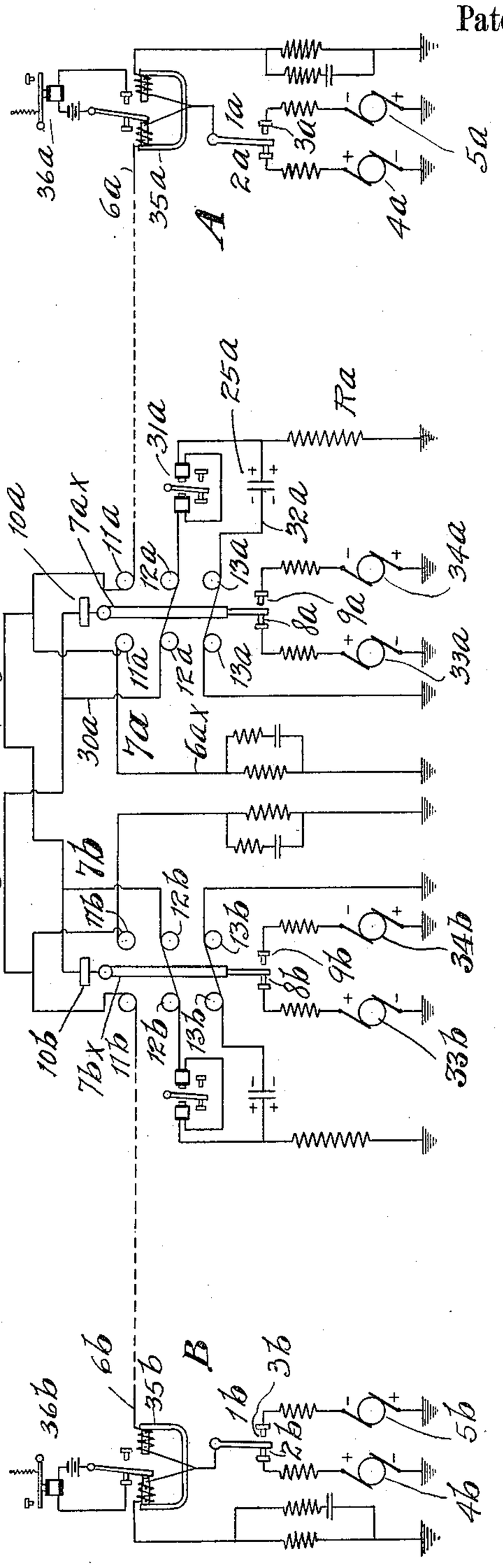
W. FINN.

TELEGRAPH REPEATER.

APPLICATION FILED JAN. 26, 1915.

1,160,097.

Patented Nov. 9, 1915.



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TELEGRAPH-REPEATER.

1,160,097. Specification of Letters Patent. Patented Nov. 9, 1915.

Application filed January 26, 1915. Serial No. 4,432.

To all whom it may concern:

Be it known that I, WILLIAM FINN, a citizen of the United States of America, and a resident of Bloomfield, in the county of Essex and State of New Jersey, have invented certain new and useful Improvements in Telegraph-Repeaters, of which the following is a specification.

My invention relates to improvements in telegraph repeaters.

In my application filed December 21, 1914, Serial No. 878,403, the repeater herein described is illustrated as arranged for operation in one direction only. In the accompanying drawing I show the said repeater arranged for operation in both directions.

The repeater herein described is particularly intended for high speed operation; for example, for use in connection with automatic telegraph systems wherein current impulses succeed each other through the line at rates far in excess of those of hand transmission. However, the repeater herein described is adapted for use on low speed circuits as well.

In high speed telegraph systems and other systems of electrical transmission and reception of signals, involving rapid current fluctuations, the speed of signaling is affected, and to some extent limited, by line conditions, such for example, as the mechanical and electrical inertia of the apparatus employed, also by what is known as the KR factor of the line (K representing the distributed electrostatic capacity of the line, and R the ohmic resistance of the line, it having been proved by extensive experiments that the length of time required for a current to reach its maximum strength at the distant end of the line varies directly as a product of the capacity K and the resistance R). These conditions prevent the recording of a signaling pulse at the receiving station until some appreciable time after that signaling pulse has started from the transmitting station.

Before a signaling impulse can actuate the ordinary main line magnetic signal receiving device, the main line current, and the magnetism created thereby in the main line signaling device, must necessarily rise to a value such as is required to effect transfer of the armature of that signal receiving device from one to the other of its contact stops. If the time interval here involved can be reduced in any way through the medium of local appliances, materially higher speed of transmission becomes possible together with better signals.

Heretofore repeaters have always, in their operation, lagged slightly behind the operation of the corresponding transmitters. In the operation of the repeater herein described there is no such lag; the repeater begins to operate the instant the corresponding transmitter begins to operate, and in general the repeater will have completed its operation before the transmitter has completed the corresponding operation. Thereby the lagging effect of the former repeaters is entirely overcome. It is obvious that the avoidance of this lag very greatly quickens the operation of the circuits comprising repeaters.

In the repeater herein described the armature of each repeating relay is carried over very positively from one stop to the other once that armature has been started in motion; the completion of such movement of the armature from the one contact stop of the other being assured, even though the impulse which started such movement terminate before the conclusion of such movement.

The movement of the armature is started, by local means, upon the diminution of the main line current which previously held that armature stationary against one or the other of its stops, and thereby the armature is caused to anticipate, in its operation, the arrival of the next succeeding line signaling impulse. Thereby all lag in the operation of the repeater is avoided.

In a broad sense, the invention involved in this repeater is also involved in the relay described and claimed in my said application Serial No. 878,403, and therefore the invention claimed herein is necessarily limited to those features which distinguish the

repeater herein illustrated and described from the relay claimed in my said companion application.

My invention consists in the combination with incoming and outgoing lines, of a polar repeating relay or relays comprising, in addition to the main circuit magnet coils, opposing magnet coils located in a leak circuit derived from the outgoing line, and means for reversing the action of the opposing coils; also in such a combination, the additional element of accelerating coils; and other features, all as hereinafter described and particularly pointed out in the appended claims.

The objects of my invention are to increase the effective speed of transmission over telegraph circuits employing repeaters, to avoid lag in repetition of signals, to obtain improved and sharper signals, particularly on high speed lines, to avoid the disturbing effects of induction and other influences tending to produce false signals, and to make the apparatus very simple indeed, and easy of construction and operation, and free from liability of derangement.

I will now proceed to describe my invention with reference to the accompanying drawing which is a diagram showing a telegraph circuit including my improved repeater.

In the drawing A and B designate transmitting stations, and numerals 1^a and 1^b designate transmitting keys having contact stops 2^a and 3^a, 2^b and 3^b respectively, and current supply means 4^a and 5^a, 4^b and 5^b, connected to stops 2^a and 3^a, 2^b and 3^b, respectively. The particular current supply means indicated are dynamo electric machines of opposite polarities, though as is well understood other sources of current supply may be employed; the particular arrangement shown being a common arrangement for transmission by current impulses of alternately opposite direction. The keys 1^a and 1^b may be vibrated either by hand or by any suitable means; and I do not limit myself to any particular means for vibrating said keys in accordance with telegraphic or other signals. The keys may be, for example, the movable contact arms of Wheatstone transmitters, or any other suitable type of automatic or machine transmitter.

6^a and 6^b designate the line conductors leading from stations A and B respectively to the repeater station C.

7^a and 7^b designate, respectively, repeating relays, 7^a being controlled by key 1^a and arranged to transmit into line 6^b, 7^b being controlled by key 1^b and arranged to transmit into line 6^a. Each repeating relay is of the nature of a polar relay having a polarized armature, 7^{ax} or 7^{bx}, playing between contact stops 8^a and 9^a or 8^b and 9^b respectively. These armature levers may be understood to be magnetized levers, similar to the magnetized armature levers employed in the so-called "polar" relays, and the rectangles 10^a and 10^b may be understood to represent, each, one pole of a magnet energizing the adjacent armature lever. The two repeating relays are entirely similar, and therefore the circuits of one only will be described. On opposite sides of the lever 7^{ax} are electro-magnets 11^a—11^a, 12^a—12^a and 13^a—13^a, each pair of magnet spools arranged to influence the lever 7^{ax} just as the magnet spools of an ordinary polar relay actuate the armature of such relay.

While I have shown the spools 11^a, 12^a and 13^a, as separate spools, for clearness of diagrammatic illustration, it will be understood that in practice only one pair of spools may, and commonly will, be employed, such spools each having three different windings corresponding to the windings 11^a, 12^a and 13^a. It is not uncommon, in polar relays, to provide each spool with two or more separate windings; but it is common for clearness of illustration to indicate such separate windings in diagrammatic drawings, as if such separate windings were on different spools.

The coils 11^a and 11^b I term "main line coils"; the coils 12^a and 12^b I term "opposing coils"; and the coils 13^a and 13^b I term "accelerating coils". The connections of relays 7^a and 7^b to the several circuits are similar, and therefore, in general only the connections of relay 7^a will be described.

Line conductor 6^a is connected to one spool 11^a, and thence to the other spool 11^a, and thence to artificial line 6^{ax}. From between the connections of the line 6^a and artificial line 6^{ax} to the main line coils 11^a, a branch conductor 6^{ay} leads to the armature 7^{bx} of repeater relay 7^b. Opposing coils 12^a are located in a leak circuit or derived circuit 30^a leading from the corresponding conductor 6^{by} through coils 12^a, and through the coils of a so-called "leak" relay 31^a to ground; such circuit 30^a containing a resistance R^a, and a condenser 25^a is bridged across the terminals of resistance R^a in a circuit 32^a passing through "accelerating" coils 13^a. To the contact stops 8^a and 9^a of repeating relay 7^a are connected sources of current supply 33^a and 34^a, having opposite poles connected to said stops. The particular function of the opposing windings or coils 12^a is to develop a polarity of magnetism that shall always be opposed to the magnetism created by the main line coils 11^a, the magnetism created by the opposing coils 12^a not being so strong, however, as that created by the working current of the main line 6^a in coils 11^a. The particular function of the accelerating coils 13^a, is, to carry the armature 7^{ax} across the gap between stops 8^a

and 9^a once the armature lever 7^{ax} has been set in motion as hereinafter described.

At the two stations A and B I have shown the usual receiving relays 35^a and 35^b and the usual sounders 36^a and 36^b. Differentially wound relays 35^a and 35^b are shown, the system shown being, therefore, adapted for simultaneous operation in both directions.

It will be apparent that with the transmitting key 1^a in the position shown, and the current from generator 4^a through that key and through main line coils 11^a of repeater 7^a holding the arrangement 7^{ax} of that repeater against stop 8^a, there will be current from the positive pole of generator 33^a through stop 8^a and the armature 7^{ax} and line 6^{by} through the two spools 11^b of repeater 7^b in parallel, and thence through main line 6^b and artificial line 6^{bx} to ground; which current, of course, will not affect repeating relay 7^b, but will affect line relay 35^b and sounder 36^b at station B; and from the line 6^{by} there will be a leak current through conductor 30^a and "opposing" coils 12^a, such leak current energizing the coils 12^a to tend to move the armature 7^{ax} to the right, though no such movement takes place while key 1^a is in the position shown. But the instant that key 1^a is moved to the right, breaking the current from generator 4^a, the leak current from generator 33^a through circuit 30^a will start the armature 7^{ax} of instrument 7^a to the right; and while the current in the leak circuit will immediately cease upon the starting of that movement of the armatures 7^{ax}, condenser 25^a will discharge through accelerating coils 13^a, so carrying the armature 7^{ax} over to the right. This movement of the armature of the instrument 7^a will probably be completed before key 1 has made contact with stop 3^a and before the next signaling impulse in line 6^a from generator 5^a has been established. Upon the establishment of the next signaling impulse, viz:—that from generator 5, coils 11^a will be energized, holding the armature of relay 7^a to the right; and the current from generator 34^a having already been established through stop 9^a, and armature 7^{ax} and line conductors 6^{by}, 6^b and 6^{bx}, there will be a current through the leak circuit 30^a and "opposing" coils 12^a tending to move the armature of relay 7^a to the left; such tendency, however, being weaker than the tendency of the main line coils 11^a to hold the armature to the right. Condenser 25^a will recharge and upon the beginning of the next movement of transmitter key 1^a to the left, the "opposing" coils 12^a will start the armature 7^{ax} toward the left, such armature being carried over against stop 8^a by the discharge of condenser 25^a through circuit 32^a and accelerating coils 13^a.

It will thus be seen that the repeating relay 7^a will repeat into line 6^b the signals received from line 6^a. It will also be apparent that the leak relay 31^a will operate in accordance with the signals transmitted as described through conductor 6^{by} and that this relay 31^a may operate local signal receiving, or signal repeating, or translating, apparatus, or may itself be a sounder.

It will further be understood that the relay 7^b will repeat, in like manner, signals received from circuit 6^b, into circuit 6^a. Because, during their movements, the armatures 7^{ax} and 7^{bx} are under the influence of their respective accelerating coils during their movements, the relays 7^a and 7^b are practically free from disturbance due to inductive interference and the like. Because the armatures of these instruments start to move, in correspondence with any movement of the corresponding transmitter, the instant that transmitter begins to move, lag in the operation of these instruments is entirely avoided and thereby the defects are in large measure eliminated and the operation of the circuit is very greatly quickened. In practical applications of these instruments to automatic Wheatstone circuits, the speed of these circuits has been increased by more than 100% of what was attainable under the ordinary method of working. These instruments are highly sensitive to weak signaling impulses, and are also relatively insensitive to extraneous disturbing influences, and, therefore, can be operated successfully over longer lines than former instruments for the same service, and can be operated at higher than the usual rates of speed.

What I claim is:—

1. In a telegraph repeater, the combination with incoming and outgoing lines, of a polar repeating relay comprising a movable armature, main-circuit electro - magnetic means connected to the incoming circuit and controlling said armature, other opposing electro-magnetic means, normally opposing, as to such armature, but exerting an influence weaker than, the influence of said main-circuit electro-magnetic means, upon said armature, said opposing electro - magnetic means located in a leak circuit derived from the outgoing line, and automatic means for reversing the action of such opposing means upon the armature upon the completion of movement of the armature in either direction.

2. In a telegraph repeater, the combination with incoming and outgoing lines, of a polar repeating relay comprising a movable armature, main-circuit electro-magnetic means connected to the incoming circuit and controlling said armature, other opposing electro-magnetic means, normally opposing, as to such armature, but exerting an influence weaker than, the influence of said main-circuit electro-magnetic means, upon said arma-

ture, said opposing electro-magnetic means located in a leak circuit derived from the outgoing line, means for terminating the influence of such opposing means upon the beginning of movement of the armature, and accelerating means arranged to influence the armature in the same sense in which that armature was previously influenced by such opposing means and arranged to begin to influence such armature when the opposing means ceases to influence such armature.

3. In a telegraph repeater, the combination with incoming and outgoing lines, of a polar repeating relay comprising a movable armature, main-circuit electro-magnetic means connected to the incoming circuit and controlling said armature, other opposing electro-magnetic means, normally opposing, as to such armature, but exerting an influence weaker than, the influence of said main-circuit electro-magnetic means, upon said armature, said opposing electro-magnetic means located in a leak circuit derived from the outgoing line, automatic means for reversing the action of such opposing means upon the armature upon the completion of movement of the armature in either direction, and accelerating means arranged to influence the armature in the same sense in which that armature was previously influenced by such opposing means and arranged to begin to influence such armature when the armature begins to move.

4. In a telegraph repeater, the combination with incoming and outgoing lines, of a polar repeating relay comprising a movable armature, main-circuit electro-magnetic means connected to the incoming circuit and controlling said armature, other opposing electro-magnetic means, normally opposing, as to such armature, but exerting an influence weaker than, the influence of said main-circuit electro-magnetic means, upon said armature, said opposing electro-magnetic means located in a leak circuit derived from the outgoing line, automatic means for reversing the action of such opposing means upon the armature upon the completion of movement of the armature in either direction, said circuit including resistance, and accelerating means arranged when the armature begins to move, to influence said armature to carry it across to the opposite side, such accelerating means comprising electro-magnetic means, and a circuit therefor, including capacity and bridged across the resistance in said leak circuit.

5. In a telegraph repeater, the combination with two main and corresponding artificial lines, of two polar repeating-relays each corresponding to one of the said main lines and arranged to repeat into the other of said main lines, and each comprising a movable armature, main circuit electro-magnetic means connected to the corresponding main line and controlling said armature, other opposing electro-magnetic means, normally opposing, as to such armature, but exerting an influence weaker than, the influence of said main-circuit electro-magnet means, upon such armature, said opposing electro-magnetic means of each said relay located in a leak circuit derived from what is, as to that relay, the outgoing line, and automatic means for reversing the action of such opposing means upon the armature upon the completion of movement of the armature in either direction.

6. In a telegraph repeater, the combination with two main and corresponding artificial lines, of two polar repeating-relays each corresponding to one of said main lines and arranged to repeat into the other of said main lines, and each comprising a movable armature, main circuit electro-magnetic means connected to the corresponding main line and controlling said armature, other opposing electro-magnetic means, normally opposing, as to such armature, but exerting an influence weaker than, the influence of said main-circuit electro-magnet means, upon such armature, said opposing electro-magnetic means of each said relay located in a leak circuit derived from what is, as to that relay, the outgoing line, and automatic means for reversing the action of such opposing means upon the armature upon the completion of movement of the armature in either direction, the leak circuit of each such relay including resistance, and each such relay comprising, further, accelerating means arranged to influence the armature in the same sense in which it was previously influenced by the opposing means of that relay and arranged to begin such influence when such armature begins to move.

7. In a telegraph repeater, the combination with two main and corresponding artificial lines, of two polar repeating-relays each corresponding to one of said main lines and arranged to each repeat into the other of said main lines, and each comprising a movable armature, main circuit electro-magnetic means connected to the corresponding main line and controlling said armature, other opposing electro-magnetic means, normally opposing, as to such armature, but exerting an influence weaker than, the influence of said main-circuit electro-magnet means, upon such armature, said opposing electro-magnetic means of each said relay located in a leak circuit derived from what is, as to that relay, the outgoing line, and automatic means for reversing the action of such opposing means upon the armature upon the completion of movement of the armature in either direction, the leak circuit of each such relay including resistance, and

each such relay comprising, further, accelerating means arranged to influence the armature in the same sense in which it was previously influenced by the opposing means of that relay, and comprising capacity bridged across the said resistance of the leak circuit.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

WILLIAM FINN.

Witnesses:
H. M. MARBLE,
PAUL H. FRANKE.

Disclaimer in Letters Patent No. 1,160,097

DISCLAIMER.

1,160,097.—*William Finn*, Bloomfield, N. J. TELEGRAPH-REPEATER. Patent dated November 9, 1915. Disclaimer filed October 19, 1916, by *The Western Union Telegraph Company*, assignee.

Enters this disclaimer—

"As to claims 1, 2, and 3 in said specification, which are in the following words, to wit:

"1. In a telegraph repeater, the combination with incoming and outgoing lines, of a polar repeating relay comprising a movable armature, main-circuit electro-magnetic means connected to the incoming circuit and controlling said armature, other opposing electro-magnetic means, normally opposing, as to such armature, but exerting an influence weaker than, the influence of said main-circuit electro-magnetic means, upon said armature, said opposing electro-magnetic means located in a leak circuit derived from the outgoing line, and automatic means for reversing the action of such opposing means upon the armature upon the completion of movement of the armature in either direction.

"2. In a telegraph repeater, the combination with incoming and outgoing lines, of a polar repeating relay comprising a movable armature, main-circuit electro-magnetic means connected to the incoming circuit and controlling said armature, other opposing electro-magnetic means, normally opposing, as to such armature, but exerting an influence weaker than, the influence of said main-circuit electro-magnetic means, upon said armature, said opposing electro-magnetic means located in a leak circuit derived from the outgoing line, means for terminating the influence of such opposing means, upon the beginning of movement of the armature, and accelerating means arranged to influence the armature in the same sense in which that armature was previously influenced by such opposing means and arranged to begin to influence such armature when the opposing means ceases to influence such armature.

"3. In a telegraph repeater, the combination with incoming and outgoing lines, of a polar repeating relay comprising a movable armature, main-circuit electro-magnetic means connected to the incoming circuit and controlling said armature, other opposing electro-magnetic means, normally opposing, as to such armature, but exerting an influence weaker than, the influence of said main-circuit electro-magnetic means, upon said armature, said opposing electro-magnetic means located in a leak circuit derived from the outgoing line, automatic means for reversing the action of such opposing means upon the armature upon the completion of movement of the armature in either direction, and accelerating means arranged to influence the armature in the same sense in which that armature was previously influenced by such opposing means and arranged to begin to influence such armature when the armature begins to move."

[*Official Gazette, October 24, 1916.*]