

Jan. 13, 1942.

V. E. ROSENE

2,269,692

ALARM SIGNALING SYSTEM

Filed Aug. 31, 1937

5 Sheets-Sheet 1

FIG. 2

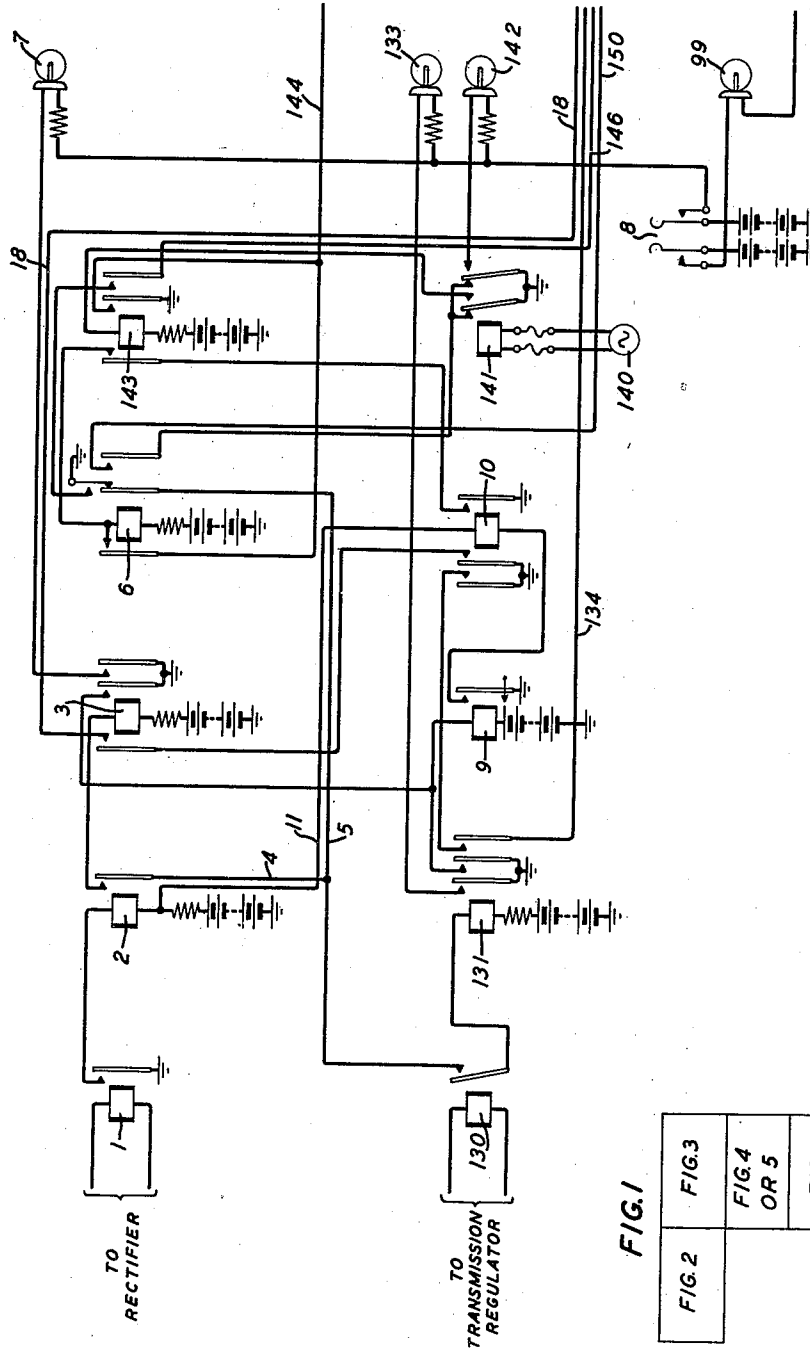


FIG. 1

FIG. 2	FIG. 3	FIG. 4 OR 5	FIG. 6
--------	--------	----------------	--------

INVENTOR
V. E. ROSENE

BY *A. H. Krigman*
ATTORNEY

Jan. 13, 1942.

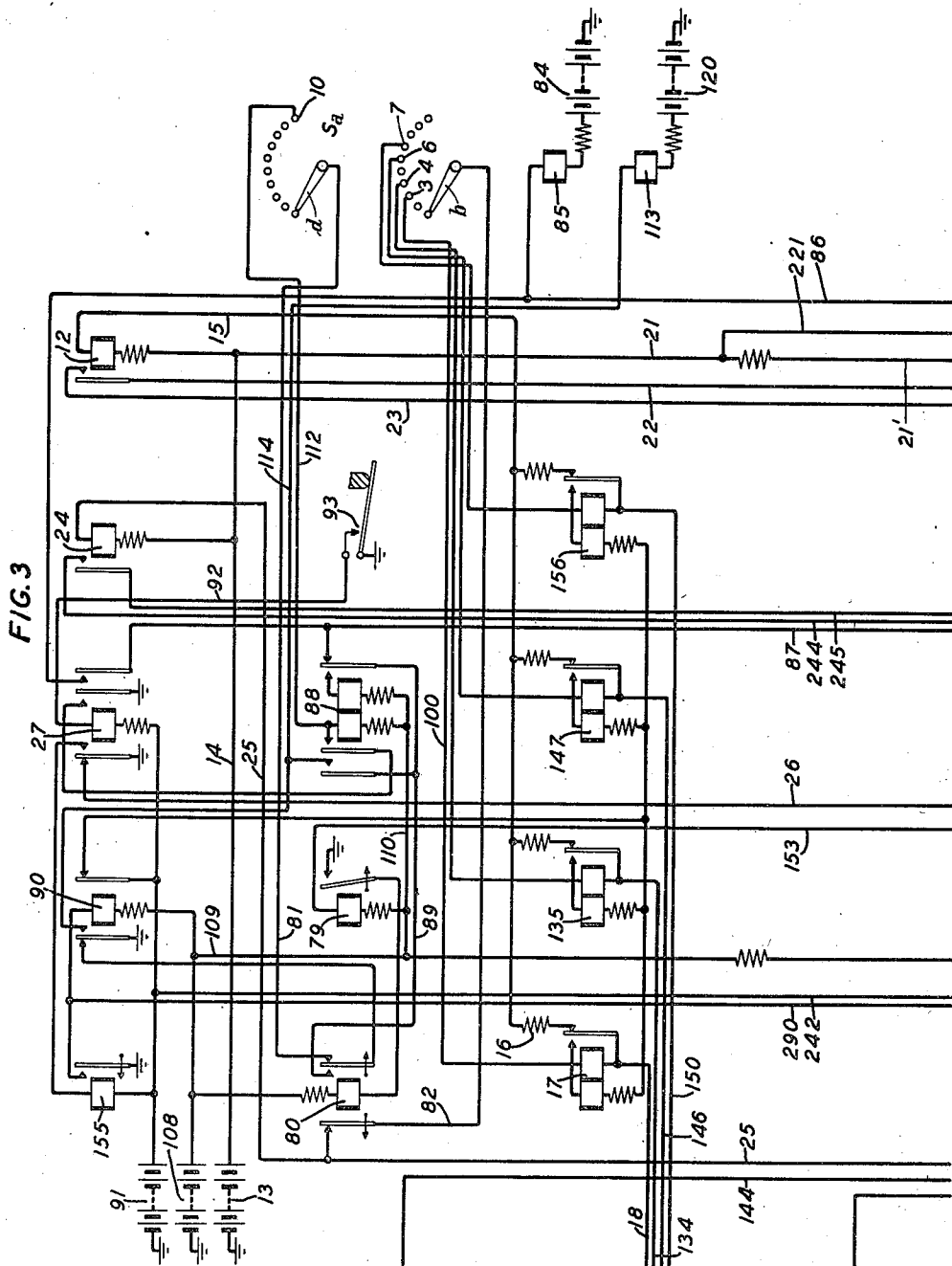
V. E. ROSENE

2,269,692

ALARM SIGNALING SYSTEM

Filed Aug. 31, 1937

5 Sheets-Sheet 2



INVENTOR
V. E. ROSENE

BY *H. L. Kingman*
ATTORNEY

Jan. 13, 1942.

V. E. ROSENE

2,269,692

ALARM SIGNALING SYSTEM

Filed Aug. 31, 1937

5 Sheets-Sheet 3

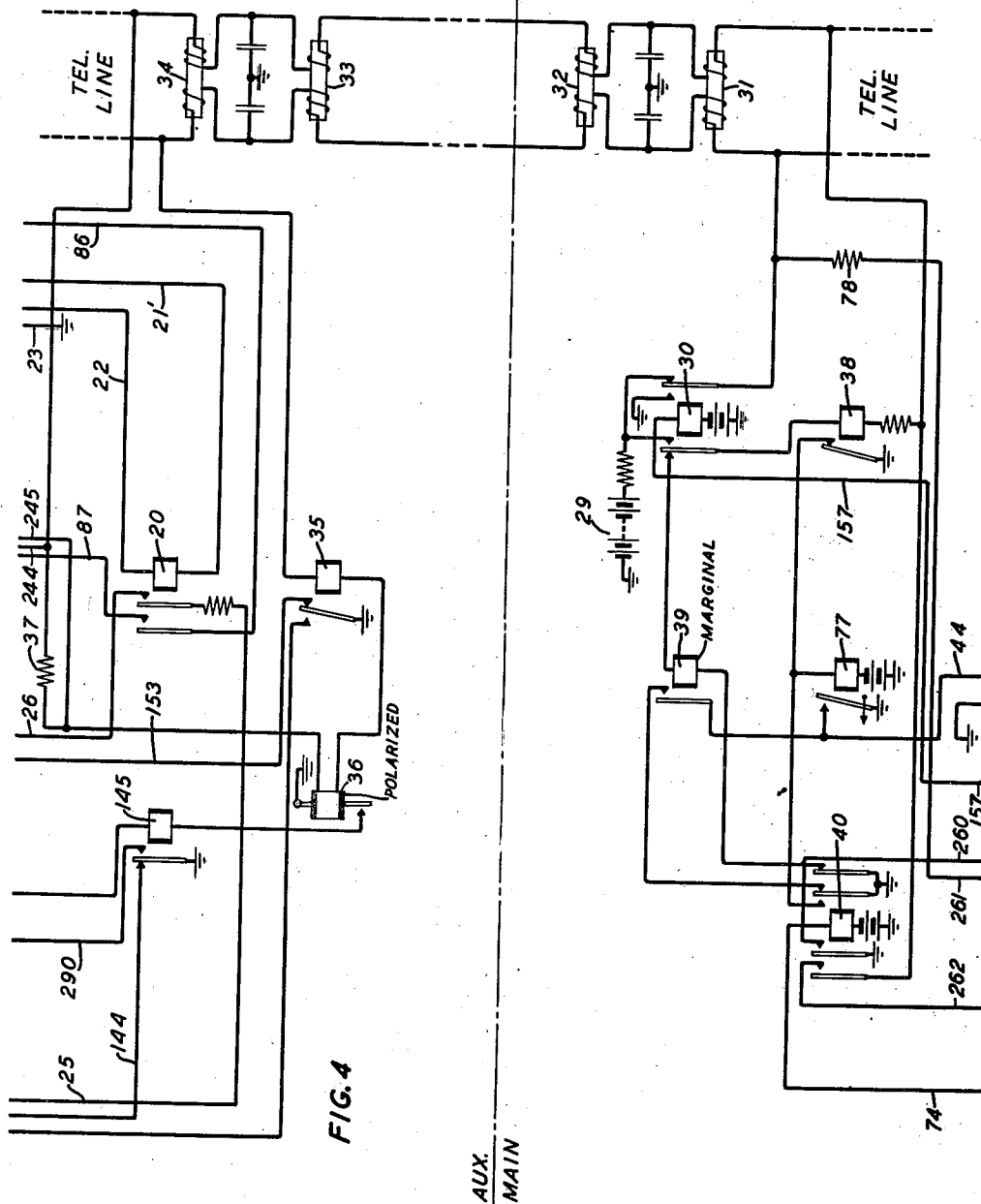


FIG. 4

INVENTOR
V. E. ROSENE

BY *H. E. Krugman*
ATTORNEY

Jan. 13, 1942.

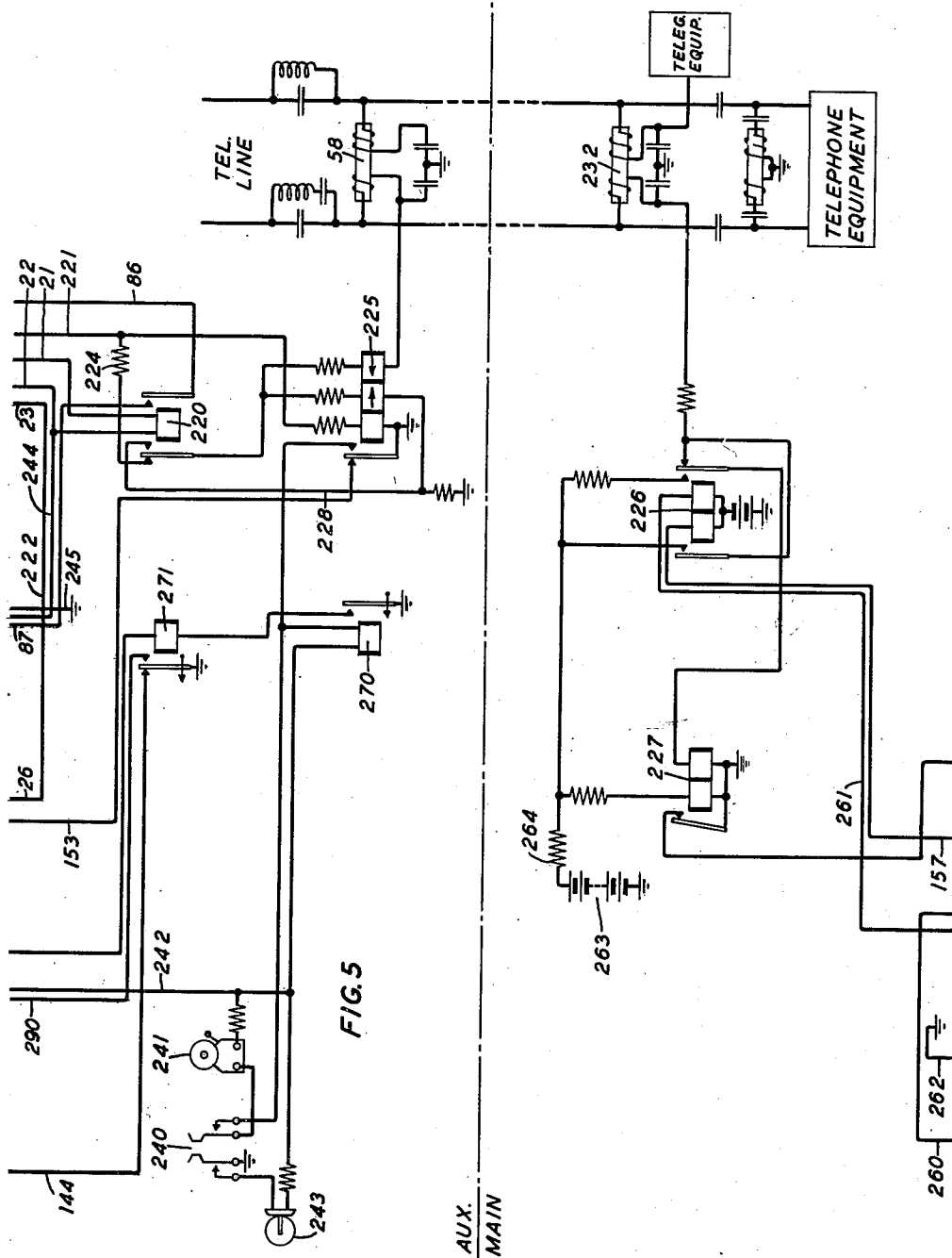
V. E. ROSENE

2,269,692

ALARM SIGNALING SYSTEM

Filed Aug. 31, 1937

5 Sheets-Sheet 4



INVENTOR
V.E. ROSENE

BK *A. J. Friedman*
ATTORNEY

Jan. 13, 1942.

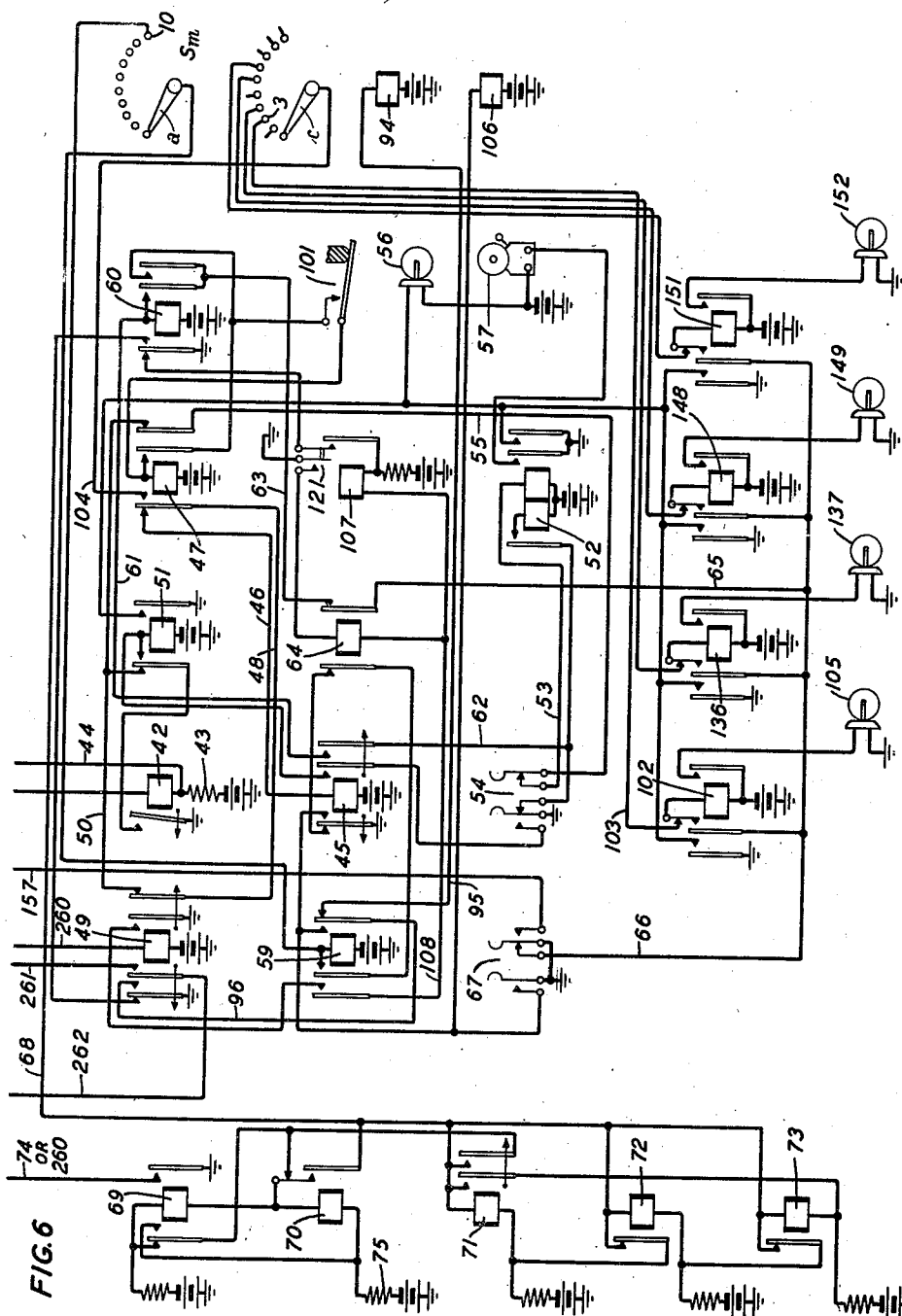
V. E. ROSENE

2,269,692

ALARM SIGNALING SYSTEM

Filed Aug. 31, 1937

5 Sheets-Sheet 5



INVENTOR
V. E. ROSENE
BY *J. H. Ferguson*
ATTORNEY

UNITED STATES PATENT OFFICE

2,269,692

ALARM SIGNALING SYSTEM

Victor E. Rosene, Astoria, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application August 31, 1937, Serial No. 161,743

5 Claims. (Cl. 177-353)

This invention relates in general to alarm systems and more particularly to the transmission of alarm signals from an unattended repeater station to an attended repeater station in carrier telephone systems of the cable and open wire types.

It is common practice in telephone transmission systems to employ telephone repeaters spaced at frequent intervals. Because of the large number of repeater stations involved in a long transmission line, it is found impractical to operate all such stations on an attended basis so that some of the stations are left unattended. Though the degree of reliability which has been attained in the development of equipment located at such unattended stations is sufficiently high to render the failure of such equipment improbable, the possibility of occasional failures is always present. It is desirable, in the event of failure of the equipment at an unattended repeater station, to have available some means whereby the attendant at an attended station may be readily appraised of such failure and be informed, as well, of the particular cause of the failure and the severity of its nature.

It is the object of this invention to provide cooperating facilities at unattended and attended repeater stations along a telephone transmission line whereby information relative to the failure of equipment at an unattended station may be transmitted to an attendant at an attended repeater station.

This object is attained in accordance with a feature of the invention by the provision of means at an attended repeater station which functions to selectively actuate alarm signals thereat in response to equipment failures at an unattended station.

More specifically, this object is attained by the use of alarm signals at an attended repeater station which are controlled by switching equipment at an unattended station, which responds to equipment failures thereat, over a normally closed loop circuit consisting, in the case of a cable carrier telephone system, of two-line conductors and, in the case of an open wire carrier telephone system, of a single line conductor and earth. At the auxiliary or unattended station a group of relays is provided, each relay corresponding to an individual alarm condition and operating upon the occurrence of an equipment failure. At the main or attended station a corresponding group of relays is provided to operate an equal number of different lamp signals. When a trouble condition occurs in the auxiliary

station, ground potential is applied to a relay in the alarm trunk circuit which relay in turn operates to transmit a start signal over the line circuit to the main station where a relay interrupter is started to function and audible and visual signals are operated. The interrupter is used to operate selector switches in both the main and auxiliary stations. The selector at the auxiliary station hunts for ground on the selector contacts and upon reaching the grounded contact, a signal device associated with the corresponding contact of the selector at the main station is actuated to register thereat the occurrence of the trouble condition existing at the auxiliary station.

The invention will be readily understood from the following detailed description made with reference to the accompanying drawings in which Figs. 2, 3, 4 and 6, when arranged in the manner indicated in Fig. 1, combine to illustrate the invention as applied to a cable circuit and Figs. 2, 3, 5 and 6, when arranged in the manner indicated in Fig. 1, combine to illustrate the application of the invention to an open wire circuit. The equipment shown on Figs. 2 and 3 and the upper halves of Figs. 4 and 5 are located at the unattended station whereas the equipment shown on the lower halves of Figs. 4 and 5 and on Fig. 6 is located at the attended station.

Cable circuit

In Fig. 2 there is shown a miscellaneous alarm circuit which functions upon the occurrence of trouble conditions at an unattended repeater station to originate alarm signals. Applicant has elected to describe the operation of the system under but four trouble conditions, it being understood that the equipment may be elaborated upon, and in actual practice is so, to provide for the transmission of a greater number of alarm signals.

Relay 1 may be considered to be actuated in any well-known manner upon the failure of a piece of apparatus, such as a rectifier, at an unattended repeater station to connect ground to the winding of relay 2 which relay operates in an obvious circuit. At its armature and front contact relay 2 causes relay 3 to operate in a circuit extending from grounded battery, winding of relay 3, front contact and armature of relay 2, conductors 4 and 5 to ground by way of the inner right-hand armature and back contact of relay 6. At its outer right-hand armature relay 3 prepares an obvious circuit for lamp 7 which may be completed by the actuation of key 8. The

lamp 7 at the auxiliary station is lighted upon the arrival of an attendant thereat and the subsequent actuation of the key 8. At its inner right-hand armature and front contact relay 3 establishes an obvious circuit for relay 9 which relay, in operating, causes relay 10 to operate in a circuit extending from grounded battery, conductor 11, winding of relay 10 to ground by way of the front contact and armature of relay 9. Relay 9, however, is slow-to-operate and a period of two and one-half minutes elapses before the circuit to relay 10 is completed. The purpose of this time delay is to allow sufficient time for the trouble condition to clear itself before the alarm signal is transmitted to the main or attended station.

It will be assumed that the trouble condition (rectifier failure), does not clear itself, and relay 10 operates. At the inner left-hand armature and front contact of relay 10 a circuit for relay 12 (Fig. 3) is established which extends from grounded battery 13, conductor 14, winding of sensitive relay 12, conductor 15, high resistance 16, back contact and right-hand armature of relay 17, conductor 18, front contact and left-hand armature of relay 3 to ground by way of the front contact and inner right-hand armature of relay 10.

Relay 20 (Fig. 4) now operates in a circuit extending from grounded battery 13, conductor 14, conductor 21, winding of relay 20, conductor 22, armature and front contact of relay 12 to ground on the conductor 23. At its left-hand inner armature and front contact, relay 20 establishes a circuit for relay 24 (Fig. 3) extending from grounded battery 13, conductor 14, winding of relay 24, conductor 25, inner left-hand armature and front contact of relay 20, conductor 26 to ground at the back contact and left-hand armature of off-normal relay 27 (Fig. 3).

The selector S_a at the auxiliary station is normally in the released position when an alarm comes in and the loop circuit between stations is normally closed. This normally closed loop extends from grounded battery 29 at the main station (Fig. 4) back contact and right-hand armature of relay 30, tip windings of coils 31 and 32 at the main station, tip conductor of the line extending between stations, tip windings of coils 33 and 34 at the auxiliary station, winding of normally energized relay 35, winding of polarized relay 36, resistance 37, ring windings of coils 34 and 33 at the auxiliary station, ring conductor of the line, ring windings of coils 32 and 31 at the main station, winding of normally energized relay 38, left-hand armature and back contact of relay 30, winding of marginal relay 39 to ground at the back contact and right-hand outer armature of relay 40. Coils 31, 32, 33 and 34 with their associated condensers are useful in the circuit to prevent the operation of the alarm circuit from interfering with telephone communication over the same line conductors.

Relay 39 is a marginal relay and does not operate until relay 24 operates to short circuit resistance 37 which it does at its armature and front contact. Relay 42 (Fig. 6), which is normally operated in an obvious circuit now releases due to the connection of ground to the winding of relay 42 and resistance 43 by way of the armature and front contact of relay 39 over conductor 44, and thence to ground at the inner right-hand armature and back contact of relay 40. Relay 42 in releasing establishes a circuit for the start relay 45 which may be traced from grounded

battery, winding of relay 45, conductor 46, back contact and left-hand armature of relay 47, conductor 48, outer right-hand armature and back contact of relay 49, conductor 50, back contact and left-hand armature of relay 51 to ground at the back contact and armature of released relay 42. Relay 52 also operates as a consequence of the release of relay 42 in a circuit extending from grounded battery, right-hand winding of relay 52, conductor 53, normal right-hand contacts of key 54, conductor 55, outer right-hand armature and back contact of relay 47, back contact and left-hand armature of relay 51 to ground at the back contact and armature of released relay 42.

Relay 52, by way of its front contact and left-hand armature locks to ground at the left-hand contacts of key 54. At its two right-hand armatures and front contacts, relay 52 establishes obvious energizing circuits for the lamp 56 and audible signal 57. The audible signal 57 may be silenced by the actuation of key 54, which opens the circuits to both windings of relay 52 causing this relay to release.

Relay 45, at its left-hand armature and back contact opens the obvious locking circuit for relay 59, which relay if operated would release to release the selector S_m , at its outer right-hand armature and front contact relay 45 establishes a circuit for relay 60 extending from grounded battery, winding of relay 60, conductor 61, front contact and outer right-hand armature of relay 45, conductor 62 to ground at the normal left-hand contacts of key 54.

Relay 60 by way of its inner right-hand armature and front contact locks in a circuit extending from grounded battery, winding and front contact and inner right-hand armature of relay 60, conductor 63, back contact and right-hand armature of relay 64, conductors 65 and 66 to ground at the right-hand contacts of recheck key 67.

At its left-hand armature and front contact, relay 60 applies ground to "start" conductor 68 which starts the relay interrupter consisting of relays 69, 70, 71, 72 and 73 operating.

Relay interrupter circuit

Ground potential on conductor 68 operates relay 73 in an obvious circuit, which relay at its armature and back contact removes a short-circuit from the winding of relay 72 causing this relay to operate. Relay 72 in like manner removes a short-circuit from the winding of relay 71 which relay operates and at its outer armature and front contact establishes an obvious circuit for relay 70. Relay 70 operates and locks directly to ground on the lead 68. Relay 69 does not operate at this time as it is short-circuited by its own back contact and armature and the outer armature and front contact of relay 71.

When relay 71 operated, it short-circuited the winding of relay 73 by way of its front contact and inner armature. Relay 73 releases and reestablishes the short circuit about the winding of relay 72 which relay releases to reestablish the short-circuit about the winding of relay 71. Relay 71 accordingly releases and at its outer armature and front contact removes the ground on lead 68 from the left-hand armature of relay 69 which allows relay 69 to operate to ground on the lead 68 by way of the armature and front contact of relay 70.

Relay 69, operated, connects ground to the lead 74 and at its left-hand armature transfers the lead from the outer armature of relay 71 to the

resistance 75 and winding of relay 70. When relay 71 releases as described above, relays 73, 72 and 71 operate again successively. When relay 71 operates the second time, ground is connected by way of the outer armature and front contact of relay 71 to the left-hand armature and front contact of relay 69 which, as already mentioned, are connected to the resistance 75 and winding of relay 70. Relay 70 accordingly releases but holds relay 69 operated. Relay 71 operated the second time causes relay 73 to release and subsequently relays 72 and 71 release in the manner previously described. When relay 71 releases the second time, ground is also removed from relay 69 which relay releases causing the removal of ground from the lead 74.

The above operation will be repeated over and over again to give an interrupted ground connection on lead 74 at the rate of approximately 25 interruptions per minute, as long as ground remains connected to the start lead 68. The first "make" pulse on the lead 74 will always be of the proper length because the interrupter starts with all relays released. The final "make" pulse on the lead 74 may be short depending on when ground is removed from the lead 68.

The relay interrupter supplies ground on lead 74 at the approximate rate of 25 times per minute. The first ground pulse operates relay 40 in an obvious circuit which relay, at its outer right-hand armature and back contact opens the loop circuit extending between stations causing relays 39 and 38 at the main station and relay 35 at the auxiliary station to release. Relay 39 released, permits relay 42 to reoperate. Relay 40, at its inner left-hand armature and front contact causes relay 49 to operate in an obvious circuit and its inner right-hand armature and front contact establishes an obvious circuit for relay 77 to hold this relay operated when relay 38 releases as already mentioned. Relay 40, at its outer left-hand armature and front contact causes the resistance 78 to be connected across the tip and ring conductors of the line on the main station side of the retard coil 31; the inner left-hand armature and front contact of relay 49 completes this connection. The connection of resistance 78 helps to discharge the line quickly and thereby hastens the release of relay 35 at the auxiliary station. Relay 35 controls the operation of lamp 99 in Fig. 2.

Relay 35 at the auxiliary station released, opens the normally energized circuit to relay 79 (Fig. 3) causing this relay to release and establish an obvious energizing circuit for relay 80. Relay 80 operated, at its right and left-hand armatures opens the leads 81 and 82 to the brushes d and b of selector Sa at the auxiliary station. The opening of lead 81 to selector brush d prevents the operation of relay 88 when the selector Sa steps to position No. 10. At its front contact and right-hand armature relay 80 establishes a circuit extending from grounded battery 84, selector rotary magnet 85, conductor 86, outer left-hand armature and front contact of relay 20 (Fig. 4), conductor 87, back contact and right-hand armature of relay 88, conductor 89, front contact and right-hand armature of relay 80 to ground by way of the back contact and left-hand armature of relay 90. The rotary magnet 85 operates in this circuit to step the selector Sa to position No. 1. In this position, relay 27 operates in a circuit extending from grounded battery 91, winding of relay 27, conductor 92 to ground at the off-normal contacts 93 of the

selector. The off-normal contacts 93 close when selector Sa operates to position No. 1 and remain closed until the selector is released. Relay 27 at its left-hand armature and back contact removes ground from the previously traced energizing circuit for relay 24, which relay releases.

Relay 49 at the main station (Fig. 6) operated, establishes a circuit for rotary magnet 94 extending from grounded battery, winding of rotary magnet 94, conductor 95, back contact and right-hand armature of relay 59, conductor 96 to ground at the front contact and outer left-hand armature of operated relay 49. Rotary magnet 94 steps selector Sm to position No. 1. Relay 49 at its outer left-hand armature removes ground from the selector brush a to prevent relay 59 from operating when the selector steps to position No. 10. At its outer right-hand armature, relay 49 opens the circuit to the start relay 45 which relay releases and at its inner left-hand armature connects, as hereinbefore mentioned, resistance 78 across the cable pair.

The relay interrupter at the main station then removes ground from conductor 74 (hereinbefore described) which causes relay 40 to release, which, in turn, releases relay 49. At its outer right-hand armature relay 40, released, again connects ground to the loop circuit to cause relays 38 and 35 to reoperate. At its outer left-hand armature, relay 40 opens the circuit to resistance 78 to prevent marginal relay 39 from operating momentarily. Relay 77 is a slow release relay which holds operated while ground to its winding is transferred from the inner right-hand armature and front contact of relay 40 to ground from the front contact and armature of operated relay 38.

Relay 35 at the auxiliary station in reoperating completes an obvious circuit to relay 79 (Fig. 3) which relay operates and in turn, releases relay 80 to close the circuit to relay 24. Relay 24 is now connected to the brush b of selector Sa by way of conductor 82, left-hand armature and back contact of relay 80 and conductor 25. If ground is found on the first contact of the selector Sa, relay 24 will operate.

Upon the occurrence of the rectifier failure at the auxiliary station as mentioned in the early part of this description, we found that ground potential at the inner left-hand armature and front contact of relay 10 (Fig. 2) was connected to contact 3 of the selector Sa at the auxiliary station by way of the left-hand armature and front contact of relay 3, conductor 18, right-hand winding of relay 17 (Fig. 3) and conductor 100. Ground potential is therefore not found at position No. 1 of the selector Sa so that the selector is advanced to position No. 2 and then to position No. 3 under control of the relay interrupter in the same manner as it was advanced to position No. 1 upon the first ground pulse reaching conductor 74 as already described.

When the brush b of selector Sa reaches contact No. 3 which is now grounded through the right-hand winding of relay 17 from lead 18, relays 24 and 17 both operate (it having been just described how this relay is connected to the brush b when relay 80 releases). Relay 24 in operating, again short circuits the resistance 37 so that marginal relay 39 (Fig. 4) in the loop circuit between stations operates and connects the ground potential at the inner right-hand armature and back contact of relay 40 to the battery side of the winding of relay 42 by way of conductor 44 thereby causing relay 42 to release.

Reverting back to the time when selector S_m at the main station stepped to position No. 1, a circuit was established extending from grounded battery, winding of relay 47 (Fig. 6), off-normal contacts 101 of the selector S_m , front contact and outer right-hand armature of relay 60, conductor 63, back contact and right-hand armature of relay 64, conductors 65 and 66, to ground at the right-hand normal contacts of recheck key 67. Relay 47 operates in this circuit and locks up on its inner right-hand armature and front contact, transferring by the operation of its left-hand armature, the lead 48, now grounded by the release of relay 42, to the brush c of the selector S_m by way of conductor 104. The circuit to the right-hand winding of relay 52 is also opened at the outer right-hand armature of relay 47.

So far there has been shown how the selectors S_a and S_m advance from one position to another until the brush of selector S_a arrives at a grounded contact. In the present description contact 3 of this selector has been grounded so that when this contact is reached by the selector S_a a corresponding contact 3 of selector S_m is reached. Now, with relay 42 (Fig. 6) released, a circuit is established extending from grounded battery, winding of relay 102, normal make-before-break contacts of relay 102, conductor 103, contact 3 and brush c of selector S_m , conductor 104, front contact and left-hand armature of operated relay 47, conductor 48, outer right-hand armature and back contact of relay 49, conductor 50, back contact and left-hand armature of relay 51 to ground at the back contact and armature of relay 42. Relay 102 operates in this circuit and locks to ground at the normal contacts of recheck key 67. At its right-hand armature and front contact relay 102 establishes an obvious circuit for lamp 105. At its outer left armature and front contact, relay 102 completes an obvious circuit for lamp 55, which lamp identifies the particular trouble condition which exists at the auxiliary station. Relay 102 also opens the lead from contact No. 3 of the selector S_m to prevent a feedback circuit when the selector brush c bridges two contacts while stepping.

The interrupter continues to operate and during the first ten pulses, causes the selectors S_a and S_m to advance over the ten contacts illustrated. When the selector S_m steps to position 10, an obvious circuit is completed to the winding of relay 59 which relay operates upon release of relay 49 which occurs after the tenth pulse of ground has been applied to and removed from the lead 74 by the relay interrupter. When ground is removed from lead 74 by the release of relay 69 after the tenth impulse of the interrupter circuit, relay 49 restores its armatures causing relay 49 to release. Relay 59, operated, locks to ground at the left-hand armature of relay 45 by way of the back contact and left-hand armature of relay 64.

Relay 59 operated, transfers the lead 96 from relay 49 which normally goes to the rotary magnet 94 of selector S_m , to the release magnet 106 of the selector S_m . Relay 59 operated, also closes a circuit from grounded battery, winding of relay 107, conductor 108, outer left-hand armature and front contact of relay 59, which circuit is completed to ground at the inner right-hand armature of relay 49 when this relay reoperates on the eleventh pulse.

In the case of the selector S_a at the auxiliary station the release relay 88 (Fig. 3) operates on its primary winding as follows: When relay 80

released as previously described, a circuit is established extending from grounded battery 108, conductors 109 and 110, left-hand winding of relay 88, conductor 112, contact No. 10 of selector S_a and the brush thereof, conductor 81, back contact and right-hand armature of relay 80 to ground at the back contact and left-hand armature of relay 90. Relay 88 in operating, transfers the lead 89 from relay 80 which normally goes to the rotary magnet 85 to the release magnet 13 of the selector S_a . Relay 88 locks to ground at the inner right-hand armature and front contact of operated relay 27 by way of its own inner left-hand armature and front contact.

The eleventh pulse from the interrupter causes relays 40 (Fig. 4) and 49 (Fig. 6) to operate in the hereinbefore described manner. Relay 40 opens the loop circuit between stations, whereupon relay 35 (Fig. 4) restores its armature which opens the circuit to relay 79 (Fig. 3), which relay thereupon releases and closes the circuit to relay 80. Relay 49 in operating completes the circuit to the release magnet 106 thereby causing the selector S_m at the main station to be returned to normal. The return of the selector to normal opens the off-normal contacts 101 in the circuit to the winding of relay 47, but this relay remains locked up as hereinbefore described.

When relay 80 (Fig. 3) at the auxiliary station operates on the eleventh pulse, a circuit is established extending from grounded battery 120, winding of release magnet 113, conductor 114, front contact and outer left-hand armature of relay 88, conductor 89, front contact and right-hand armature of relay 80 to ground at the back contact and left-hand armature of relay 90. A circuit was also established for the energization of the right-hand winding of relay 88 extending from grounded battery 108, conductors 109 and 110, right-hand winding of operated relay 88, front contact and right-hand armature of relay 88, front contact and right-hand armature of relay 80 to ground at the back contact and left-hand armature of relay 90.

When the eleventh pulse from the interrupter released the selector S_m at the main station, ground was supplied from relay 49 to operate relay 107 as previously described. Relay 64 cannot operate while ground is connected directly to relay 107 but will operate in series with relay 107 as soon as relay 49 releases to remove this ground. The ground for the series operating circuit for relays 107 and 64 is found at contact 121 associated with relay 107. When relay 64 does operate, ground is removed from relays 60 and 59 causing them to release. Relay 60 released, disconnects ground from the start lead 68 to stop the interrupter and supplies ground to short circuit relay 107 causing this relay to release and in turn, release relay 64. Relay 60 released, also opens the locking circuit to relay 47, causing this relay to release.

When ground was present on lead 18 (Fig. 2) due to the trouble condition at the auxiliary station, relays 24 and 17 (Fig. 3) both operated in series, as hereinbefore described. Relay 17 then locked up to ground on lead 18 by way of its front contact and left-hand winding from grounded battery 91 by way of the back contact and right-hand armature of relay 90 (Fig. 3). Relay 17 operated, disconnects resistance 16 from ground on the lead 18 which caused relay 12 to release. Relay 20 (Fig. 4) then releases and opens the circuit to relay 24 (Fig. 3) which later

releases when relay 80 releases and opens a parallel circuit to relay 24.

Ground on any lead, such as 18, will operate relay 24 as already described, through the corresponding selector contact, such as contact 3, and will also lock up the corresponding relay, such as relay 102 (Fig. 6). If an alarm comes in while the selector is stepping and is not registered on the first cycle, this alarm will immediately cause the alarm circuit to go through its cycle a second time after the release of the selectors at both stations.

The foregoing description covers the transmission of an alarm signal from an auxiliary station to a main station upon the occurrence of a rectifier failure at the first station. Such an occurrence causes the lead 18 to be grounded which results in the operation of relay 52 to bring in a general alarm at the main station, applies ground potential to a particular contact of the selector S_a at the auxiliary station, causes the start of a relay interrupter which drives the selectors S_a and S_m at the two stations substantially simultaneously until the first-mentioned selector arrives at the grounded terminal, whereupon relay 102 at the main station functions to actuate signals which identify the nature of the trouble condition at the auxiliary or unattended station.

In the event of a failure of equipment of another nature such as a transmission regulator with which relay 130 (Fig. 2) is associated, this relay releases in any well-known manner to cause relay 131 to operate in a circuit extending from grounded battery, winding of relay 131, armature and back contact of relay 130, conductor 5 to ground at the inner right-hand armature and back contact of relay 6. Relay 131 in operating establishes an obvious circuit for slow-to-operate relay 9 which, when it operates, causes the operation of relay 10. At its innermost armature and front contact relay 131 prepares a circuit for lamp 133 which may be completed upon the actuation of key 8 upon the arrival of an attendant at the normally unattended auxiliary station. When relay 10 operates, and assuming the trouble condition persists, ground potential at the outer left-hand armature of relay 10 is connected to the lead 134 by way of the outermost armature and front contact of relay 131. The lead 134 corresponds to the lead 18 mentioned during the previous description of the transmission of an alarm signal upon the failure of a rectifier at the auxiliary station. The lead 134 passes through the right-hand winding of relay 135 (Fig. 3) to the contact No. 4 of the selector S_a . The operation of the system from this point on is the same as that described in connection with the grounding of contact No. 3 of the selector S_a with the exception that relay 136 (Fig. 6) operates to energize the lamp signal 137 to identify the particular nature of the trouble condition.

It will now be assumed that the source of outside power indicated at 140 fails. Under this condition relay 141 restores its armatures, the outer one thereof preparing an obvious circuit for lamp signal 142. At its inner armature and back contact, relay 141 establishes an obvious circuit for relay 143 which relay performs no function at this time.

When the power failure occurs, the rectifier and regulator alarms also function causing relays 2, 3 and 131 to operate. The slow-to-operate relay 9 is accordingly energized and when operated, causes relay 10 to operate in an obvious circuit.

Relay 10 at its right-hand armature and front contact connects ground to the winding of relay 6 by way of the left-hand armature and front contact of relay 143. Relay 6 accordingly operates.

Relay 6 at its inner right-hand armature and back contact removes ground from the lead 5 which causes relays 3 and 131 to release to prevent rectifier and regulator alarms from being registered in the attended office during a power failure. At its left-hand armature and front contact relay 6 locks up to ground on the lead 144 which terminates at the front contact and inner right-hand armature of relay 143 and also at the back contact and armature of relay 145 (Fig. 4). Relay 6 is also under control of relay 10. At its alternate make-before-break contacts, relay 6 connects ground by way of the front contact and outer right-hand armature of relay 143 to conductor 146 which corresponds to the leads 18 and 134 of previous descriptions. The lead 146 is connected to the contact No. 6 of selector S_a at the auxiliary station by way of the right-hand winding of relay 147 (Fig. 3). The operation of the system from this point on is the same as previously described except that relay 148 and lamp 149 function in a manner obvious to identify the power failure condition.

When the power is restored, relay 143 releases and ground at the front contacts and armatures of relay 141 is connected to the lead 150 by way of the outer right-hand armature and front contact of relay 6. The lead 150 corresponds to leads 18, 134 and 146 and is connected to the contact No. 7 of selector S_a . The system then functions in the manner previously described whereby relay 151 and lamp 152 (Fig. 6) function to register the power restoration alarm. When relay 141 reoperates, relay 143 releases and disconnects the ground on lead 146.

In the previous descriptions of the transmission of alarm signals from an unattended station to an attended station it was assumed that the loop circuit interconnecting the stations was closed as would normally be the case. If, for any reason, the loop circuit is open upon the occurrence of a trouble condition relay 35 (Fig. 4) restores its armature and the circuit to relay 79 is opened so that relay 79 is released. Relay 80 accordingly operates to cause the selector S_a to step in a manner already described. Ground from the off-normal contact 93 will then operate relay 27 which in turn operates relay 155 in an obvious circuit. This relay after an appreciable interval of time (2 to 3 minutes) closes an obvious circuit to relay 90 which relay operates. Relay 90 at its left-hand armature removes ground from the selector rotary magnet 85 and applies it to the selector release magnet 113 causing the selector to release. The selector in the released position releases relay 27 which removes ground from relay 155 causing this relay to release quickly and in turn release relay 90. If the loop circuit remains open, the selector will again operate which causes the reoperation of relays 27 and 155 to again release the selector. This action continues until the loop circuit is closed. Relay 90 operated, also releases any of the relays 17, 135, 147 and 156 which may have been locked up.

An open loop circuit between stations, will also cause relay 38 (Fig. 4) to restore its armature and the circuit to relay 77 is opened so that relay 77 is released. Relay 42, therefore releases and causes relays 45 and 52 to operate. Relay 52

operated, effects the operation of the lamp 56 and audible signal 57. Relay 45 operated, causes relay 60 to operate to start the interrupter. The operation of the release key 54 in this case releases relay 52 to stop the audible signal 57, opens the circuit to the winding of relay 60 and closes a circuit to relay 51 extending from grounded battery, winding of relay 51, front contact and inner right-hand armature of operated relay 45 to ground at the left-hand contacts of key 54.

The circuit to relay 51 will be completed when relay 45 operates a second time after the release of selector S_m at the main station and the subsequent release of relay 47 as hereinbefore described. Relay 45 is slow-to-release and operates in a circuit extending from grounded battery, winding of relay 45, conductor 46, back contact and left-hand armature of relay 47, outer right-hand armature and back contact of relay 49, back contact and left-hand armature of relay 51 to ground at the armature of released relay 42. Relay 45 operated, closes the circuit to relay 51, which operates and opens the circuit to the winding of relay 45. Relay 45 then releases and key 54 may be released. Relay 51 operated, also closes a circuit at its front contact and right-hand armature to keep lamp 56 lighted. When the loop circuit between stations is restored, relays 38, 77 and 42 reoperate and relay 51 releases to restore the circuit to normal.

Rechecking signals

When it is desired to verify the lamp signal received from the auxiliary station the recheck key 67 (Fig. 6) may be actuated by the attendant at the main or attended station. The actuation of key 67 causes relay 30 (Fig. 4) to operate in a circuit extending from grounded battery, winding of relay 30, conductor 157 to ground at the right-hand alternate contacts of key 67. The key 67 may be actuated while the selectors are stepping if so desired. Relay 30 operated, reverses the battery polarity on the loop circuit which causes the polarized relay 36 (Fig. 4) to operate. The key 67 operated, also releases the selector S_m and removes ground from the relays 102, 136, 148 and 151 which releases these relays and extinguishes the associated lamps 105, 137, 149, 152. Relay 38 (Fig. 4) in the loop circuit may release momentarily when relay 30 operates but the associated relay 77 being slow-to-release will remain operated. Relay 35 (Fig. 4) and relay 79 (Fig. 3) may also release upon the operation of relay 30 but will immediately reoperate. Relay 80 (Fig. 3) being slow-to-operate will remain released.

When polarized relay 36 (Fig. 4) operated, ground was supplied to cause relay 145 to operate in an obvious circuit which relay in turn, caused relay 90 to operate in an obvious circuit by way of lead 290. Relay 145 operated, also removes ground from conductor 144, which will release locked-up relay 6 (Fig. 2), when the outside power source is restored. The power restoration alarm registered by lamp 152 (Fig. 6) cannot therefore be rechecked. Relay 90 operated, supplies ground at its left-hand armature and front contact to the release magnet 113 of selector S_a at the auxiliary station to release the selector in case it is operated and also removes ground from relays 17, 135, 147 and 156 at the auxiliary station causing them to release. The release of these relays, key 67 and relays 30, 36, 145 and 90, causes the alarm circuit to start operating again to re-light the same lamps such as 105, 137, 149, 152

(Fig. 6) which were lighted before due to the fact that they reconnect the leads 18, 134, 146 and 150 to the winding of relay 12.

Open wire circuit

The alarm system as applied to open wire circuits is illustrated by Figs. 2, 3, 5 and 6 arranged in the manner shown in Fig. 1. In this case the alarm circuit between stations is operated over a single conductor with a ground return. A duplex telegraph circuit is used supplied with 130-volt telegraph battery 263 at the main station and a 152-volt battery 13 at the auxiliary station. When the telegraph circuit is idle, the higher voltage battery at the auxiliary station is delivering current to hold a relay operated in the main station. An alarm in the auxiliary station will operate a relay to substitute ground for the higher voltage battery normally connected to the line circuit causing the release of a relay at the main station which operates an audible alarm and starts the relay interrupter. The selector at the auxiliary station is caused to operate by the connection of the lower voltage battery to the line circuit at the main station which causes a relay in the auxiliary station to operate and in turn step the selector. The selector in the main station is caused to operate in step with the auxiliary station selector.

The disclosures of the open wire and cable circuit arrangements are the same except that Fig. 5 of the former replaces Fig. 4 of the latter. It is quite apparent therefore that a major portion of the detailed description of the cable circuit arrangement just given will apply to the open wire circuit so that it is deemed permissible in the description of the latter to resort to abbreviated circuit description wherever possible.

In the description of the cable circuit arrangement it has been shown how the leads 18, 134, 145 and 150 become grounded to effect the transmission of alarm signals to the attended station upon the occurrence of certain conditions at the unattended station such as rectifier, regulator and power failures and power restoration. The following description will cover only the condition of rectifier failure which results in the application of ground potential to the lead 18.

Ground on lead 18 operates relay 12 (Fig. 3) in the manner previously described and as a result, relay 220 (Fig. 5) operates in a circuit extending from grounded battery 13 (Fig. 3), conductors 14 and 21, winding of relay 220, conductor 22, armature and front contact of relay 12, conductors 23, 222 and 26 to ground at the back contact and left-hand armature of relay 27. The selector S_a is normally in the released position when an alarm comes in and the line circuit between stations is normally closed with 152-volt battery 13 connected at the unattended office and ground connected at the main office.

The normally closed line circuit extends from grounded battery 13 (Fig. 3), conductors 14, 21, 221, resistance 224, back contact and left-hand armature of relay 220, right-hand winding of polarized relay 225, left-hand winding of impedance coil 58, line conductor interconnecting the two stations, left-hand winding of impedance coil 232, back contact and right-hand armature of relay 226 to ground by way of the right-hand winding of polarized relay 227. Relay 227 is normally operated in the idle condition of this circuit. The left-hand winding of relay 227 biases the relay in a non-operate direction. It will be noted at this time that relay 225 comprises three

windings, the right-hand winding referred to as the line winding, the middle winding known as the network winding and the left-hand winding which is a biasing winding. The right-hand and middle windings are differential with respect to each other so that current in the circuit just traced for the right-hand winding tends to release the relay but is balanced by the current in the middle winding which tends to operate the relay so that under this condition the net effect is zero. The left-hand biasing winding tends to hold the relay 225 released.

When relay 220 (Fig. 5) operates, as described, ground is connected to the line circuit by way of conductor 228 and the front contact and left-hand armature of relay 220 in place of battery 13 thereby causing relay 227 to release. The release of relay 227 removes ground from the winding of relay 42 (Fig. 6) causing this relay to release. As in the description of the cable circuit arrangement, relay 42 released, operates relays 45 and 52 the latter locking up to key 54 and effecting the operation of lamp signal 56 and audible signal 57. Relay 45 operated, releases the selector S_m if it is locked up and also supplies ground to relay 60 which relay operates and locks up through the right-hand armature and back contact of relay 64 to ground at the recheck key 67.

Relay 60 operated, starts the interrupter circuit functioning from ground on the "start" lead 68. Relay 60 also removes ground from the first make contact associated with the armature of relay 107 which allows this relay to operate at a later time.

The audible signal 57 may be stopped from operating by the operation of key 54 which releases relay 52 as soon as the interrupter has started and caused relay 47 to operate as previously described.

The relay interrupter circuit including relays 73, 72, 71, 70 and 69, supplies ground on lead 260 at the approximate rate of 25 times per minute as long as the lead 68 remains grounded. The first ground pulse operates relay 49 in an obvious circuit which includes the conductor 260 shown on Fig. 5. Relay 49 operated, steps the selector S_m at the main station to position No. 1 and removes ground from the brush a to prevent relay 59 from operating when the selector steps to position No. 10.

When the selector S_m stepped to position No. 1, ground from the off-normal contacts 101 operated relay 47 which transferred the lead 48 from the relay 45 to the lead 104 to the brush c of the selector. The circuit to relay 52 also opened when relay 47 operated.

At its inner left-hand armature and front contact relay 49 establishes a circuit extending from grounded battery, right-hand winding of relay 226 (Fig. 5), conductor 261, inner left-hand armature and front contact of relay 49, conductor 262 to ground. Relay 226 operates in this circuit and at its right-hand armature and front contact establishes an obvious circuit to the right-hand winding of relay 227 and at its left-hand armature and front contact connects the 130-volt battery 253 to the line circuit through resistance 264 thereby causing relay 225 to operate in a circuit extending from grounded battery 263, resistance 264, front contact and left-hand armature of relay 226, left-hand winding of impedance coil 232, line conductor, left-hand winding of impedance coil 53, right-hand winding of relay 225 to ground by way of the left-hand ar-

mature and front contact of relay 220. It will be noted that the middle winding of relay 225 is now short circuited by the left-hand armature of relay 220 so that relay 225 operates by way of its right-hand winding as just described.

Relay 227 operated, reoperates relay 42 (Fig. 6) over an obvious circuit. Relay 49 operated opens the circuit to "start" relay 45 which relay releases. Relay 225, operated, opens the energizing circuit for relay 79 (Fig. 3) causing this relay to release and in turn complete the circuit to relay 80 which relay thereupon operates. Relay 80 operated, opens the circuits from the brushes of the selector S_a and supplies ground to operate the selector to position No. 1. Relay 225 also causes the audible signal 241 to be operated (when key 240 is actuated) in a circuit extending from grounded battery 91, conductor 242, bell 241, right-hand contacts of key 240 (when closed) to ground at the front contact and armature of relay 225. When key 240 is operated the lamp 243 is lighted as a guard signal. With the selector in position No. 1, relay 27 operates to remove ground from relay 220 (Fig. 5) causing this relay to release which transfers the right-hand and middle windings of relay 225 from ground to battery 13. Current now flows in the middle winding in the operate direction and the current reverses in the right-hand winding to release the relay. The effect of the current in the middle winding overcomes the effect of the current in the right-hand winding and relay 225 remains operated.

The interrupter at the main or attended station then removes ground from the lead 74 which causes the release of relay 49 in Fig. 6 and relay 226 in Fig. 5. Relay 225 thereupon releases to stop the bell signal 241 from ringing and causes relay 79 (Fig. 3) to reoperate which in turn releases relay 80 to close the circuit to relay 24. If ground is found on contact No. 1 of the selector S_a relay 24 operates. Ground, however, in the present description has been applied to the contact No. 3 of the selector S_a so that, under the control of the interrupter, the selector is advanced from position No. 1 through position No. 2 and thence to position No. 3.

When contact No. 3 of selector S_a at the auxiliary station is reached by the brush b , relay 24 operates in series with the right-hand winding of relay 17 when relay 80 releases. This causes relay 226 (Fig. 5) to operate in a circuit extending from grounded battery 13, conductors 14 and 21, winding of relay 220, conductor 244, front contact and armature of relay 24, conductor 245 to ground. Relay 220 operated, transfers the line circuit from battery 13 to ground at its left-hand armature causing relay 227 to release. Relay 42 (Fig. 6) thereupon releases.

When relay 49 (Fig. 6) releases as described above, ground is supplied to contact No. 3 of the selector S_m which operates relay 102 and locks this relay to ground at the recheck key 67. Relay 102 operated, lights lamps 105 and 56 and opens the lead from contact No. 3 of the selector S_m .

The interrupter continues to operate and during the first ten pulses causes the alarm circuit to function in a manner similar to that described for the first pulse. When the selector S_m steps to position No. 10, a circuit is completed to the winding of relay 59 which relay operates on release of relay 49 and locks up to ground at the left-hand armature and back contact of relay 45. Relay 59 operated, transfers the lead 96

from relay 49 which normally goes to the rotary magnet 84 to the release magnet 106. Relay 59 also prepares a circuit for relay 107 which circuit is completed to ground at the inner right-hand armature and front contact of relay 49 so that when relay 49 operates relay 107 will operate.

At the auxiliary station, relay 88 operates by way of its left-hand winding as follows: Ground is supplied by relay 80 when this relay releases, to the brush *d* of the selector *S_a* which causes relay 88 to operate when the selector reaches position No. 10. Relay 88 operated, transfers the lead 89 from relay 80 which normally goes to the rotary magnet 85, to the release magnet 113. Relay 88 locks up by way of its left-hand winding to ground on the front contact and inner right-hand armature of relay 27.

The eleventh pulse from the interrupter causes relay 49 (Fig. 6) to operate and complete an energizing circuit for relay 226 (Fig. 5) extending from grounded battery, right-hand winding of relay 226, conductor 261, front contact and inner left-hand armature of relay 49 to ground on conductor 262. Relay 226 operated, causes relay 225 (Fig. 5) to operate which in turn, releases relay 79 (Fig. 3). Relay 80 operates upon the release of relay 79.

When relay 49 (Fig. 6) operates on the eleventh pulse, release magnet 106 is operated from ground at the outer left-hand armature and front contact of relay 49, conductor 96, right-hand armature and front contact of relay 59, to grounded battery through the winding of release magnet 106. This causes the selector *S_m* at the main station to release and open its off-normal contacts 101 in the circuit to the winding of relay 47. Relay 47 remains locked up to be released later when relay 60 releases.

When relay 80 (Fig. 3) operates on the eleventh pulse, ground is supplied to the release magnet 113 of the selector *S_a* at the auxiliary station causing the release of the selector. At its right-hand armature, relay 80 closes an energizing circuit for the right-hand winding of relay 88. Relay 88 releases when relay 80 releases which deenergizes the right-hand winding of relay 88. The left-hand winding of relay 88 was deenergized when the selector and relay 27 released.

When the eleventh pulse from the interrupter released the selector *S_m* at the main station, ground was also supplied from relay 49 to the winding of relay 107 which relay operated and supplied ground at its contacts 121 to relay 64. Relay 64 cannot operate while ground remains connected directly to relay 107 but will operate in series with relay 107 as soon as relay 49 releases to remove this ground. When relay 64 does operate, ground is removed from relays 47, 60 and 59 causing them to release. Relay 60 released, disconnects ground from the start lead 68 to stop the interrupter and supplies ground to short circuit relay 107 causing this relay to release and in turn release relay 64.

When ground was present on the lead 18 due to the rectifier failure at the auxiliary station, relay 24 (Fig. 3) operated in series with relay 17 through its right-hand winding. Relay 17 locked up through its left-hand winding from battery 91 by way of the right-hand armature and back contact of relay 90. Relay 17 operated, disconnects resistance 16 from the grounded lead 18 which causes relay 12 to release. When relay 80 (Fig. 3) releases and opens the circuit to relay 24 causing this relay to release, relay 220 (Fig. 5) releases.

Rechecking alarm signals

When it is desired to verify the lamp signal such as 105, 137, 149 and 152 received from the auxiliary station, the recheck key 67 (Fig. 6) at the main station must be operated to cause relay 226 (Fig. 5) to operate by way of its left-hand winding over conductor 151. Key 67 operated, also releases the selector *S_m* and removes ground from relays 102, 136, 148 and 151 releasing them if operated. The lamp signals 105, 137, 149 and 152 are accordingly extinguished.

Relay 226 operated, holds relay 227 operated and operates relay 225. Relay 225 operated, operates slow-to-operate relay 270 in approximately 5 seconds which then operates relay 271 over an obvious energizing circuit. Relay 225 also releases relay 79 to cause relay 80 to operate but the selector *S_a* does not operate because the circuit to the rotary magnet is open at the right-hand armature of relay 220. When relay 271 operates, relay 90 operates to release the selector if locked up and the relays 17, 135, 147 and 156 which may have been locked up. Relay 271 is slow to release with sufficient delay so that when relay 225 releases to release relay 270 and to reoperate relay 79 which in turn releases relay 80, relay 90 is still operated when relay 80 releases. Then relays 271 and 90 release and the selector remains released. The release of relays 17, 135, 147 and 156, if operated, starts the alarm circuit operating again and the same lamp signals such as 105, 137, 149 and 152 will be relighted.

It is evident from the foregoing descriptions of the cable circuit and open wire systems that the occurrence of a failure at the unattended station, in each case, causes ground potential to be applied to a particular terminal of a selector switch thereat and a general signal to be transmitted over the interconnecting circuit to the attended station. The occurrence of the failure also causes a relay interrupter circuit at the attended station to start functioning to drive a selector switch thereat and also to interrupt the interconnecting circuit which causes the selector switch at the unattended station to operate in step with the selector switch at the attended station and hunt for the grounded terminal. Upon the arrival of the selector at the unattended station at the grounded terminal, the selector at the attended station has reached a corresponding terminal with which there is associated a signal control device which operates and causes a lamp signal to be lighted. The lamp signals at the attended station may be differently colored in order to differentiate between minor and major trouble conditions which exist at the unattended station.

It is to be understood that the line circuits interconnecting the two stations are also used for communication purposes between the stations it being only necessary for the attendants to associate their telephone equipment (not shown) with the interconnecting line circuit by way of jacks which are normally associated with the line circuit. Impedance coils 58 and 232 (Fig. 5) with their associated condensers assist in preventing interference between the telephone, telegraph and alarm circuits.

What is claimed is:

1. In a system for transmitting alarm signals between repeater stations, a first station, a second station, a normally energized circuit interconnecting said stations, a first and a second relay included in said circuit, a selector switch at said first station having a plurality of ter-

minals, a selector switch at said second station having a corresponding number of terminals each of which is associated with a signal control device, alarm originating means at said first station, means responsive to the operation of said alarm originating means for marking one of the terminals of the selector switch at said first station and for altering the electrical characteristic of said interconnecting circuit to cause the actuation of said first relay, an interrupter at said second station responding to the operation of said first relay to step the selector at said second station, means responsive to the operation of said interrupter for again altering the electrical characteristic of said interconnecting circuit to effect the actuation of said second relay, means controlled by said second relay for stepping the selector at said first station and causing it to hunt for the marked terminal, and means operating in response to the arrival of the first station selector at a marked terminal for similarly marking a corresponding terminal of the selector at said second station to cause the operation of the signal control device associated therewith.

2. In a system for transmitting alarm signals between repeater stations, a first station, a second station, a normally energized circuit interconnecting said stations, a marginal relay and a normally operated relay included in series in said interconnecting circuit, a selector switch at said first station having a plurality of terminals, a selector switch at said second station having a corresponding number of terminals each of which is associated with a signal control device, alarm originating means at said first station, means responsive to the operation of said alarm originating means for marking one of the terminals of the selector switch at said first station and for altering the resistance of said interconnecting circuit to cause the operation of said marginal relay, an interrupter at said second station responsive to the operation of said marginal relay to step the selector at said second station, means responsive to the operation of said interrupter for opening said interconnecting circuit to effect the release of said normally operated relay, means responsive to the release of said normally operated relay for causing the selector at said first station to hunt for the marked terminal, and means operating in response to the arrival of the first station selector at a marked terminal for similarly marking a corresponding terminal of the selector at said second station to cause the operation of the signal control device associated therewith.

3. In a system for transmitting alarm signals between stations, a first station, a second station, a circuit interconnecting said stations and extending between battery potential at said first station and ground potential at said second station, a normally energized relay and a second relay having a pair of normally energized differential windings, the winding of said first relay and one of the windings of said second relay being included in said interconnecting circuit, a selector switch at said first station having a plurality of terminals, a selector switch at said second station having a corresponding number of terminals each of which is associated with a signal control device, alarm originating means at said first station, means responsive to the operation of said alarm originating means for marking one of the terminals of the selector switch at said first station and for connecting ground

potential to said circuit at said first station in place of the battery potential to cause the release of said normally energized relay, an interrupter at said second station responsive to the operation of said first relay to step the selector at said second station, means responsive to the operation of said interrupter for connecting battery potential to said interconnecting circuit at said second station to cause said second relay to operate, means responsive to the operation of said second relay for causing the selector at said first station to hunt for the marked terminal, and means operating in response to the arrival of the first station selector at the marked terminal for similarly marking a corresponding terminal of the selector at said second station to cause the operation of the signal control device associated therewith.

4. In a system for transmitting alarm signals between stations, a first station, a second station, a normally energized circuit interconnecting said stations, a relay included in said normally energized circuit, a selector switch at said first station having a plurality of terminals, a rotary magnet for operating said selector switch, a selector switch at said second station having a corresponding number of terminals each of which is associated with a signal control device, alarm originating means at said first station, means responsive to the operation of said alarm originating means for marking one of the terminals of the selector switch at said first station and for causing said connecting circuit relay to function, an interrupter at said second station, relay means controlled by said connecting circuit relay for causing the operation of said interrupter, means controlled by said interrupter for operating the rotary magnet of said second selector switch to cause said selector switch to operate, means also controlled by said interrupter for altering the electrical condition of said interconnecting circuit, means responsive to the altering of the electrical condition of said interconnecting circuit for operating the rotary magnet of said first selector switch to cause said selector switch to hunt for the marked terminal, and means operating in response to the arrival of the first station selector switch at the marked terminal for causing the operation of the signal control device associated with a corresponding terminal of said second station selector switch.

5. In a system for transmitting alarm signals between stations, a first station, a second station, a first relay having an armature, a back contact and a grounded front contact, a battery at said first station, a relay at said second station, a circuit interconnecting said stations extending from a terminal of said battery at said first station to a ground connection at said second station by way of the armature and back contact of said first relay and an operating winding of the relay at said second station, whereby the relay at said second station is normally operated, alarm originating means at said first station, means responsive to the operation of said alarm originating means for operating said first relay, whereby the armature of said first relay disengages its back contact and engages its front contact to cause the battery connection to said circuit to be opened and a ground connection substituted therefor, whereby the relay at said second station is released, and a signal at said second station responsive to the release of the relay at said second station.

VICTOR E. ROSENE.