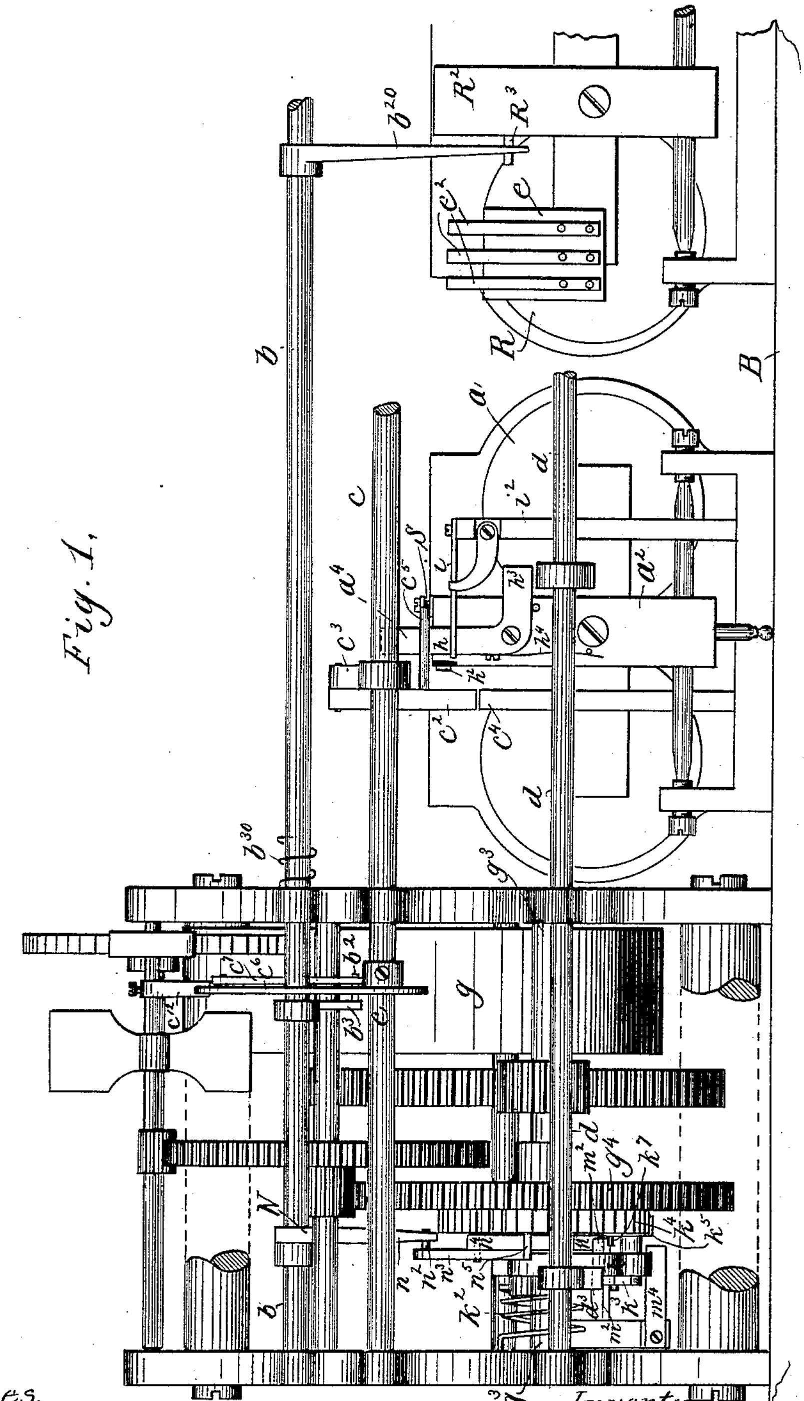
(No Model.) 4 Sheets—Sheet 1.

M. G. CRANE & F. W. COLE.

REPEATER FOR ELECTRIC CIRCUITS.

No. 468,473. Patented Feb. 9, 1892.

Fig. 1.



Witnesses,
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Att'y.

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Fig. 3,

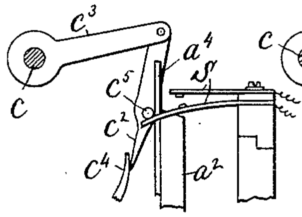

Fig. 4,

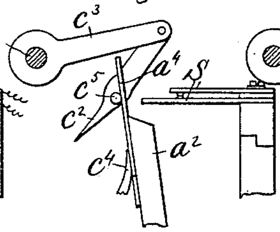

Fig. 5,

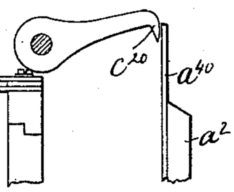

Fig. 6,

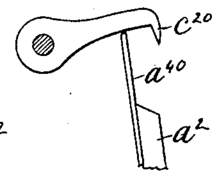

Fig. 2,

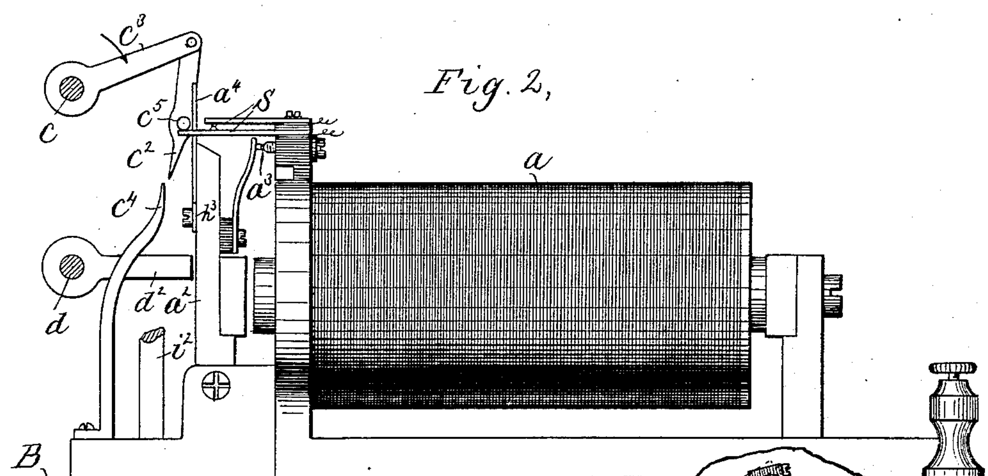

Fig. 7,

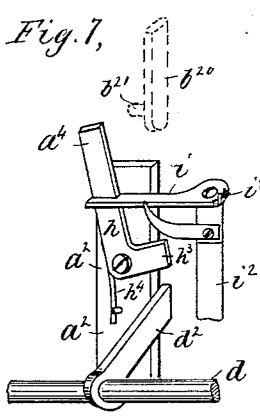

Fig. 8.

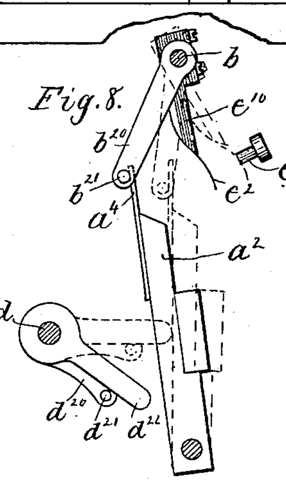

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Fig. 9,

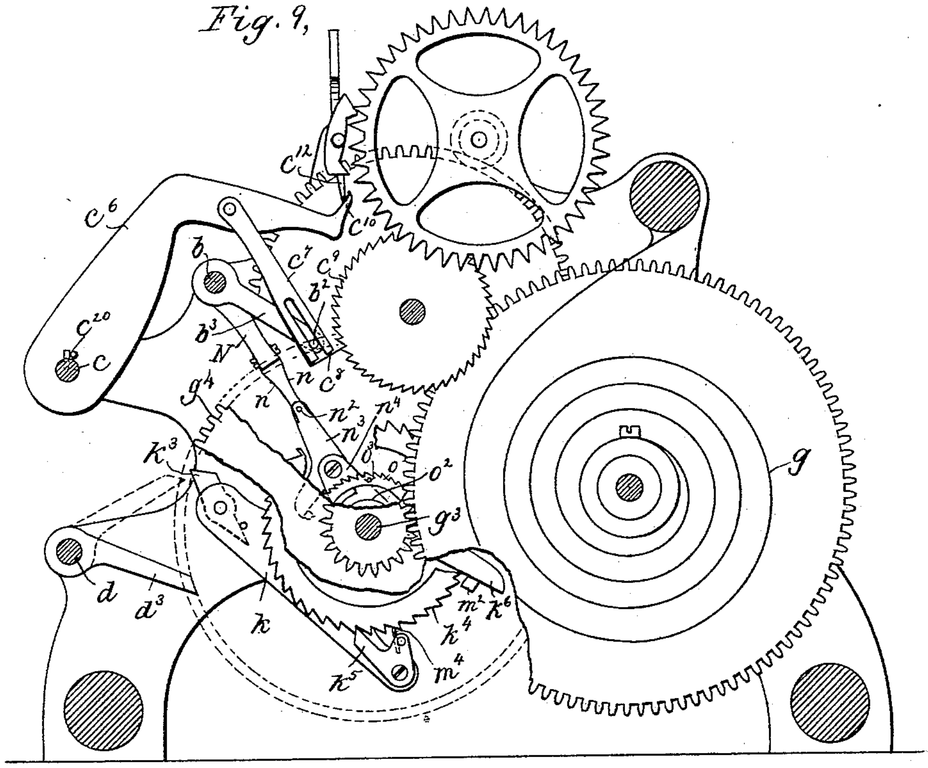

Fig. 12,

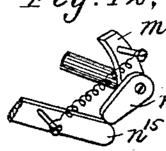

Fig. 10,

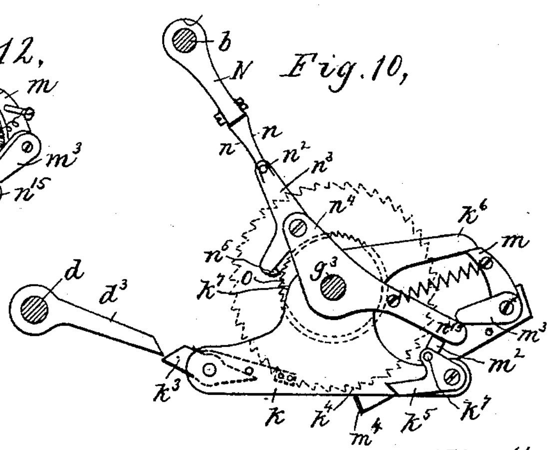

Fig. 11,

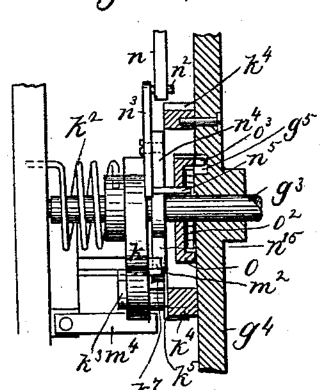

Fig. 13,

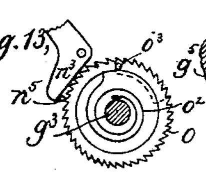

Fig. 14.

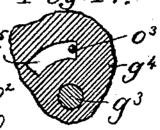

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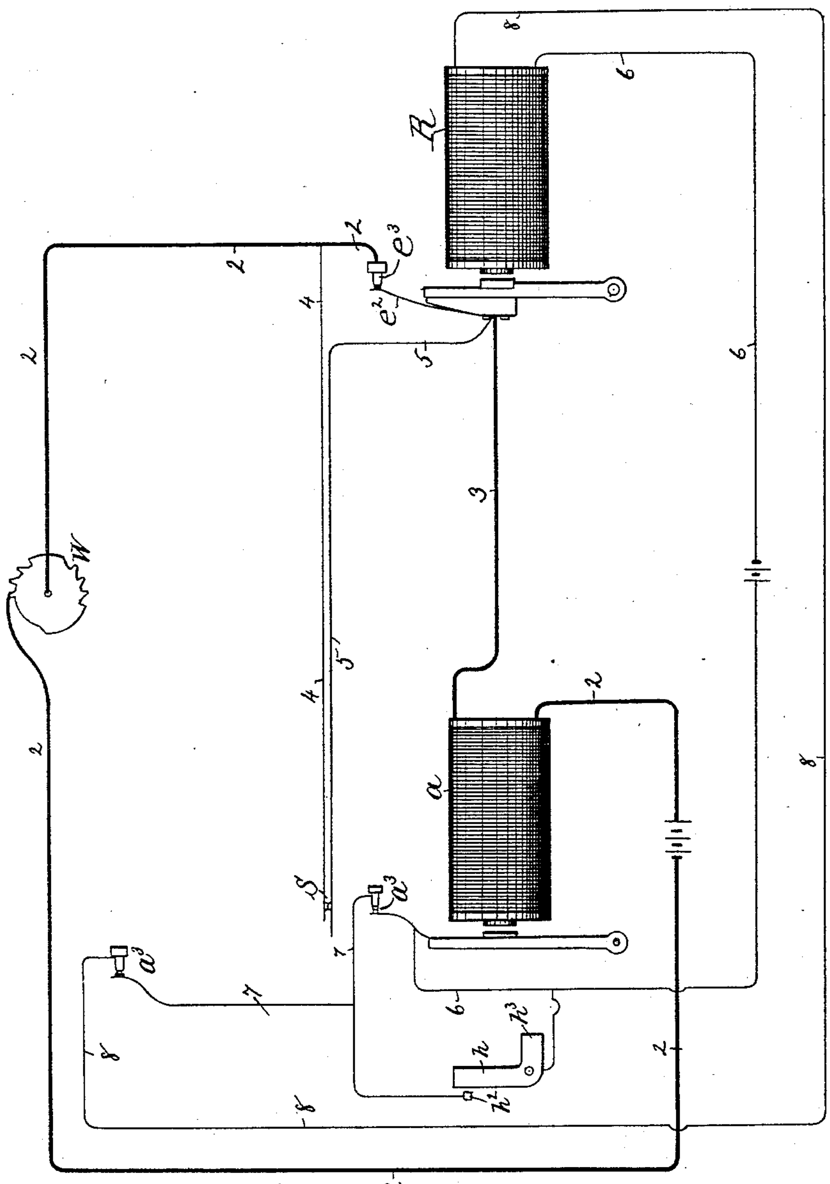
Fig. 15.



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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

MOSES G. CRANE AND FREDERICK W. COLE, OF NEWTON, MASSACHUSETTS.

REPEATER FOR ELECTRIC CIRCUITS.

SPECIFICATION forming part of Letters Patent No. 468,473, dated February 9, 1892.

Application filed July 2, 1889. Serial No. 316,332. (No model.)

To all whom it may concern:

Be it known that we, MOSES G. CRANE and FREDERICK W. COLE, of Newton, county of Middlesex, and State of Massachusetts, have invented an Improvement in Repeaters for Electric Circuits, of which the following description, in connection with the accompanying drawings, is a specification, like letters and figures on the drawings representing like parts.

Our invention relates to a repeater or instrument by which electric signals transmitted over any one of a number of circuits, all co-operating with said repeating-instrument, are automatically transmitted over the rest of the circuits of the set, such instruments being commonly employed in connection with fire-alarm circuits for the purpose of transmitting or repeating the signals that may be received from a signal-box on any one circuit over all the circuits of the system. The signals are usually produced by opening and closing the circuits which are commonly normally closed and with the currents applied to them, and the signals generally consist of a number of consecutive short closures of the circuit separated from one another by definite short intervals of time, and the break-wheels of the transmitting-boxes are usually so made that while a signal is being transmitted the time of closure of the circuit is shorter than the interval between two consecutive closures, during which interval the circuit remains open.

For convenience the instrument forming the subject of this invention will be described as if intended to operate for signals of the character just referred to, although it is obvious that the repeating-instrument forming the subject of this invention might be employed with signals of other character—as, for example, when closures of varying duration are used to produce signals composed of dots and dashes, such as used in the Morse alphabet, or when the signals are given by changes in the character or condition of the current other than total interruption and reestablishment of the current.

It is necessary for a repeating-instrument for the purpose above set forth that the instrument should be capable of operation by any one of the several circuits, and that on the moment that one circuit begins to transmit a signal the repeating-instrument should be removed from control of all the other circuits until that signal is completed, so that in case a signal should be transmitted in another circuit before the first was completed there should be no interference between the two signals or messages.

The object of the present invention is to produce a repeater capable of operating as rapidly as a magnet-armature can respond distinctly to changes in a circuit in which it is included, so that the message can be received on one circuit and repeated over several other circuits as quickly as it could be received if no such repetition had to be provided for. In order to accomplish this result, the repeating-instrument is in accordance with this invention provided with a number of electro-magnets, one in each circuit, and adapted to respond directly to the signals originally transmitted in said circuit, the armatures of said magnet each actuating directly or through the intervention of a relay a number of circuit-changers co-operating with all the circuits connected with the repeater, so that the movement of any one armature immediately produces a break or change in all the circuits connected with the repeating-instrument. The said armatures are each provided with a lock or detent, all of which locks are connected to move simultaneously and each of which is normally disengaged from its corresponding armature, leaving it free to move; but on the backward or retractive movement of any one armature all the locks are immediately moved and all except the one corresponding to the armature which has moved to operate them are by such movement thrown into engagement with and lock the corresponding armatures in such position that they are unaffected by changes in their magnets, while the particular armature that has moved to operate the locking device is itself in such relation to its lock as to be left free to respond to its magnet, so that it will go on responding to the message that is being transmitted in its own circuit, and each of its movements will produce a corresponding change in all the other circuits; but the said change in the other circuits, or, in fact, any change made from any point in any of the said other circuits, is unable to affect the armatures of the repeater-magnets therein, owing to the effect of the before-mentioned lock. It is necessary that the lock should remain in engagement with the several armatures during the entire period of time occupied by the message that is being originally transmitted, but that the armatures should be unlocked as soon as possible after such message is finished, so as to leave the repeater in condition to respond to the next message which may be transmitted in any one of the circuits. This result is effected by means of a mechanical motor or clock-work having a time-movement and being controlled by each of the armatures of the several repeater-magnets in such manner that the said motor begins to operate at the first backward or opening movement of any one of the armatures, and in its operation begins to operate a restorer for the armature at each forward or closing movement of said armature, which restorer is so arranged that it requires a period of movement of the motor slightly greater than the longest closure of the circuit that occurs in the transmission of any continuous message before it can restore the lock to its original position and unlock all of the armatures. The magnet that is responding to a message throws the lock-restorer back to its original starting-point at each break of said message, so that as long as the armature is responding to the successive impulses of the message the restorer cannot move far enough to unlock the armatures; but shortly after the magnet-armature comes to rest in normal attracted position at the end of a message it completes the movement of the restorer which returns the locks to their original or normal position and releases all of the armatures, leaving the repeater ready for the next operation, and finally stops the restoring-motor itself. Means are also provided for preventing the derangement of the working parts in case any one or more of the main circuits should be permanently broken, grounded, or otherwise deranged, so that its magnet remains in abnormal condition.

From the previous description it will be understood that while one of the magnets is demagnetized the motor that restores the locking devices is running, and if the said magnet should remain demagnetized for an indefinite period the said motor would run down. In order to prevent this, an additional restoring device is employed which will restore the repeater, with the exception of the deranged circuit, to its normal condition and leave it unaffected by the magnet the circuit of which is deranged, so that the remaining circuits can operate in the normal manner.

There are various other features, which contribute to the efficiency of the devices which will be hereinafter explained.

Figure 1 is a front elevation of a sufficient portion of a repeating-instrument to illustrate this invention; Fig. 2, a side elevation of one of the main circuit-magnets and a portion of the devices that co-operate directly with the armature thereof; Figs. 3 and 4, details representing said devices in different positions, to be referred to; Figs. 5 and 6, modifications thereof; Fig. 7, a perspective view of a portion of the devices that restore the repeater to normal condition when one of the main lines is deranged; Fig. 8, a detail representing a modification of said devices; Fig. 9, a side elevation of the time-motor that restores the armature-locks to their original or normal condition after a signal has been transmitted and restores the repeater to normal condition in case one of the main circuits is deranged; Fig. 10, a detail representing a portion of the devices shown in Fig. 9 in different positions; Figs. 11, 12, 13, and 14, details of the restoring mechanism that operates when one of the main lines is deranged, and Fig. 15 a diagram representing one arrangement of the circuits that may be employed.

One only of the main-line magnets a is shown in Fig. 1; but it is to be understood that there will be one of said magnets included in each main circuit of the entire set of circuits in which the signals are to be repeated, and that said magnets will be placed side by side in line with one another on a suitable base or support B, and that devices will co-operate with the armatures of the several magnets, which devices are alike for each magnet, so that those co-operating with one magnet only need be described.

As shown in Fig. 1 and in the diagram, Fig. 15, the message received on any one line is repeated over the other main lines through the intervention of a relay-magnet R, which may be mounted upon the base or support B at the end of the row of main-line magnets, as shown in Fig. 1, and is included in a local circuit controlled by contacts a^3, operated by the armature-levers a^2 of the main-circuit magnets a, (see Fig. 2,) the said pairs of contacts controlled by the several main-circuit magnets being in series in the local circuit of the relay, so that the opening of any one will open the said local circuit, and thus cause the relay-magnet R to respond. The armature-lever R^2 of said relay-magnet R is provided with a pin or projection R^3, which co-operates with an arm b^{20}, connected with a shaft b in such manner that each vibration of said magnet causes the said arm b^{20} to swing and oscillate the shaft b, which is a rock-shaft, and is controlled wholly by such movement of the armature-lever R^2, being swung in one direction by the retractive movement of said armature and moved back to its original position by means of a spring b^{30} when the armature is again attracted. The movement of the armature R^2 is in this instance utilized to repeat the signal or message on the other circuits, the said armature or the shaft b moved by it being provided with a contact-carrier e, (see Fig. 1,) provided with a number of contacts e^2, one included in each main circuit and co-operating with corresponding stationary contacts e^3, (see Fig. 15,) so that the separation of the contacts e^2 e^3 upon the retraction of said armature produces the break in the other main circuits which immediately follows the break in any one circuit that permitted the armature-lever a^2 of the corresponding main-circuit magnet to be retracted, and thus open the local circuit, and when the relay-armature is again attracted by the closure of the local circuit by the main-circuit magnet that was originally operated the resulting forward movement of the said relay-armature will again close all the other main circuits.

Inasmuch as the breaking of the main circuits in which the signal is repeated depends upon and thus follows in time the retractive movement of the armature of the magnet that was operated by a break external to the repeater, there is a very short interval of time between the retractive movement of the armature that is first effected by an external change in its circuit and the demagnetization of the other main-circuit magnets, which interval is depended upon to effect the locking or retaining of the armatures of the other main-circuit magnets in operative condition, while the locking device for the armature of the externally-effected main-circuit magnet is operated in such manner as to leave said armature in condition to respond to further changes in the circuit, and thus continue to affect the relay, as will now be described.

A rock-shaft or lock-actuating bar c is provided with a lock c^2 for each armature, (shown in Figs. 2, 3, and 4 as consisting of a finger or projection hanging from the end of an arm c^3, fixed upon said rock-shaft c,) so that when the latter turns a short distance in the direction of the arrow, Fig. 2, the said projection c^2 drops in at the front of a stationary projection c^4 at the rear of the armature-lever of each magnet that is energized, (see Fig. 3,) but falls at the rear of said projection c^4 corresponding to any armature that is retracted at the moment when or just before the said locking device falls. (See Fig. 4.) The said lock is provided with a projection or pin c^5, extending across the rear of a projection a^4 on the armature-lever a^2 of the main-circuit magnet, so that in case the said locking device drops at the front of the projection c^4—*i. e.*, between it and the armature—the said projection c^5 prevents the armature from making its retractive movement, as shown in Fig. 3; but if it falls at the rear of said projection c^4 or away from the armature it does not interfere with the movement of the armature, which by the engagement of the parts a^4 c^5 merely swings the lock c^2 back and forth on its pivot at the end of the arm c^3. The pin c^5, in the downward movement of the lock, also co-operates with a circuit-closer S, the purpose of which will be hereinafter explained, it separating the contacts of said circuit-closer when the lock falls in front of the projection, so as to lock the armature from retractive movement, but being disengaged from the said circuit-closer and leaving the contacts together in case the armature is retracted and moves the lock to the rear of the projection c^4 before the lock drops, as is the case with the magnet through which the message is being received. As a modification of this locking device or even in addition thereto, an arm similar to c^3 might be provided with a locking projection c^{30}, that co-operates directly with a projection a^{40} on the armature-lever, as shown in Figs. 5 and 6, said projection c^{30} dropping at the rear of the projection a^{40} on the armature in case the lock is operated while the magnet is energized, as shown in Fig. 5, or falling at the front of said projection if the armature was retracted before the lock fell, as is the case with the magnet that is responding to the message, in which case the parts will come to the position shown in Fig. 6, the lock permitting the forward movement of the armature, and the projection a^{40} being made somewhat yielding or elastic, if need be, so as to permit the full forward or attractive movement of the armature.

With either construction of the locking device it may be operated by the following mechanism. (Best shown in Figs. 1 and 9.) The said rock-shaft c (see Fig. 9) is provided with a controlling-arm c^6, which is normally supported in position to keep the locking devices c^2 raised, as shown in Fig. 2, by means of a prop c^7, provided with a preferably slightly-yielding finger c^8, that rests in the teeth of a ratchet c^9, connected with one of the arbors of a clock-work motor or train of wheel-work shown as actuated by a mainspring g. If the projection c^8 on the prop c^7 is thrown out from the teeth of the ratchet c^9, the arm c^6 will drop, permit the rock-shaft c to turn, and lower the locks c^2 to the position shown in Figs. 3 and 4; and if the finger c^8 is again thrown into engagement with the teeth of the ratchet c^9 and the train of wheel-work is moving the arm c^6 will gradually be carried thereby back to its normal position, raising the locks to their normal position, as best shown in Fig. 2.

The motor is so timed that a movement of greater duration than that of any closure in the message is required to move the arm c^6 far enough to disengage the locks from their operative relation to the armature and other parts represented in Figs. 3 and 4, and, if desired, the arm c^6 may be loose on the shaft c and engage it by means of projections c^{20}, so that the rock-shaft will be moved only during the last part of the upward movement of the prop c^7. The arm c^6 is also provided with a detent c^{10}, that engages with a projection c^{12} from the governor or balance of the train of wheel-work, or otherwise engages with said train so as to stop its movement as the arm c^6

in being raised by the ratchet arrives at its normal position, and so as to permit the train to start the moment the arm is dropped by the disengagement of the finger c^8 and ratchet c^9, as before mentioned. This engagement and disengagement of the finger c^8 and the ratchet c^9 is effected by a projection b^2 on an arm b^3 from the rock-shaft b, which is itself operated by the arm b^{20}, (see Fig. 1,) engaged by the projection R^3 on the armature-lever of the relay-magnet R in such manner that when said armature is retracted the projection b^2 throws the projection c^8 out from the teeth of the ratchet; but when said armature is attracted it throws it into engagement with the said ratchet c^9, so that as the shaft b responds to the movement of the main-circuit armature the said finger c^8 will, during the transmission of a message, be retained in engagement with the ratchet c^9 only during such periods of time as are occupied by the closures of the circuit forming part of the message, which periods of time are, as before stated, too short to bring the locking parts back to their normal position, and at the end of each closure the finger c^8 is again disengaged, so that the prop drops to its lowest position, and it cannot be moved far enough to restore the locks to their normal position until it has been held in engagement with the ratchet a sufficient time by one continuous closure of the circuit, which can only occur after the message has been completed. The projection b^2 engages with the prop b^3 by means of a slot or guide-groove, as shown in Fig. 9, so as to permit of the movement of the prop with the ratchet, but at the same time to control its position as to engagement with the ratchet at all times by the movement of the arm b^3. As the closures during the transmission of a signal are usually of very short duration, the time required to restore the locks to their normal position after the final closure of the circuit at the end of a message may be made very short, at the end of which time the entire instrument will be restored to the normal condition ready to respond to a message coming in on any line.

The parts thus far described are all that is necessary for the normal operation when all the lines are in working condition, and the normal operation will be best understood in connection with the diagram, Fig. 15, which represents the main-circuit magnet that is receiving the message only. The said main circuit may be traced as follows: From one terminal of the magnet a by wire 2 out from the main station and to the signal-box or break-wheels W, by which the messages are to be transmitted, and back to the main office, where it connects with one of the members of the circuit-closer e^2 e^3, operated by the relay-magnet R, from the other member of which circuit-closer the line is completed, as shown at 3 to the other terminal of the magnet a, a battery being included at any desired point. A branch circuit 4 5 around the relay-contacts e^2 e^3 includes and is controlled by the switch S, that is operated by the armature-lock, as before stated, said switch being closed for the magnet that is responding to a message, as shown in the diagram, but being opened for all other main-circuit magnets immediately after the first break of the magnet that is responding to a signal in its own circuit. Thus the circuit-closer corresponding to e^2 e^3 for all other circuits will have complete control of these circuits, which may thus respond to the movements of the relay-armature; but the circuit-closer e^2 e^3 of the one circuit in which the message is being originally received will have no control of that circuit, as the shunt 4 5 will be closed, thus leaving said circuit wholly under control of the external transmitter or break-wheel that may be operating.

The magnet a in the main circuit in which the message is being originally received controls the relay by its contact a^3 in the local circuit, which may be traced as follows: From one terminal of the relay-magnet R by wire 6 to one member of the circuit-controller a^3 of the first magnet, and from the other member thereof by wire 7 to the circuit-controller a^3 of the next magnet, and so on, the second member of the last circuit-controller a^3 being connected by wire 8 back to the other terminal of the relay. Any one of the circuit-controllers a^3 may thus control the local relay-circuit 6 7 8; but as all but one are locked in their closed position immediately after a message begins the said local circuit remains until completion of a message under control of that one which is not locked.

It may happen, owing to some derangement of some one of the main circuits, that the corresponding magnet would remain demagnetized, and, if so, the contact a^3 would remain open and the relay-armature in its retracted position, which would leave the lock-propping device c^8 disengaged from the ratchet c^9, keeping all the other armatures locked out of operative position, and, furthermore, leaving the restoring-motor running continuously until it would run down. To avoid such derangement of the repeater, the parts, with the exception of the deranged circuit, may be automatically restored to normal condition ready to operate with all the circuits that are in operative condition externally to the repeater by the following mechanism: In order to re-engage the prop-finger c^8 with the ratchet c^9, it will be necessary merely to move the shaft b to its normal condition, which may be done by closing the local circuit of the relay over that one of the circuit-breakers a^3 which happens to be open, and to accomplish this result the local-circuit wires 6 7, for example, leading from the two members of the said circuit-breakers a^3, may be connected with two members h h^2 of a normally-open switch, which may be mounted directly upon the armature-lever a^2 of each main-circuit magnet, it constituting the projection a^4 thereon before referred to. The said switch is shown in Figs. 1 and 7 as made in the form of an elbow-lever, its movable member h having an arm h^3 extending laterally to one side of the armature-lever, as best shown in Fig. 7, and when said lever is retracted the said arm h^3 stands over an arm d^2 from a rock-shaft d, so that if said rock-shaft is turned the said arm d^2 will turn the switch h^2 in the direction to close it, and thus complete the local relay-circuit around the open point a^3. A spring h^4 (see Fig. 7) tends to throw the switch open, when the arm d^2 is again dropped; but while the armature remains in its retracted position the switch-lever is retained in its closed position by a dog or lock i, shown as pivoted on a support i^2 near the armature-lever and acted upon by a spring i^3, that tends to throw its shoulder into engagement with the switch when the latter is moved by the arm d^2 while resting against the arm i. A stop i^1 limits the movement of the dog i toward the magnet, so that in case the magnet should be energized by the restoration of the circuit to the normal condition it will draw the switch h forward out of engagement with the lock i, when the spring h^4 will snap the switch back to its normal position and the magnet will be ready to operate in the normal way. The rock-shaft d, that throws the switch when a magnet remains demagnetized, as described, has its own movement controlled by the same motor that restores the armature-locking devices in the normal operation, as before described, and in such manner that the said rock-shaft will be moved upward and then released after the motor has been running for a period of time greater than the longest opening of the circuit forming part of a normal message, and such upward movement will cause the relay to be energized, which in turn will throw the finger c^8 into engagement with the ratchet c^9, and thus after a short additional interval will raise the locks and stop the motor and thus bring the entire repeater to normal operative condition. This movement of the rock-shaft d is produced by a swinging yoke k, pivoted loosely on one of the arbors g^3 of the motor and acted upon by a spring k^2, (see Fig. 11,) tending to turn it in the opposite direction to that in which the arbor g^3 is turning. The said plate is provided with a pivoted finger k^3, adapted to engage an arm d^3 on the rock-shaft d, so that when moved by its spring k^2 from the position shown in Fig. 10 to that shown in Fig. 9 it will swing the arm d^3 quickly upward and then release it, such movement being sufficient, through the action of the arm d^2, to throw the switch h of any magnet that may be demagnetized, as will be understood from Figs. 2 and 7. The finger k^3 is brought to the position below the arm d^3 and the spring k^2 is strained or wound up the first time that the motor is set in operation during the transmission of a signal by means of a ratchet k^4, turned by one of the wheels, as g^4, of the motor-train or by said shaft g^3, as will be understood from Figs. 9 and 11, the said ratchet engaging a pawl k^5 on the yoke k, as shown in Fig. 9. The said ratchet k^4, which is represented in section in Fig. 11, in which the other parts are shown in front elevation, will the first time that the repeater is operated after the yoke k has come to the position shown in Fig. 9 carry the said yoke to the position shown in Fig. 10, in which movement a projection k^6 from the yoke passes a pawl m, that is pivoted on the stationary frame-work, and which then supports the said yoke against the action of its spring k^2 until the pawl m is tripped by means which will be hereinafter described. Just after the arm k^6 has passed by the pawl m and the latter has snapped back beneath the arm k^6 a projection k^7 from the pawl k^5 comes against a projection m^2 from the stationary frame-work, so that the further movement of the ratchet and swinging yoke turns the pawl k^5 out from engagement with the ratchet k^4, (shown in dotted lines in Fig. 10,) thus leaving the yoke k disengaged from the ratchet and supported wholly by the engagement of its arm k^6 with the pawl m, the plate k then remaining in the position shown in Fig. 10 until some one of the main-line circuits remain broken for a greater length of time than occurs in the normal transmission of a message, after which the said yoke will be released by the disengagement of the pawl m and will be swung around by the action of its spring, and thus operate the rock-shaft d to effect the restoration of the repeater to normal condition, as before described. The disengagement of the pawl m after such a period of time is effected by the following devices controlled by the shaft b, which, as before described, responds to changes of conditions of the main-line circuit. The said shaft b is provided with an arm N, having spring-fingers n that embrace a projection n^2 from a pawl n^3, pivoted on a plate n^4, which is mounted loosely on the shaft g^3 between the yoke k and the ratchet k^4, as shown in Figs. 10 and 11. When the shaft b is in the normal condition, as when the main circuits are all closed, the arm N causes a lateral projection N^5 of the pawl n^3 to be disengaged from a ratchet o, (shown in section, Fig. 11, and in full lines in Fig. 13,) and when the said shaft b is in abnormal position, as when any of the main-line circuits is opened, it causes the said projection n^5 to engage with the ratchet o, as shown in Fig. 13. The said ratchet o is also loose on the shaft g^3 and acted upon by a light spring o^2, tending to rotate the ratchet in the same direction that the shaft g^3 is turning, but yielding and being, as it were, wound up in case the said ratchet is restrained from turning, as by engagement of the pawl n^3, while the shaft g^3 is turning. The said shaft is arranged to have a limited movement only with relation to the shaft g^3, at the end of which movement it is positively engaged by said shaft or some part moving with it. As shown in this instance, the wheel g^4, to which the ratchet k^4 is attached, is provided with a recess g^5, (see Figs. 11 and 14,) into which a projection o^3 from the ratchet o extends. The plate n^4, upon which the pawl n^3 is pivoted, has a projecting portion n^5, that normally rests between the stationary projection m^2 and an arm m^3, connected with the pawl m, that supports the arm k^6, (see Figs. 10 and 12,) and the said pawl m affords a sufficient resistance to the movement of the plate m^4 to overcome the strength of the spring o^2, acting on the ratchet o, in case the said ratchet o is engaged by the shoulder n^5 of the pawl n^3. Thus any time that the shaft b is turned upon the breaking of one of the main circuits, so as to throw the pawl projection n^5 into engagement with the ratchet o, the said ratchet will merely be prevented from turning for a time, and if after a short interval the shaft b should be turned back again, as will happen in the normal operation, the pawl o will be released and its spring o^2 will throw it forward to the forward limit of the movement which it has independent of the shaft—that is, until the pin o^3 engages the shoulder at the forward end of the recess g^5 with relation to the direction in which the parts are moving. (Indicated by the arrow, Fig. 14.) If, however, the projection m^5 should remain in engagement with the pawl o for a considerable period of time—that is, somewhat greater than the longest break in the circuit forming part of the normal message—the pawl o would be restrained from turning, until finally the shoulder at the other end of the recesses g^5 would overtake the projection o^3, as shown in Fig. 14, after which the train of wheel-work would forcibly move the ratchet o and with sufficient power to turn the plate n^4, with the shaft, until its arm n^5, by acting on the arm m^3, would throw the pawl m from beneath the arm k^6 of the yoke k, which would then be moved suddenly by its spring k^2 from the position shown in Fig. 2 to that shown in Fig. 9 and in such movement would turn the rock-shaft d, and thus effect the restoration of the repeater to the normal condition, as before described. The said plate has a portion k^7 which at the end of said movement engages the pawl n^5, and thus positively disengages it from the ratchet o, as otherwise the frictional hold between the teeth of the ratchet and pawl might be too great for the spring-fingers m to overcome. The projection k^7 of the pawl k^5 also comes against a somewhat-yielding projection m^4 on the stationary frame-work and throws the pawl k^5 into engagement with the ratchet k^1 again (see Fig. 9) ready to cause the yoke to be set back to the position shown in Fig. 10, with its spring k^2 wound, upon the next operation of the repeater.

The distance between the shoulders at the end of the recess g^5, that determines the amount of movement that the ratchet o may have independently of the shaft, is such that the time of the motor in moving these shoulders through the distances between them is greater than the longest normal break in any of the circuits, so that in the normal operation the ratchet o will never be overtaken and positively engaged with the wheel-work, but will at each impulse of a message be released and moved by its spring o^2 to its forward position.

So far as the operation of the devices last described is concerned, it makes no difference in what manner the rock-shaft d or part moved by the yoke k effects the restoration of the repeater to its normal condition, and the invention so far as relates to said devices is not limited to that construction in which the said rock-shaft d operates a switch, as h, on the armature-lever of the magnet in the deranged circuit. A modification of the means by which the shaft d effects the restoration is represented in Fig. 8, in which the said shaft d is provided with an arm d^{20}, having a pin d^{21}, that engages an arm d^{22}, loose on said shaft d and standing at the rear of the main-circuit armature-lever a^2. In this construction the rotation of the shaft d moves the arm d^{22} from the full to the dotted line position, and in said movement the said arm pushes back the armature to its normal position, as shown in dotted lines, thus closing the local circuit of the relay at a^3, in case the relay construction is adopted, as shown in Figs. 2 and 15. If the circuit of the magnet remains open after its armature is restored by the arm d^{22}, as just described, said armature will remain pressing back against the said arm and by the frictional pressure against the end thereof will retain said arm in dotted-line position, Fig. 8, mechanically holding the armature in the position to close the local circuit of the relay. The armature-restoring arm d^{22} does not, however, carry the armature quite so far forward as it is carried by the attraction of the magnet, and consequently, although all the arms d^{22} are moved up when the restoring mechanism operates, only the one which engages and restores the armature will remain held up by the friction against said armature. The other armatures, being held by the magnetism, will not be touched by the arms d^{22}, which will fall back immediately after the restoring movement—that is, the oscillation of the shaft d—has taken place. The loose connection of the arms d^{22} with the shaft d permits any one to remain in dotted-line position, holding the armature of a magnet the circuit of which is broken in position to close the local circuit of the relay. It is not, however, essential to the operation of the other parts of the apparatus that a relay should be used. Instead of this construction, each main-circuit armature-lever a^2 might co-operate with an arm b^{20} (see Fig. 8) on the rock-shaft b, which would control the motor, the same as before, and would also be provided with the contact-carrier e^{10}, corresponding to the one e shown in Fig. 1, said contact-carrier controlling the contacts e^2 e^3 in the several main circuits, which will thus be opened and closed directly by each movement of the main-circuit armature a^2 that is responding to a message. The restoration last referred to following an abnormally-prolonged break in any main circuit might with this construction be effected mechanically, as shown in Fig. 7, by having the arm b^{20} engaged by the upwardly-projecting portion a^4 of the switch h, which no longer need perform the functions of an electric switch, but which in its normal position would engage with the projection b^{21} on the arm b^{20}, as shown in Fig. 8, causing the said arm to respond to each movement of the armature, but which when thrown to abnormal position by the action of the arm d^2, as shown in Fig. 7, would slip laterally away from the projection b^{21}, thus releasing the arm b^{20} and permitting the shaft b to be restored to its normal position by the action of its spring b^3, Fig. 1. It is also true that the lock-restoring mechanism—that is, the ratchet c^8, prop c^7, and parts operated thereby—does not depend for its operation on the specific construction of the lock or the part that controls the main-circuit armature. Two mechanical modifications of the said lock are represented in Figs. 3 and 4 and 5 and 6, respectively; but it is obvious that other modifications might be made, it being essential only that the parts operated by the ratchet c^8 and arm c^7, under control of the shaft b, should be such that when the said shaft b is moved the magnet which moved it should be retained under control of its external circuit, while the other magnets should be also out of control of their circuits external to the repeater, so that said circuits should be controlled wholly by the repeater until the first message was completed.

We claim—

1. The combination of a number of main-line electro-magnets, each in a main circuit independent of the others, with a lock-actuating bar and a number of locks connected therewith, one co-operating with the armature of each of said magnets, the said lock-actuating bar being controlled by each of said armatures, as described, the said locks being moved upon the retraction of any one of the said armatures and retaining all except the armature which was retracted in normal position for a predetermined period of time after said movement, at the end of which period said lock-actuating bar is moved and unlocks all the armatures, substantially as and for the purpose described.

2. The combination of a number of main-line electro-magnets, each in a main circuit independent of the others, with locks for the armatures of said magnets, connected to operate simultaneously, a motor and detent therefor, and lock support or prop adapted to be engaged with and disengaged from said motor and when so engaged to restore the locks to normal condition by its movement derived from said motor, and intermediate mechanism between said prop and the armatures, whereby said prop is disengaged from the motor when any armature moves from its normal condition and is engaged therewith when said armature returns to its normal position, substantially as described.

3. The combination of a number of main-line electro-magnets, each in a main circuit independent of the others, with locks for the armatures of the said magnets, connected to operate simultaneously, a motor and detent therefor, and lock support or prop adapted to be engaged with and disengaged from said motor and when so engaged to restore the locks to normal condition by its movement derived from said motor, and intermediate mechanism between said prop and the armatures, whereby said prop is disengaged from the motor when any armature moves from its normal position and is engaged therewith when said armature returns to its normal position, and a restorer controlled by said motor and armatures, as described, said restorer being called into action only after one of the armatures has remained in abnormal position a predetermined period of time and then operating to effect the engagement of the lock-prop with the motor, substantially as described.

4. The combination of a number of main-line electro-magnets, each in a main circuit independent of the others, and a series of circuit-breakers, one in each of said main circuits, and the entire series being controlled by the movement of any one of said armatures, with a second circuit-closer in multiple arc with each of said main-line-circuit closers controlled by said armatures, as described, being closed in that one only of said main circuits in which a signal is being transmitted from an external station, substantially as and for the purpose described.

5. The combination of a number of main-line magnets and locks co-operating therewith, as described, with the motor and ratchet operated thereby and the projection co-operating with said ratchet as described, to control the position of said locks, and being itself controlled as to engagement with said ratchet by any one of said magnets, substantially as described.

6. The combination of a number of main-line electro-magnets and locks co-operating therewith with a motor and detent therefor, as c^{10}, operatively connected with said locks, and a prop or support for said detent, as c^7, which when disengaged from said motor releases the detent therefor and throws the locks into operation, and intermediate mechanism between said prop and the armatures of the said magnets, whereby the said prop is disengaged from the motor when any armature is moved from its normal position and is engaged therewith when said armature returns to its normal position, substantially as described.

7. The combination of a number of main-line magnets and several circuit-closers in the several circuits thereof operated by any one of said magnets, as described, with the spring-actuated yoke k and its retaining pawl

or support m, the releasing-arm for said support, and ratchet and pawl for operating the same, the said ratchet having a limited movement independently of said motor, at the end of which movement it is positively engaged by said motor, and the engagement of said ratchet with its pawl being effected by any of said armatures when in abnormal position, substantially as described.

8. The combination of the clock-work or motor and spring impelled yoke k, and ratchet and pawl by which said yoke is moved against the stress of its spring, the holding pawl or detent for retaining said yoke, with its impelling-spring strained, a projection for disengaging the pawl from the ratchet when the yoke is so held, and the trip for disengaging the said detent from said yoke, substantially as and for the purpose described.

9. The combination of a number of main-circuit magnets in independent main circuits, with a relay and local circuit therefor, and circuit-breakers controlled by the several main-circuit magnets and arranged in series in said local circuit, as described, and independent circuit-closers in said local circuit at each main-circuit magnet, adapted to be operated to close said local circuit when the circuit breaker controlled by the corresponding magnet remains in abnormal position beyond a predetermined period of time, substantially as described.

10. The combination of a number of main-circuit magnets with a stationary projection c^4 at the rear of the several armature-levers thereof, a rock-shaft c, and locking device c^2, connected therewith and co-operating with said armature-levers and stationary projections, substantially as and for the purpose described.

11. The combination of a number of main-circuit magnets and armatures therefor and locks co-operating therewith, as described, with a rock-shaft c, connected with said locks, a motor and arm connected with said rock-shaft, and a prop for said arm operated by said motor, as described, the engagement of the prop with the motor being controlled by any one of said main-circuit magnets, substantially as described.

12. The combination of a number of main-line electro-magnets, each in the main circuit independent of the others, with a lock-actuating bar and a number of locks connected therewith for the armature of said magnets, said lock-actuating bar being controlled by each of said armatures, as described, operating all the locks simultaneously, and a number of independently-movable armature-restorers, as d^{22}, one corresponding to the armature of each of said magnets, and an actuator common to all said armature-restorers, substantially as described.

13. The combination of a number of main-circuit magnets and armatures therefor with a number of armature-restorers d^{22} and actuating rock-shaft d therefor, said restorers being loosely connected with said shaft and the latter having connected therewith parts that engage said restorers and move the same positively in the direction to engage any armature that may be retracted and move the same toward its attracted position, said restorer remaining in frictional engagement with the armature as long as the latter remains unattracted by the magnet, substantially as described.

In testimony whereof we have signed our names to this specification in the presence of two subscribing witnesses.

MOSES G. CRANE.
FREDERICK W. COLE.

Witnesses:
JOS. P. LIVERMORE,
M. E. HILL.