidirectional from the alarm line monitoring circuits 31 to the remote alarm sources.

Detailed Description

Referring to FIG. 2, there is shown a schematic block diagram of the alarm source 11 and the associated source monitoring circuit 21.

In one application of the invention to an unauthorized entry detection system, the alarm sources 11-14 comprise intrusion detector means, such as an entry switch for indicating an unauthorized entry of the protected area. However, other types of alarm indications, such as the presence of a fire may be conveyed from protected areas to a central monitoring location using the apparatus provided by the present invention. In the embodiment illustrated in FIG. 2, the alarm source 11 is shown to include an alarm switch 15 having normally closed contacts 15a.

The alarm contacts 15a are connected over a pair of conductors 16, 17 to the alarm converter circuit 26 which converts the open or closed contact position to a logic level output signal which, for example, may indicate an alarm condition as a logic 1 level and the absence of an alarm as a logic 0 level. The alarm converter in this example merely connects line 17 to ground and line 16 to line 26a. However if the alarm source is not a pair of contacts, but, for example, a voltage input the alarm converter functions to transduce such input voltage to a signal compatible to the code complementor 27 input. The output of the alarm converter circuit is extended via conductor 26a to an input of the code complementor circuit 27. A second input to the code complementor circuit 27 is connected to the output of the pseudo-random code generator circuit 25.

The code generator circuit 25 associated with alarm source monitoring circuit 21 consists of a four stage shift register 45 having feedback connections over conductors 46 and 47 from the first and fourth stages respectively connected through an "exclusive OR" circuit 48 to the input of the first stage. The exclusive OR circuit 48 provides a logic 0 output whenever the two inputs to the exclusive OR circuit are the same logic level, and provides a logic 1 output whenever the inputs are different logic levels. Code generator circuit 25 preferably includes at least a 16 stage register and may be as much as a 32 stage register capable of generating

a pseudo-random sequence of bits, the length of the sequence being given by the relationship $2^N - 1$ where N is the number of stages which comprise the shift register of the code generator circuit 25. In the present example, for convenience only, a four stage register 45 is used, fifteen bits being provided. Thus, it is apparent that the shift register 45 may comprise any number of stages, and that correspondingly, a sequence of bits given by the relationship $2^N - 1$ will be provided. The number of bits desired would be dependent upon the amount of security required and the economics of the system.

To illustrate the operation of the code generator it is assumed that initially all stages are loaded with logic 1 levels and that the register 45 is thereafter cycled under the control of interrogate or sync pulses provided by a sync pulse generator 34 of the alarm line monitoring equipment 31, transmitted via cable 30 to the remote alarm zone equipment 21-24. The sequence of words given in Table I will appear in the stages of the shift register 45.

TABLE I

Clock Pulse	Register Stage (Initial)	1	2	3	4
1		1	1	1	1
2		0	1	1	1
3		1	0	1	1
4		0	1	0	1
5		1	0	1	0
6		1	1	0	1
7		0	1	1	0
8		0	0	1	1
9		1	0	0	1
10		0	1	0	0
11		0	0	1	0
12		1	0	0	0
13		1	1	0	0
14		1	1	1	0
15		1	1	1	1

Since initially, stages 1 and 4 both contain binary 1's, the exclusive OR circuit 48 provides a logic 0 output which is gated into the first stage of the shift register 45 with receipt of the first sync pulse as can be seen in step 1. The sync pulse also shifts the logic 1's from stages 1-3 to stages 2-4, respectively. When the second clock pulse is received, the outputs of stages 1 and 4 are different, and accordingly the exclusive OR circuit 48 will provide a logic 1 output which will be gated into first stage of the shift register 45 as the bits in stages 1 through 3 are gated into stages 2-4, respectively. In a similar fashion for sync pulses 3-14, outputs fed back to the input of the first stage cause the sequence of words given in Table I to be generated.

The sequence given in Table I repeats after the 15 sync pulse. Thus, it is seen that 15 pseudo-random words are provided when the number of stages of the shift register is equal to four. The total number of combinations of N bits is 2^N , so only one combination is missing. The missing multibit word is 0000 which can be seen to repeat itself or have a trivial cycle of one in the code generator circuit.

As has been indicated in the foregoing, the code generators which comprise the alarm source monitoring circuits 21-24 are identical. Moreover, the reference code generator 32, shown in FIG. 1, associated with alarm line monitoring equipment 31 at the central monitoring position is also identical to the alarm source code generator, such as code generator 25 of circuit

21. Accordingly, the feedback connections of the registers which comprise these code generators are the same as those shown for register 45 which comprises code generator 25. The code generators are, so to speak, programmed identically and furthermore they operate in synchronism under the control of clock or sync pulse generator 34 associated with the alarm line monitoring equipment 31 at the central locations.

The code generators which comprise alarm source monitoring circuits 21-24 and code generator 32 of the alarm line monitoring circuit 31 each produces the pseudo-random code given in Table I. Under the control of the multiplexer, one of the code bits, or one multi-bit word generated by each code generator associated with the alarm sources 11-14 are transmitted in sequence via transmission line 30 to the alarm line monitoring equipment 31 shown in FIG. 1. The reference code generator 32 associated with the alarm line monitoring equipment 31 simultaneously provides an identical sequence of bits or multi-bit words and the bits thus provided are compared by the logic comparator circuit 33. If the bits are identical, the protected zones and the transmission lines are taken to be secure. If the bits are different, the comparator circuit 33 provides an output signal which registers an alarm in the alarm register 26.

In accordance with one embodiment, alarm signals provided by the alarm source monitoring circuits 21-24 are coded so that the alarm signals are indistinguishable from the line monitoring code provided by the remote code generators, such as code generator 25. Such coding is accomplished by the code complementor circuit 27 which, in turn, is controlled by the alarm converter 26 responsive to an alarm from an associated alarm source 11 at protected area 1. The code converter 27 complements the outputs provided by the code generator 25 so that the alarm condition is detectable at the monitoring end by the alarm line monitoring equipment 31 but is indistinguishable from other codes on the line 30 to a person attempting to tamper with the line. An alarm is defined as a logic 1 level and the absence of an alarm as a logic level 0. The complementing operation corresponds to an exclusive OR operation, as shown in Table II.

TABLE II

Code generator bits	0	1	0	1
Alarm bits	0	0	1	1
Output bits	0	1	1	0

As can be seen in FIG. 2, for alarm source monitoring circuit 21, the output of the alarm converter circuit 26 is connected to one input 50 of the exclusive OR circuit 49 which comprises the code complementor circuit 27 and the output of the code generator circuit 25 is connected to a second input 51 of the exclusive OR circuit 49 which comprises the code complementor 27. Thus, in accordance with the truth table given in Table II, whenever the alarm bit is a logic 0 level indicating the absence of an alarm, the code generated by the code generator 25 will be passed to the output of the code complementor 27 to the multiplexer 28. On the other hand, whenever the alarm bit is a logic 1 level indicating an alarm condition, the output of the code generator 25 will be inverted and the inverted output will be passed to the multiplexer 28.

MULTIPLEXER CIRCUITS

Referring again to FIG. 1, the output of each of the alarm source monitoring circuits 21-24 are connected over branch lines 52-55 to individual inputs of a time division multiplexer circuit 28. Preferably, the multiplexer circuit 28 is located within the area protected by one of the alarm sources, such as area one which is protected alarm source 11. As has been indicated, each code generator provides the same pseudo-random code sequence as shown in Table III.

TABLE III

Reference Code Generator	1 0 1 0 1 1 1 1	0 0 0 1
Remote generator-source 1	1 0 1 0 1 1 1 1	0 0 0 1
Remote generator-source 2	1 0 1 0 1 1 1 1	0 0 0 1
Remote generator-source 3	1 0 1 0 1 1 1 1	0 0 0 1
Remote generator-source 4	1 0 1 0 1 1 1 1	0 0 0 1
Remote generator-source 5	1 0 1 0 1 1 1 1	0 0 0 1
Remote generator-source N-1	1 0 1 0 1 1 1 1	0 0 0 1
Remote generator-source N	1 0 1 0 1 1 1 1	0 0 0 1
Time Period	1 2 3 4 N-1 N N+1 N+2	
	5 6 7 8	

The multiplexer 28 transmits a bit from a given remote generator during a given time period, interleaving the information in time such that during a first time interval, information from the code generator 25 associated with the alarm source 11 in area 1 is transmitted over the main trunk alarm line 30 to the central monitoring equipment 31. During a second time interval, the information from the code generator associated with alarm source 12 in area 2 is transmitted over alarm line 30 to the central monitoring equipment 31, etc., until the Nth information bit provided by the code generator associated with alarm source 14 in area N is returned to the central monitoring equipment 31. The bits which are transmitted from each location are circled in Table III. Then the scan repeats with the N + 1 bit produced by code generator 25 associated with alarm source 1 being returned to the alarm line monitoring equipment 31.

It is pointed out that the resulting code sequence transmitted to the central monitoring circuits 31 during time intervals 1, 2, 3, etc., (as shown in Table III) specifically those bits circled in Table III, is identical to the code sequence produced by any individual remote code generator and to the code produced by the reference code generator in the central monitoring area.

Thus, a comparison of the multiplexed code received from the remote equipment and the reference code generated in the central monitoring facility simultaneously provides for the security of the branch lines 52-55 connected from the individual remote alarm monitoring circuits 21-24 to the multiplexer 28 as well as the main trunk line 30 connected from the multiplexer 28 to the central monitoring area 31.

The security of each branch line 52-55 is checked once in the same time that the security of the main trunk line 30 is checked "N" times.

As has been pointed out, the closure of the alarm contacts of a given alarm detector such as contacts 15a associated with alarm source 11, enables the code complementing circuit 27 which inverts the code issuing from the code generator for that zone. Thus, when confirming the code for zone 2, for example, an alarm would indicate that zone 2 had been violated or that the branch cable 2 zone has been tampered with. In contrast, failure of a number of the code bits to coincide

on a given cycle would suggest the main trunk cable 30 had been tampered with.

Through the provision of a latching circuit or a time delay, an alarm indication provided by an alarm source can be maintained for a time sufficiently long that the alarm will be transmitted to the alarm monitoring circuits 31 by at least two cycles of complemented codes. That is, an alarm will be held on for a period of time sufficiently greater than the time required to scan all remote points at least once such that the alarm indication will be transmitted to the alarm line monitoring circuits at least twice.

The multiplexer circuit 28 shown in block diagram form in FIG. 3 includes a ring counter 60 having N stages. The multiplexer circuit 28 further includes a set of output gates, such as gates 61-64 one for each stage of the ring counter 60. The ring counter 60 provides an individual stage for each alarm source, such as alarm sources 11-14. The last stage N of the ring counter 60 is connected over lead 66 to the input stage of the ring counter 60.

The outputs of the stages 1, 2, 3, 4, . . . N of the ring counter 60 are individually connected to inputs of the AND gates 61-64, respectively. The AND gates 61-64 are individually associated with the alarm source monitoring circuits 21-24, (FIG. 1) respectively, and are operable when enabled to selectively extend the coded output signals provided by the alarm monitoring circuits 21-24 to the central monitoring equipment 31. Thus, a second input of each AND gate 61-64 is individually connected to the output of the alarm monitoring circuits 21-24 respectively. The outputs of the AND gates 61-64 are connected to OR circuit 110, whose output is fed to AND gate 112. AND gate 112 is gated by clock driven monostable oscillator circuit 114 to transmit over half duplex terminals 30R and 30C (FIG. 1). One commercially available monostable oscillator suitable for the application is the type SN 74121.

One of the stages of the ring counter 60 contains a logic 1 level bit, and the remaining stages contain logic 0 level bits. The logic 1 level is shifted through the stages of the ring counter 60 by the sync pulses provided by the central monitoring equipment 31 for driving the pseudo-random code generators associated with the alarm sources, such as code generator 25 which comprises alarm monitoring circuit 21 associated with alarm source 11. The sync pulses received on line 30 B are extended to the ring counter 60 of the multiplexer circuit 28 via sync pulse line 67. The logic 1 level provides an enabling signal for the AND gate that is connected to the output of the stage which contains the logic 1 level. Thus, for example, if the logic 1 level is in the first stage of the ring counter 60, an enabling signal will be extended to one of the inputs of AND gate 61 which is associated with alarm monitoring circuit 21. Thus, if alarm monitoring circuit 21 is providing a logic 1 output, AND gate 61 will be enabled and the logic 1 level will be passed to line 30 for transmission to the central monitoring equipment 31. If, on the other hand, the alarm monitoring circuit 21 is providing a logic 0 output, gate 61 will not be enabled and will provide a logic 0 output to the line 30. As the logic 1 level is shifted through the ring counter 60, the outputs of the alarm monitoring circuits 21-24 are sequentially connected to the transmission line 30 over respective gates 61-64.

Accordingly, as each AND gate is enabled in sequence, such gate will provide a logic 1 output whenever the associated line supervision circuit is providing a logic 1 output and will provide a logic 0 output whenever the associated line monitoring circuit is providing a logic 0 output.

Only one of the AND gates 61-64 will be enabled at a given time, and accordingly, the output provided by only one of the line supervision circuits 21-24 will be passed by OR circuit 110 to the central monitoring equipment 31 during a given time period.

MULTIPLE BITS FROM EACH ZONE

In the foregoing description, it was assumed that the multiplexer circuit 28 was operative to effect the sequential transmission of one bit from each of the alarm monitoring circuits 21-24. However to minimize nuisance alarms which may be caused by the error in one bit of the pseudo-random sequence of bits provided by a given line monitoring circuit it may be desirable to transmit a multi-bit code comprising a plurality of bits from each location. For example, four bits can be transmitted from each remote location by connecting a divide-by-four pulse counter circuit 68 in place of link 69 in series with the sync pulse line 67 and the ring counter 60. Accordingly, the ring counter 60 of the multiplexer 28 will be stepped once for each four bits read out with every four advance cycles of the code generators, and accordingly, four code bits will be extended to the AND gates 61-64 for each cycle of multiplexer circuit 28.

ALARM MONITORING EQUIPMENT

Referring to FIG. 4, the code bits transmitted from the remote station by the multiplexer 28 and cable 30 are extended to a first input 71 of the code comparator 33 of the alarm monitoring equipment 31. A second input 72 of the code comparator circuit 33 is provided by the reference generator 32. The reference code generator 32 is identical to each of the code generators associated with the alarm source monitoring circuits 21-24, such as code generator 25 associated with alarm monitoring circuit 21. The reference code generator comprises a four stage shift register 73 and an exclusive OR circuit 74 having inputs 75 and 76 respectively connected to the outputs of the first and fourth stages of the shift register 73, and an output 77, connected to the input of the first stage of the shift register 32. The reference code generator 32 is controlled by sync pulses provided by sync pulse generator 34 to provide the sequence of pseudo-random bits shown in Table III that is provided by each of the code generators associated with the alarm sources 11-14. It is pointed out that the sync pulse generator 34 provides gating signals for the shift registers associated with each code generator including the reference code generator 32 such that each code generator provides the same output during a given cycle of the sync pulse generator. The sync pulse generator provides a sync pulse at the completion of each cycle to advance the code generators to the next code in the sequence. Sync pulse generator 34 also will drive monostable multivibrator 114 (FIG. 3) with a delay to initiate the return of the code bits from the remote alarm source locations, one at a time under the control of the multiplexer circuit 28.

The sync or interrogate pulses in addition to advancing the state of all code generators will also advance the

state of the ring counter 60 (FIG. 3) of the multiplexer 28 associated with the remote alarm sources 11-14 and a ring counter 86 (FIG. 4) of the demultiplexer circuit 35 of the alarm line monitoring circuits 31. Transmission delays anywhere in the system can be compensated for by adding corresponding delays in the faster portions of the system by using a monostable multivibrator such as multivibrator 114 in FIG. 3.

The code comparator circuit 33 may comprise a logical comparator circuit, such as an exclusive OR circuit 78. The exclusive OR circuit 78 provides a first output level, such as a logic 0 level whenever the signals on inputs 71 and 72 are the same, as is the case when no alarm is being transmitted from a remote alarm source. On the other hand, whenever the signals on inputs 71 and 72 are not the same, the exclusive OR circuit 78 provides a second output, a logic 1 level which indicates the presence of an alarm.

The comparator circuit 33 further includes a latch circuit 79 connected to the output of the exclusive OR circuit 78 and operable when set to initiate a sustained alarm output in response to the detection by the comparator circuit of either a single or a multiple code difference. The latch circuit 79 remains latched until a reset pulse from a voltage source (not shown) is applied to the RESET input of the latch circuit 79. To avoid nuisance alarms resulting from a single code difference caused by noise or an "inadvertent" dropped bit, the latch circuit 79 may be driven by a counter 80 which will inhibit operation of the latch circuit 79 until several successive bits are in error.

The outputs of the code comparator circuit 33 are passed to the demultiplexer circuit 35. The demultiplexer circuit 35 is similar to the multiplexer circuit 28 associated with the remote alarm source monitoring circuits and includes a multistage ring counter 86 and a plurality of AND gates, such as gates 81-84 shown in FIG. 4. The AND gates 81-84 drive alarm lamps 91-94, respectively, which comprise the alarm register circuit 36. A separate alarm lamp, such as lamps 91-94, is provided for each alarm source, such as alarm sources 11-14, respectively.

The ring counter 86 has N stages, one for each alarm source. One of the stages of the ring counter 86 contains a logic 1 level bit and the remaining stages contain logic 0 level bits. The outputs of ring counter stages, such as stages 1, 2, N-1 and N, are individually connected to one input of the AND gates 81-84, respectively. Second inputs of AND gates 81-84 are connected together to the output of the latch circuit 79 of the code comparator circuit 33.

The demultiplexer circuit 35 serves to provide an enabling signal for AND gates 81-84, in sequence, as the multiplexer 28 sequentially gates the outputs of the alarm source monitoring circuits 21-24 onto the alarm transmission line 30. It is pointed out that the demultiplexer circuit 35 operates in synchronism with the multiplexer circuit 28 and accordingly, when the sync pulse line to multiplexer 28 includes a divide-by-four circuit 68 for enabling the transmission of multiple bits from each alarm location, the demultiplexer sync line would include a similar divide-by-four circuit 68'.

Thus, for example, when the logic 1 level is contained in the first stage of the ring counter 86 of the demultiplexer circuit 35, the single logic 1 level contained in the ring counter 60 of the multiplexer 28 will also be in the first stage of ring counter 60. The logic bit con-

tained in the ring counter 86 of the demultiplexer circuit 35 is shifted from stage to stage of the counter (and simultaneously from stage to stage of counter 60 of the multiplexer 28) under the control of sync pulses provided by the system sync pulse generator 34. Therefore, assuming initially that the logic 1 level bit is stored in the first stage of the counter 86, (and counter 60) an enabling signal will be provided to an input of AND gate 81 and thereafter in a controlled sequence to inputs of AND gates 82-84 as the logic 1 level bit is shifted through the counter 86. At the same time, initially the output of alarm source monitoring circuit 21 will be gated onto the transmission line 30, and then in sequence the outputs provided by alarm source monitoring circuits 22-24.

Accordingly, whenever one of the alarm sources, such as alarm source 11, is providing an alarm indication thereby complementing the code transmitted by the associated alarm source monitoring circuit 21, the logic 1 output provided by the code comparator circuit 33 will be gated through AND gate 81 when the gate 81 is enabled by the output of counter 86 to light alarm indicator lamp 91 corresponding to alarm source 11 to register an alarm at alarm zone one.

ALTERNATIVES

An added feature of the invention is what one might call second level encoding. The pseudo-random sequence generator represents the first level of coding. The second level of coding would derive from changes made from time to time in the feedback connections of the pseudo-random code generators such as code generators 28 and 32.

For example, the output may be taken from any stage or from several stages - this can be varied on a fixed time basis or after a preset number of cycles. The output code can be complemented periodically. The feedback connections can be changed via inputs on switches, inputs read from punched cards, or tape or read-only memories. Thus, in FIGS. 2 and 4, the outputs of the first and fourth stages of shift registers 45 and 73 are shown connected over switches 147, 146, and 175, 176 to input of corresponding exclusive OR circuits 48 and 74. The feedback connections can be changed by opening switches 146, 147, 175 and 176 and closing switches 146', 147', 175' and 176' whereby the outputs of the second and third stages of shift registers 45 and 73 are connected to inputs of exclusive OR circuits 48 and 74, respectively. Consequently, code generators 25 and 32 will each provide a further pseudo-random sequence of bits with the bit sequence provided by code generator 25 being identical with the sequence provided by code generator 32.

The coded signals need not be transmitted pulses, but rather they may appear as modulation of carrier signal such as a tone transmission system. This would in no way detract from the operation of the invention as described to this point, and it may enhance it as the tone signals would tend to keep the line "busier" from the attacker's point of view; it would thus be harder to simulate the codes. Also, note that the modulation of a carrier can be 100 percent modulation; thus "tone bursts" can be used as can the switching between two tones such as is done in the frequency shift keying systems used in telegraphy.

The preferred implementation of the code generators described in detail in this disclosure is not the only im-

plementation possible. It does, however, represent an economical solution to the problem. In the broadest context, any code generator capable of being duplicated and similarly capable of producing a large number of arbitrary codes can be used. Thus any sort of memory system, in particular a read-only-memory, which is capable of a sufficient amount of storage could be used. Also, a card reader or tape reader loaded with sufficient coded cards or tape could be used to generate the required line security codes.

Moreover while an exemplary embodiment of the invention employs multiplexing to permit transmission of output codes provided by the alarm source monitoring circuits of a plurality of alarm sources, it is apparent that each alarm source monitoring circuit could be connected by a separate transmission line directly to an alarm line monitoring circuit which is individually associated with a given alarm source.

We claim:

1. In a security system including a transmission line carrying alarm information from at least one protected area to a central monitoring area that is remote from the protected area, means at said protected area for generating a monitor code comprising a selected sequence of code bits for transmission over the transmission line from said one protected area to the central monitoring area, means for modifying the code bits provided by said generating means to indicate an alarm, means at said central monitoring area for generating a reference code comprised of a selected sequence of code bits that is identical to the monitor code sequence, means for comparing the monitor code with the reference code, and means for providing an alarm indication whenever the codes are different.

2. In a transmission line security system including a transmission line for carrying alarm information from at least one protected area to a central monitoring area that is remote from the protected area, alarm source means including intrusion detector means at said protected area, alarm source monitoring means at said protected area including first code generator means for generating a monitoring code comprising a known pseudo-random sequence of bits for transmission to said central monitoring area over the transmission line at predetermined intervals and modifying means controlled by said intrusion detector means in response to the detection of an unauthorized entry to modify the code bits generated by said first code generator means, and transmission line monitoring means at said central monitoring area including second code generator means for generating a reference code that is identical with the monitoring code, and code comparator means for receiving the monitoring code transmitted to said central monitoring area and comparing the monitoring code with the reference code, and register means controlled by said code comparator means providing an alarm indication whenever the codes are different.

3. A transmission line security system as set forth in claim 2 wherein said first code generator means comprises first multistage shift register means, and first feedback means including exclusive OR gating means connected between outputs of certain stages of said shift register means and the input of said shift register means.

4. A transmission line security system as set forth in claim 3 wherein said second code generator means includes further multistage shift register means and sec-

ond feedback means including further exclusive OR gating means connected between outputs of certain stages of said further shift register means and the input of said further shift register means.

5 5. A transmission line security system as set forth in claim 4 wherein said first feedback means includes means for altering the feedback connections of the shift register means of said first code generator means whereby said first code generator means provides a further pseudo-random sequence of bits, and wherein said
10 second feedback means includes means for altering the feedback connections of the shift register means of said second code generator means whereby said second code generator means provides a pseudo-random sequence of bits that is identical with the bit sequence provided by said first code generator means.

6. A transmission line security system as set forth in claim 2 including sync pulse generating means for synchronizing the operation of said first and second code generator means to provide a pseudo-random sequence of bits at said predetermined intervals.

7. In a transmission line security system including a transmission line for carrying alarm information from at least one protected area to a central monitoring area that is remote from the protected area, alarm sources means including intrusion detector means at said protected area, alarm source monitoring means at said protected area including first code generator means for generating a monitoring code comprising a known sequence of bits for transmission to said central monitoring area over the transmission line at predetermined intervals and code complementing means controlled by said intrusion detector means in responsive to the detection of an unauthorized entry for inverting each bit of the bit sequency generated by said first code generator means, and transmission line monitoring means at said central monitoring area including second code generator means for generating a reference code that is identical with the monitoring code, and code comparator means for receiving the monitoring code transmitted to said central monitoring area and comparing the monitoring code with the reference code, and register means controlled by said code comparator means providing an alarm indication whenever the codes are different.

8. A transmission line security system as set forth in claim 7 wherein said alarm source monitoring means further includes alarm converter means controlled by said detector means for providing first and second logic level signals to indicate respectively, that the protected area is secure or that an unauthorized entry has occurred, and wherein said code complementing means includes exclusive OR gating means having a first input connected to the output of said alarm converter means and a second input connected to the output of said first code generator means, the output of said code complementing means being connected to said transmission line whereby the code bits output at said first code generator means are passed over said code complementing means to said transmission line whenever a first logic level signal is provided by said alarm source converter means and the code bits output at said first code generator means are inverted by said code complementing means as they are passed to said transmission line whenever said second logic level signal is provided by said alarm source converter means.

9. A transmission line security system as set forth in claim 7 wherein the bits of at least two successive pseudo-random bit sequences are inverted by said code complementing means whenever an unauthorized entry is detected.

10. A transmission line security system as set forth in claim 7 wherein said code comparator means includes gating means for comparing each bit of the monitoring code received from said one protected area, with each bit of the reference code and providing an enabling signal whenever one or more of the bits of the monitoring code differs with the bits of the reference code and latch means responsive to said enabling signal to provide an alarm output representing an alarm condition
15 said register means being controlled by said alarm output to register said alarm.

11. A transmission line security system as set forth in claim 10 wherein said code comparator means includes counter means for providing a further enabling signal for said latch means whereby said latch means provides an alarm output only when two or more successive bits of the monitoring code sequence differ with corresponding bits of the reference code sequence.

12. A transmission line security system as set forth in claim 10 wherein said code comparator means comprises exclusive OR gating means having a first input connected to said transmission line for receiving the monitoring code transmitted from said protected area and a second input connected to the output of said second code generator means for receiving the reference code, said exclusive OR gating means providing a first logic level output wherever the code bits compared are the same and a second logic level output for enabling said latch means whenever the code bits compared are different.

13. In a transmission line security system including a transmission line for carrying signals from a plurality of protected areas to a central monitoring area that is remote from said protected areas, each of said protected areas having individual monitor code generator means for generating a line monitoring code comprising a selected sequence of code bits, switching means for sequentially connecting the output of each of said monitor code generator means to said transmission line to thereby pass a different bit of the sequence of bits provided by each monitor code generator means to said transmission line during successive time intervals whereby a further selected sequence of bits is transmitted to said central monitoring area over said transmission line with successive bits of the further bit sequence being provided by different ones of said monitor code generator means, reference code generators means at said central monitoring area for generating a reference code comprising a selected sequence of code bits, each bit of which is normally identical with corresponding bits of the further bit sequence at any given time, and means for comparing the further bit sequence with the reference bit sequence and providing an indication whenever any of the corresponding bits of the two sequences are different.

14. A transmission line security system as set forth in claim 13 wherein said code generator means all generate a known pseudorandom sequence of code bits and wherein the further bit sequence provided by said switching means is identical to the pseudo-random sequence of bits provided by each of said monitor code generator means.

15. In a transmission line security system including a transmission line for carrying alarm information from a plurality of protected areas to a central monitoring area that is remote from the protected area, each of said protected areas having individual alarm indicating means, monitor code generator means for generating a known sequence of coded bits, and means controlled by said alarm indicating means to modify the code bits generated by an associated monitor code generator means, multiplexer means for sequentially connecting the output of the monitor code generator means at each of said protected areas to the transmission line to enable the transmission to said central monitoring area of a different one or more of the bits provided by each of said monitor code generator means thereby providing a further sequence of coded bits, and transmission line monitoring means at said central monitoring area including reference code generator means for generating a sequence of coded bits that is identical with the further bit sequence provided by said multiplexer means, comparator means for receiving the further bit sequence and comparing each bit of the further bit sequence with the corresponding bit of the reference bit sequence, and alarm registering means controlled by said comparator means for registering an alarm whenever one or more of the bits of the further bit sequence differs with corresponding bits of the reference bit sequence.

16. A transmission line security system as set forth in claim 15 wherein said alarm registering means includes demultiplexer means controlled by said comparator means whenever one or more of the bits of the further bit sequence differs with corresponding bits of the reference bit sequence to identify each bit of the further bit sequence which differs with a corresponding bit of the reference bit sequence.

17. A transmission line security system as set forth in claim 16 wherein said multiplexer means comprises a plurality of gate circuits, each having a first input individually connected to an output of the code generator means of one of said protected areas, and means for selectively enabling the gate circuits to pass at least one bit of the sequence generated by an associated code generator means to the transmission line.

18. A transmission line security system as set forth in claim 17 wherein said demultiplexer means comprises a further plurality of gate circuits including an individual demultiplexer gate for each protected area, said demultiplexer gates having first inputs connected together to the output of said comparator means and means for sequentially enabling each of said demultiplexer gates whereby each demultiplexer gate provides a first logic level output whenever the compared bits are the same, and a second logic level output whenever the compared bits are different.

19. A transmission line security system as set forth in claim 18 wherein said alarm registering means further includes a separate indicator for each of said protected areas, each indicator being individually connected to the output of one of said demultiplexer gates to be energized whenever the corresponding demultiplexer

gate provides said second logic level output.

20. A transmission line security system as set forth in claim 18 wherein said multiplexer enabling means includes multi-stage ring counter means having a separate stage for each protected area and an enabling signal stored in one of the stages of said multi-stage ring counter means, each of said multiplexer gate circuits having a second input connected to the output of a corresponding one of the stages of said ring counter means, and wherein said demultiplexer enabling means includes further multi-stage ring counter means having a separate stage for each protected area and an enabling signal stored in one of the stages of said further multistage ring counter means, each of said further gate circuits having a second input connected to the output of a corresponding one of the stages of said further ring counter means, and sync pulse generating means for providing sync pulses for the ring counter means of the multiplexer and demultiplexer means for shifting said enabling signal from stage to stage of said ring counter means whereby said enabling signals are selectively applied to the second inputs of said gate circuits in sequence.

21. A transmission line security system as set forth in claim 20 wherein the monitor code generator means associated with said protected areas and said reference code generator means each include multi-stage shift register means and associated feedback means for selectively connecting outputs of certain stages of said shift register means to the corresponding input of said shift register means, said sync pulses being extended to the shift register means of said monitor and reference code generator means to shift the signals output from associated gating means through the shift register means of said code generator means whereby said sequence of coded bits is provided at the output of the shift register means of said monitor and reference code generator means.

22. A transmission line security system as set forth in claim 20 wherein the monitor code generator means associated with said protected areas and said reference code generator means each include multi-stage shift register means and associated feedback means for selectively connecting the outputs of certain stages of said shift register means to the corresponding input of said shift register means of said monitor and reference code generator means to shift the signals output from an associated gating means through the shift register means of said code generator means whereby said sequence of coded bits is provided at the output of the shift register means of said monitor and reference code generator means, said multiplexer means and said demultiplexer means each including pulse divider means for dividing the sync pulse rate by a predetermined number of the coded bits of the sequence provided by each monitor code generator means and sequentially transmitted over said transmission line to said central monitoring area and compared with a corresponding number of bits provided by the reference code generator means.

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