(No Model.) 3 Sheets—Sheet 1.

W. F. GARDNER.

ELECTRIC TIME SYSTEM.

No. 490,744. Patented Jan. 31, 1893.

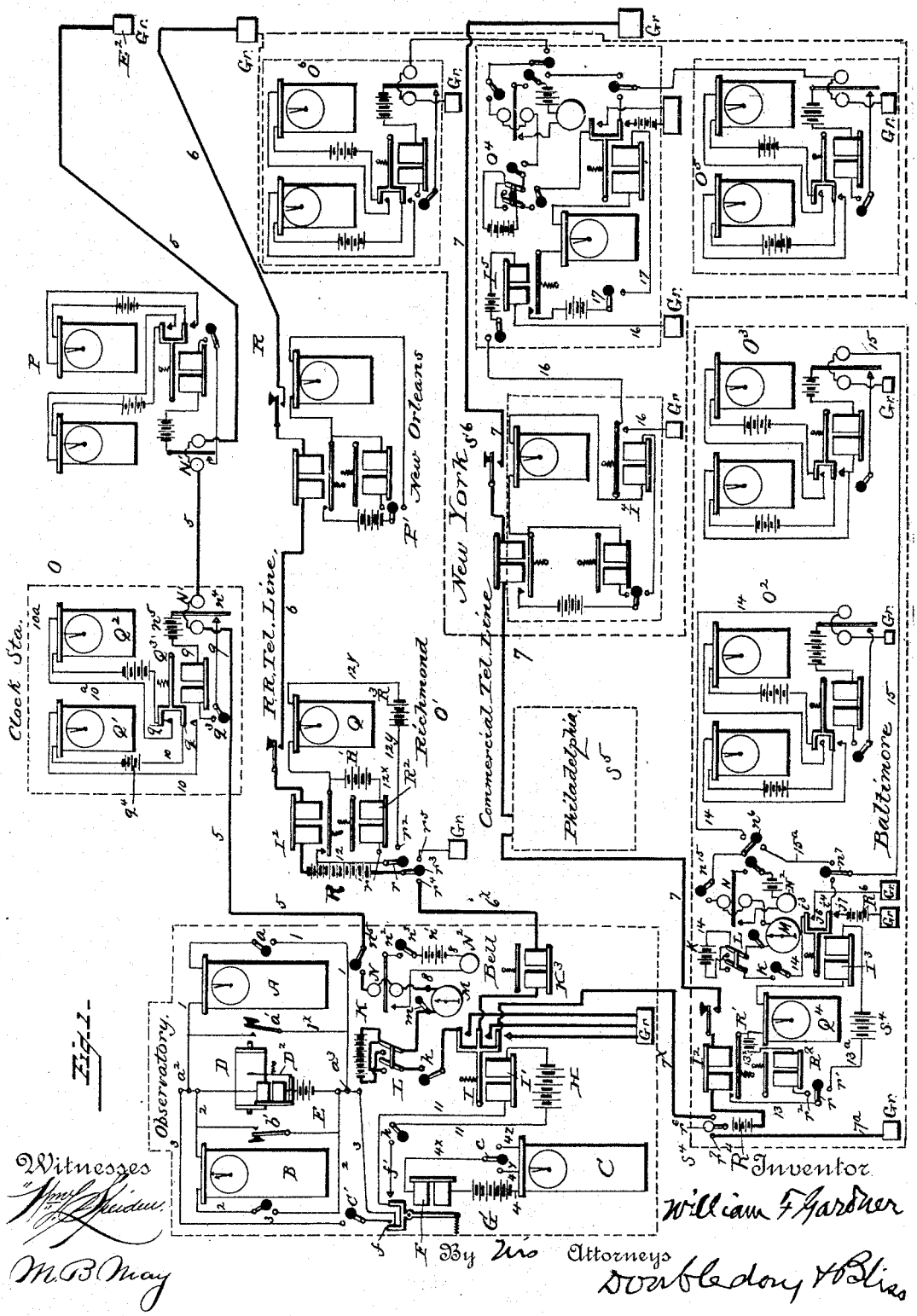

Fig. 1.

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W. F. GARDNER.

ELECTRIC TIME SYSTEM.

No. 490,744. Patented Jan. 31, 1893.

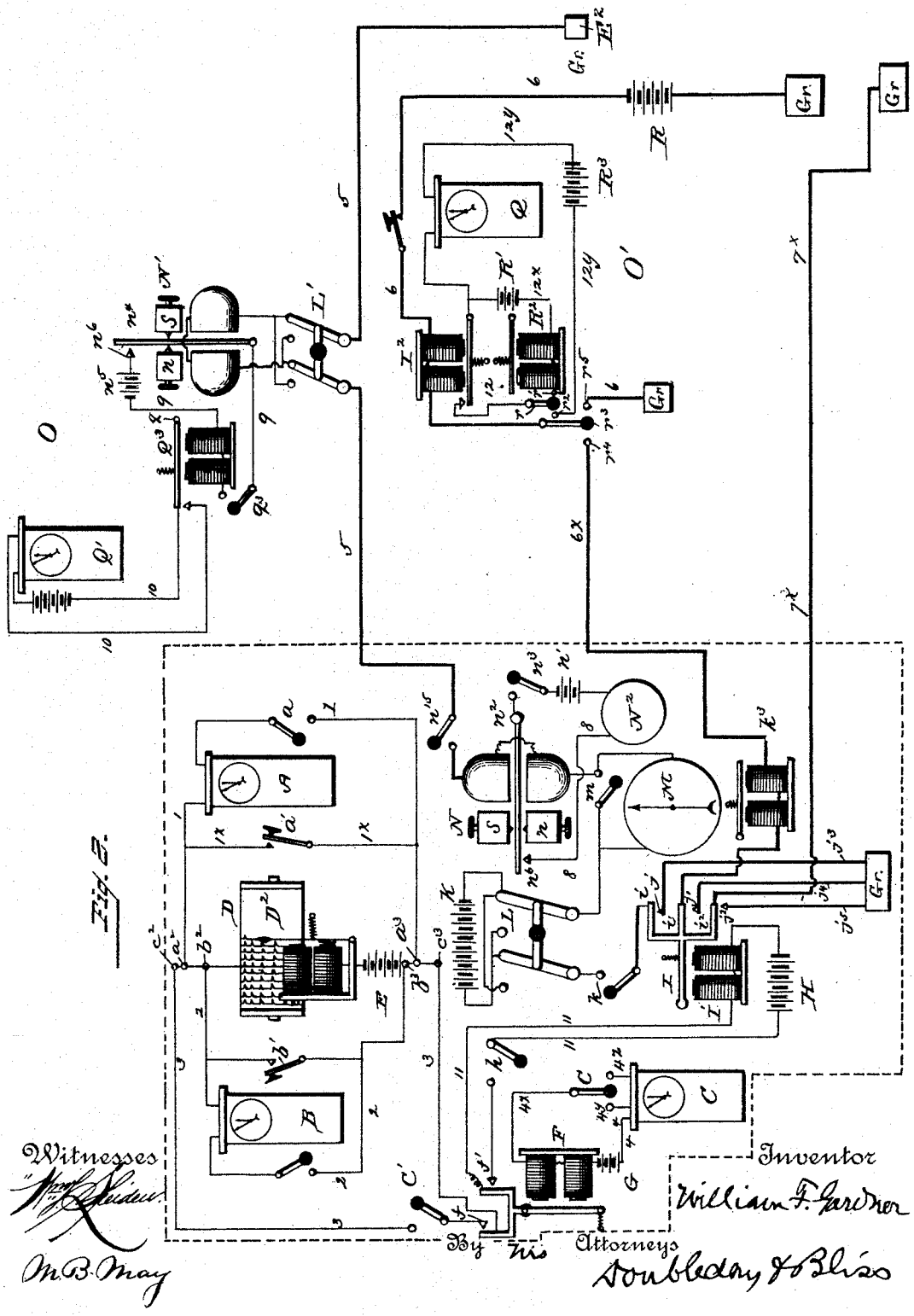

Fig. 2.

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(No Model.) 3 Sheets—Sheet 3.

W. F. GARDNER.

ELECTRIC TIME SYSTEM.

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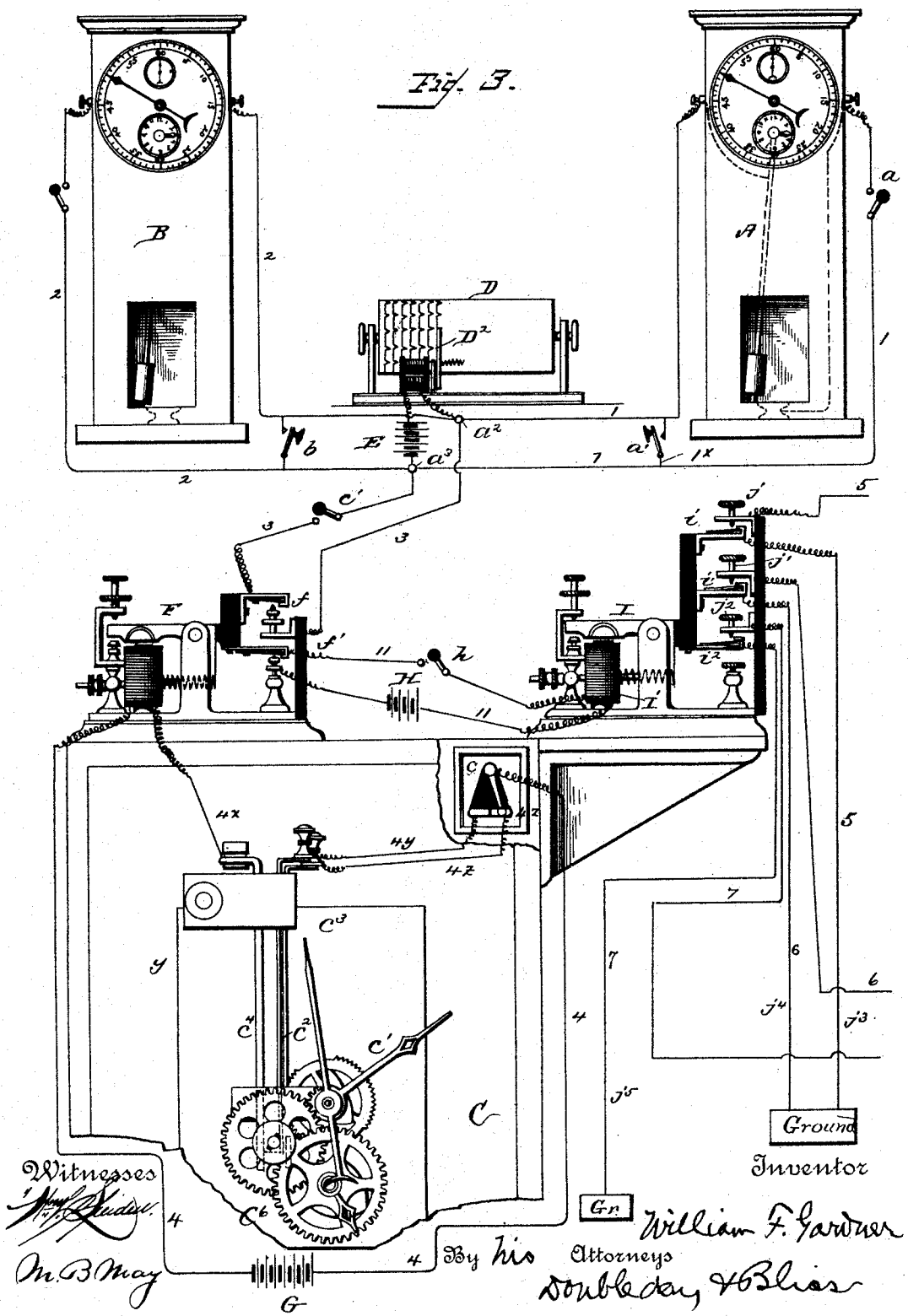

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UNITED STATES PATENT OFFICE.

WILLIAM F. GARDNER, OF WASHINGTON, DISTRICT OF COLUMBIA.

ELECTRIC TIME SYSTEM.

SPECIFICATION forming part of Letters Patent No. 490,744, dated January 31, 1893.

Original application filed December 13, 1888, Serial No. 293,452. Divided and this application filed September 4, 1891. Serial No. 404,760. (No model.) Patented in France December 10, 1889, No. 201,080.

To all whom it may concern:

Be it known that I, WILLIAM F. GARDNER, a citizen of the United States, residing at Washington, in the District of Columbia, have invented certain new and useful Improvements in Time Systems, (for which Letters Patent were granted me in France on the 10th day of December, 1889, No. 201,080,) of which the following is a specification, reference being had therein to the accompanying drawings.

In the accompanying drawings I illustrate one of the forms of apparatus that can be used to carry out the present invention, which relates to improvements in the art of transmitting and receiving time-signals, and in the method of operating and testing the electric circuits of a time system. The claims relating to the apparatus I have presented in other applications, towit; Serial No. 377,024, filed January 7, 1891, and Serial No. 293,452, filed December 13, 1888, and of which latter the present application is a division.

Figure 1, is a diagrammatic view showing an observatory or central transmitting station and some of the parts included in outside stations. Fig. 2, is a similar view showing somewhat more extensively some of the ways of applying my improved system. Fig. 3, is a diagrammatic view of the transmitting mechanism.

First, referring to what I herein term the observatory station, I have represented in Figs. 1, 2 as forming parts thereof an astronomical clock at A, a mean time clock at B, a transmitting clock at C, and a chronograph at D, in connection with various electrical circuits, as at 1, 1,—2, 2, 2—3, 3,— and 4, 4^x, 4^y 4^z. The first three being operated by a common battery at E, and the latter by a battery at G.

The astronomical clock A is in circuit with a marking instrument of the chronograph by means of the parts 1, 1, 1, there being a switch at a, and binding posts at a^2, a^3, together with the key a' in a cross circuit 1^x, adapted to short circuit or cut out the clock A. The switch a being closed, it will be seen that the impulses from the clock A will be transmitted to the chronograph in an obvious manner.

The mean time clock B is, by means of the circuit 2, 2, also connected with the marking instrument, of the chronograph, there being a cut out or short circuit key at b'. The wires of the circuit 2, 2, 2, are fastened to the binding posts b^2, b^3. Clock B being in operation its impulses will be indicated by the marking instruments at D^2 of the chronograph. Both the clocks A and B being in operation their impulses will be indicated at the same point. If their impulses are synchronous, but one mark will be made for each impulse, but if they are not, each clock will exhibit its indications separately from those of the other, and in this way, a comparison can be readily made.

The transmitting clock C contains mechanism substantially similar to that shown and described in my earlier patent No. 287,015, dated October 23, 1883, said mechanism comprising two sets of devices for making and breaking an electric circuit, one set having in circuit the parts 4, 4^x, 4^y, and the other having the parts 4, 4^x, and 4^z, there being a common battery G, and a repeater F. The first set of make and break devices is utilized to transmit certain predetermined impulses or preliminary time signals, and the second set transmits a final signal, or electric impulse, such as I employ for synchronizing clocks at a distance from the transmitting clock C, all of which will be fully understood by a reference to the aforesaid patent. But I do not wish the present invention to be in all respects limited to devices exactly similar to those in that patent.

By turning the switch c, to the left, a current from battery G passes through the circuit having parts 4, 4^x, 4^y and through the repeater to the preliminary signaling devices; by turning it to the right it passes through the circuit having the parts 4, 4^x, 4^z, and the signaling or synchronizing or controlling device.

The repeater F has two points ff'. The point f is adapted to close the above mentioned circuit 3, 3, 3, through the battery E, it being a circuit also including the marking instrument of the chronograph at D, and having the terminals of the wires secured to the binding posts c^2, c^3. If the switch c be closed, the impulse of the transmitting clock C will be indicated by the motion of the repeater lever at

F closing the contact at f, and if the switch at c' be closed the said impulse of the transmitting clock will be also indicated by the marking instrument at D^2. By means of the devices arranged in this way, or one substantially similar thereto, it will be seen that an accurate visual comparison can be made between the clocks A, B, and C, two or more. Ordinarily in practice, a comparison is first made of the clocks A, B, the astronomical clock and the mean time clock, for the purpose of ascertaining the error of the latter, at the time of the comparison, the mean time clock being allowed to remain unchanged or uncorrected although its daily or other variations are carefully noted. Then, after the comparison of these has been completed, by means of the chronograph, the mean time clock and the transmitting clock C are similarly compared, the circuit 2, 2, 2, being closed for the one and the circuits 3, 3, 3, and 4, 4^x, 4^y, for the other. If, as a result of said comparison it is ascertained that the transmitting clock C is slightly out of true time, it is accelerated to such an extent as to advance it to the proper point, it and the mean time clock B still remaining in circuit with the chronograph, which latter indicates the acceleration. On the other hand if the clock C is too fast, it is retarded until the chronograph indicates that it is at the proper point in relation to the mean time clock B.

Suppose that the transmitting clock C has been so changed as to indicate absolutely correct time, I will describe the manner of transmitting by it, electric impulses which can be utilized to convey a program of signals or to control, regulate or synchronize distant clocks. The point at f', of the repeater F, above referred to, is in a circuit 11, 11, with a local battery at H, there being in this circuit 11, an electric magnet I', of a multiple pointed repeater I. At h, there is a switch whereby this local circuit 11, can be opened and closed as desired. The repeater at I, can be provided with as many points as there are main lines from which it is desired to transmit the impulses for signaling, correcting, synchronizing or other purposes. As shown, the repeater has three contact arms, i, i', i^2, see Fig. 2, with three contact points j, j', j^2. Each has an earth connection j^3, j^4, j^5, and is or may be connected by branches to a main line circuit, one indicated by 5, 5, 5, another by 6, 6, 6^x, and a third by 7, 7, 7^x.

For the purpose of illustrating and describing some of the various uses to which the invention can be applied, let it be supposed that the circuit 5, 5, 5, is one extending out from the observatory station for the sole purpose of operating, controlling, regulating or synchronizing clocks, or for transmitting time signals; that the circuit 6, 6, 6^x, extends out from the said station for the purpose of transmitting signals along the line of one or more railways, and for operating, controlling, or synchronizing the clocks thereon; and that the circuit 7, 7, 7^x, extends out from the signals and for regulating and controlling clocks along the line of a telegraph company extending to different points, at each of which it is desired to take from the main line, the signals or correcting or synchronizing impulses. As just said, the main line or circuit 6, 6, 6^x, is indicated as passing out from the observatory station to a series of railroad stations. The latter are generally indicated in Fig. 1, by O' P', there being for this circuit a battery at R, at some point distant from the observatory station. That is to say, the circuit 6, 6, may be regarded as one of the main telegraph lines now in use by railroads. It is provided with one or more switches such as at r^3, by which the main line can be connected to the ground as at r^5, outside of the observatory, or can be connected as at r^4, to an observatory branch 6^x. As aforesaid, the said branch is in the observatory station connected to the arm i', of the repeater I, the corresponding contact j', running to earth. This line 6, 6, 6^x, at the railroad station O', passes through the electro-magnet of a main line relay at I^2, adapted to close one or more local circuits. In Fig. 1 a circuit is shown having two loops, one at 12, 12^x, including battery R', and sounder R^2, and the other at 12, 12^y, including battery R^3, and clock Q, both including the switch r, and the armature of relay I^2. When switch r, is at r', the circuit through the sounder is closed and the clock cut out; when at r^2, the clock is in circuit and the sounder cut out. As generally, a relatively low electro-motive force is required to operate the sounder, the battery R', is made weaker than the battery R^3, the latter having a higher electro-motive force for the purpose of powerfully affecting the time signaling apparatus and also if desired, opening and closing secondary local circuits. At the station P', there is an arrangement of apparatus similar to that at O', and of such stations, there may be as many as may be desired. Now at a predetermined time, say three or four minutes before it is expected to receive the time signal or the program of signals or a clock controlling or other impulse from the observatory station, the operator in the station at O', moves the switch r^3, from point r^5, to point r^4. At the proper time thereafter, the operator in the observatory places the switch c, on point 4^y in the preliminary signal circuit of transmitting clock C, and the preliminary signal impulses are, through repeater F, felt in circuit 11, through the repeater I, in circuit 6, 6^x, and through the repeater I', in circuit 12, 12^x, where they are indicated to the operator by the sounder R^2, switch r, being at this time on the point r'. After the preliminary signal or signals have been transmitted, the operator in the observatory moves switch c, to the point at 4^z, and the operator at station O', moves the switch r, to point r^2, whereby the mechanism in the observatory is adjusted to send out the

final impulse and the circuit at the station is arranged to pass its impulse through the clock Q, the sounder being cut out. After switches c, and r, are thus adjusted, the next electric impulse caused through the last described series of circuits, results in setting the hands of the clock at Q to the predetermined point, it being for the present supposed that this clock is adapted for this purpose. Simultaneously, the clocks at station at P, and all others along the railway telegraph line are effected similarly, the various operators adjusting properly their switches r. After the final signaling or the synchronizing has been accomplished, the switch at r, is moved to point r', and that at r^3, to point r^5, whereupon the telegraph line is in a normal condition for ordinary work.

In the observatory, there is an indicator at K^3, in circuit 6, 6, which manifests to the attendant there, whether or not the line is receiving the signals sent out.

Referring now to the circuit 5, 5, 5, which, as above said, is intended solely for time signaling, or for actuating or regulating clocks directly from the observatory or transmitting station, it will be seen that said circuit either actually or possibly includes the earth connection j^3, contacts j, i, switch at k, and pole changing switch at L, and battery K, a galvanometer M, and polarized relay N, and a switch at n^{15}, all within the observatory or central transmitting station, and then the out-going line wire 5, 5, extending to the substations O, and P, &c., there being at each of the latter, a polarized relay N', the stations being indefinite in number, and the main line ultimately terminating in earth as shown at E^2. The switch at m, cuts out or in the galvanometer M. The polarized relay N, opens or closes a circuit 8, 8, including a small battery at n', a switch n^3, armature n^2, and a bell, clock or indicator N^2. At each of the distant stations O, P, &c., I prefer to have substantially the same apparatus. The armature n^4, of the polarized relay N', closes local circuits 9, 9, having battery n^5, magnet of repeater Q^3, and switch q^3. Arms q, of repeater Q^3, close the circuits 10, 10, 10^a, &c., each including a signaling or clock controlling, actuating or synchronizing mechanism. The clocks adapted to be synchronized are shown at Q', Q^2, each with its independent circuit, but there may be variation both as to the signal receiving devices and as to the number in a circuit.

Now if it be supposed that the switches h, k, n^{15}, q^3, are all closed, it will be seen that an impulse in circuit 4, 4^x, 4^z will, (through repeaters F, I, N', and Q^3) be experienced in circuits 10, 10^a, which can be indicated by signal receiving apparatus, or utilized to synchronize or otherwise to test the clocks Q', Q^2. When a circuit of the character of this at 5, 5, and its indicating devices, are connected with such a clock as that at Q', the switch k, is not closed until after the preliminary signals have been given (in cases where they are employed). But as soon as the switch c, is moved to the contact at 4^z, the switch k is closed so that the final impulse in the circuit 4, 4^x, 4^z, is experienced in the outgoing circuit 5, 5. When so arranged, and switch k is open it is impossible to impart to the clocks Q', Q^2, accidental impulses.

Still referring to the circuit 5, 5, and the parts therein, I will describe the method I have devised for testing. Experience shows that it is frequently necessary to test a circuit such as this, for the purpose of ascertaining whether there is any undue leakage, or a complete break, and also to locate a place of leakage or break if one is found to exist.

I prefer to locate the principal portion of the essential parts of the testing apparatus in the observatory or signal-transmitting station, but that is not necessary. Referring to Figs. 1 and 2, it will be seen that the "four-point" or pole-changing switch L is in such position as to turn a positive or direct current from battery K to line. Under such circumstances, the armatures n^2, n^4, of the polarized repeaters or relays N, N', are drawn toward the north poles n of the permanent magnets constituting part of the said repeaters, and the armatures n^4 at the distant stations are brought against the contacts which close the local circuits 9, 9. That is to say, when a direct current is thrown to line 5, 5, from battery K, the clock circuits will be closed; and this is the case when the parts are being operated from the transmitting clock C in the way above described.

At some time when the line 5, 5, is idle, the testing is accomplished as follows. First, the pole changing switch L is shifted, throwing a reverse current to line. This instantly throws the armature levers n^2 n^4 toward the south poles s of the permanent magnets, and away from the contacts that close the clock circuits, so that the latter will not be affected. Then the switch m is opened, which throws the galvanometer M into circuit. If the latter indicates the normal amount of resistance, it may ordinarily be presumed that the circuit is in working order. But if from these indications or from any other source of knowledge, a leakage or break should be found to exist, the place can be ascertained as follows. At one of the series of stations O, P, &c, the switch q^3 is opened preventing any liability of the clocks at that station being affected by the following manipulation. Then at that station, the terminals of the electromagnet of the polarized relay are reversed, either by changing the wires in the binding posts, or by a reversing switch as at L', Fig. 2. The result of this is to draw the armature n^4 toward the north pole of the permanent magnet, that is, draw it in the same direction that it is drawn when the clocks are to be affected, because although a reverse current is to line, it is traversing the coils in this particular station in a direction opposite to that in which it is trav-

ersing those in the other stations of the series. Therefore the armatures of all the other repeaters or relays will remain away from their local circuit contacts, and their clocks will be safe. The clock in the station which is being tested is safe by reason of the opening of the switch q^3 above mentioned. Suppose that the first station tested is the middle one of the series. If, after the above acts have been performed, it is seen that the armature n^4 at that station moves toward its contact, it is proven that there is no trouble on the line between that station and the battery. Thereupon the wire terminals are replaced, or the switch L′ is put back to its normal position, the armature n^4 instantly leaving its contact and resting against the south pole s, and the switch q^3 is again closed. Then the one testing the line goes to the next, or some other, station, more remote from the battery and repeats this series of steps. The tests are continued until a faulty point is discovered. In the mean time each and all of the clocks have been continuing in their normal movements without any interference from the electric impulses sent over the main line.

By means of the bell or indicator at N^2, battery n', and the other parts of circuit 8, 8, in the observatory, or transmitting station, the attendant can be informed as to when the local circuits are being closed and opened when the reverse current from battery K is to line.

From the above it will be seen that with my system, I can, from one and the same transmitting or observatory station, operate several circuits differing materially from each other in their purpose and connections.

The third main line 7, 7, passing out from the observatory station, may be regarded as one of the long lines now used for telegraphing. It is shown as extending from the observatory station, first to the central office S^4, of a city or important center. At such main office, the branch which extends to the observatory can be connected to the main line battery R^4, by means of a switch r^6. When this switch is turned to the contact at r^7, the observatory end of the line is cut off and the wire at the telegraph station is grounded through the branch 7^a. The circuit 7, 7, involves the main line relay I^2, adapted to close the local circuit 13, 13^x, including a sounder R^2, and having a switch r, adapted to be put to either point r', or r^2. There is a clock shown at Q^4, for the convenience of the central telegraph station. This local circuit, together with the clock branch 13^a, the sounder, the battery R′, the relay and the main line 7, 7, is substantially similar to that in railway telegraph station O′, above described. And in a similar manner, the operator at this station, by means of a switch r^6, can get signals from the observatory and by means of his switch at r, can pass electrical impulses through the circuit 13, 13^a, including the clock Q^4. As it is desired to transmit to numerous points throughout the city or region around this central telegraph station, to accomplish this, I put in the branch 13^a, of the local circuit a multiple repeater. That shown at I^3, has points j^6, j^7, against which the arms i^3, i^4, can impinge. From the repeater arm i^3, there passes a circuit indicated generally by 14, 14, it comprising a switch k, a pole changing switch L, a battery K, a galvanometer M, a polarized relay N, a bell N^2, a switch n^5, and other parts similar to those above described as being included within the observatory station, and there being, in addition thereto, a switch at n^6, for a purpose to be described. The circuit 14, 14, after passing out from its central station, extends out through more or less of the city to one and another of a series of clock stations as illustrated at O^2, and finally to earth. The clock station at O^2, is substantially similar to that above described and shown at O, and the parts thereof need not be here again described in detail. The other arm of the repeater at I^3, forms part of a circuit 15, 15, which, when closed, includes a battery at R^6, the battery being grounded on one side. This circuit 15, 15, extends out directly from the central or transmitting station under ordinary circumstances, it also passing out to one or another of a series of clock stations, each of which is provided with a polarized relay, a local circuit, a multiple repeater and one or more clock circuits as shown at O.

By means of the polarized relay, the battery K, and the pole changing switch L, of the central telegraph station now being described, and above referred to, it will be seen that the circuit 14, 14, can be tested in the manner above set forth, for circuit 5, 5.

In order to test the circuit 15, 15, by means of the same apparatus and to avoid the necessity of duplicating them, I employ a branch circuit as shown at 15^a, which is adapted to be connected with the battery K, the galvanometer and the polarized relay, there being a switch at n^7, for cutting out the battery R^6,; if necessary, the circuit 14, 14, being cut out by the switch n^6. The parts being properly related, it will be seen that the above described testing signals can be as readily sent over line 15, 15, as over line 14, 14. Although only two clock circuits are illustrated as extending from this station, it will be understood that any desired number of them may be used, it being only necessary to vary the multiple repeater at I, in such way as to accommodate all of the lines desired, or to employ the system of repetition herein set forth by a local circuit of sufficient strength to operate a number of repeaters.

Considering further the circuit 7, 7, which, as above said, may be regarded as a telegraph line largely in use, I have indicated at S^5, by dotted lines, another such station, which, however, may be regarded as including parts substantially similar to those just above described at the station at S^4. At the next station S^6, on the main line 7, 7, another plan of distrib-

uting signals is illustrated. The station S^6, is an ordinary telegraph station such as is found in the larger cities, the essential parts of which are shown, comprising those which have been indicated in describing the stations at O′, and at S^4. But, in this case, none of the apparatus especially intended for distributing the time signals or for testing the time signals or for testing the signaling apparatus, is situated at the central station. It is in a separate station O^4, at a distance from the main telegraph station S^6 being connected therewith by means of a circuit 16, 16. This circuit is closed by repeater I^4, at the telegraph office, from the main line. A time signal received at the telegraph office S^6, over the main line 7, 7, will be transmitted to the repeater I^5, in the central time station O^4. From this repeater, it is taken into a local circuit 17, which, with the exception of its lacking a telegraph sounder, is substantially similar to that shown in the combined telegraph and time station S^4. And, from this circuit 17, 17, it is transmitted in various directions, as for instance to the receiving stations O^5, O^6, by apparatus substantially similar to that in the station at S^4. This transmitting station O^4, also has a testing apparatus located therein.

I herein refer to a "main line" and also to "local circuits" and mean to be understood much in the ordinary sense. The "main line" here is the initial or governing line receiving electric impulses in the first instance, and through the repeaters, transmitting it to the "local circuits." Of course these terms are somewhat relative and are not to be considered as referring to the magnitude of a secondary circuit or the number of devices included therein. Thus the line 5, 5, may be regarded as a main line in relation to the observatory apparatus and in relation to apparatus at such clock stations as at O, P. And a precisely similar line as at 15, 15, may be regarded as a local circuit in relation to the main line 7, 7, although it, (line 15, 15,) may not really be of greater magnitude than the line 5, 5; but in relation to the station S^4, and the clock stations O^2, O^3, it may be regarded as a "main line." Again, such a line as that at 6, 6, may both begin and terminate at points so remote from the station corresponding to the "observatory" station illustrated, that it is not practicable to connect it in the way shown; but in such case, the observatory branch 6^x of line 6, 6, to the left of point r^4, can be connected with a station such as at S^4, S^5, S^6, of some other telegraph lines, by devices such as are shown in the observatory station. And, in such case, while the railroad telegraph line is, on one hand, a "main line" in respect to the various circuits opened and closed by it, it may be considered as a local circuit in so far as it is in turn opened and closed by the circuit 7, 7, or its equivalent.

It will be seen that time signal receiving devices can be employed in carrying out my system differing from the clocks and their attachments herein particularly shown, there being at the present time other well known devices which can be used as equivalent for these herein to receive time signals, they being telephone bells, &c., depending for their action on an electric impulse.

I herein mention "telegraphic or telephonic sounders," &c., and now mean to be understood as referring to the circuits and instruments ordinarily used in telegraphing or telephoning during the greater part of the day for purposes of correspondence, or sending messages from point to point, but which, or some of which, I utilize during short intervals for the transmission of time signals.

It will be seen that if at any time the apparatus connecting the observatory (or the station from which the time signals are transmitted) and one of the receiving stations, such as that shown at O′, or S^4, should be out of order so that time signals could not be received at the last said station at the usual moment, the operator at said station can nevertheless synchronize, regulate or adjust the clocks or time signal receiving devices at the other stations along the line by means of his key, ordinarily used for telegraphing, or by any other suitable device. At such time the local circuits, as at 12^a, the sounders therein, and the clocks at the several stations can be treated in the same way as they can when use is made of a transmitting clock similar to that at C. When this is being done under such circumstances it will be seen that such a station as that at O′, or S^4, is to be considered as "a time signal transmitting station adapted to be connected to the main line," as I herein describe it, and that it contains "time signal transmitting apparatus."

What I claim is:

1. The herein described improvement in the art of transmitting and receiving time signals, it consisting in sending from a transmitting station, a series of electric impulses of a predetermined number over the main line of an electric telegraph circuit and through a main line repeater to a local circuit, receiving a part of the said impulse in a telegraphic sounder or equivalent instrument in said local circuit, and then, before all the said impulses have been transmitted, switching into the said local circuit one or more clocks or equivalent time signal receiving instruments whereby the remaining said impulse or impulses of the series are transmitted to the said clocks or instruments, substantially as set forth.

2. The herein described improvement in the art of transmitting and receiving time signals, it consisting in sending from a transmitting station, a series of electric impulses of a predetermined number over a main line and through a main line repeater to local circuits and of different electro-motive force, receiving a part of said impulses in a telegraphic sounder in the weaker of said local

circuits, and then receiving the remainder of said impulse or impulses of the said series in the stronger local circuit, substantially as set forth.

3. The herein described improvement in the method of operating and testing the electric circuits of a time signaling system, it consisting in imparting electric impulses to a main line, and causing said impulses to close local circuits, each through a polarized relay by a current of given polarity, and in testing such main line by imparting thereto a current of opposite polarity and reversing the direction in which the last said current traverses the magnets of the said polarized relays, substantially as set forth.

In testimony whereof I affix my signature in presence of two witnesses.

WILLIAM F. GARDNER.

Witnesses:
MARCUS L. BYNG,
J. C. STIER.