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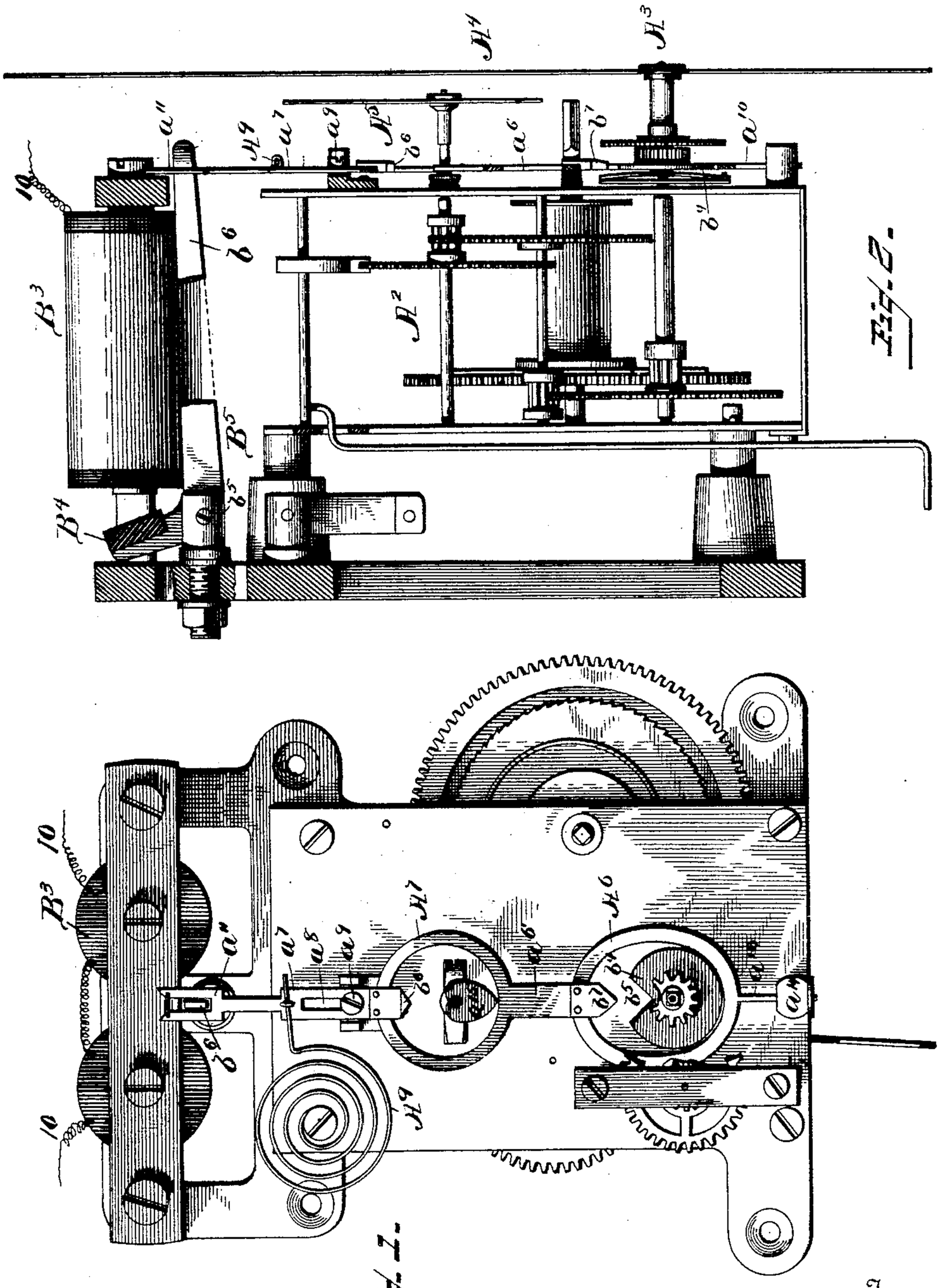
W. F. GARDNER.

CLOCK SYNCHRONIZING DEVICE AND SYSTEM.

No. 480,577. Patented Aug. 9, 1892.



Witnesses
W. F. Gardner.
B. H. Sommers.

Inventor
William F. Gardner
By his Attorneys
Doubleday & Bliss

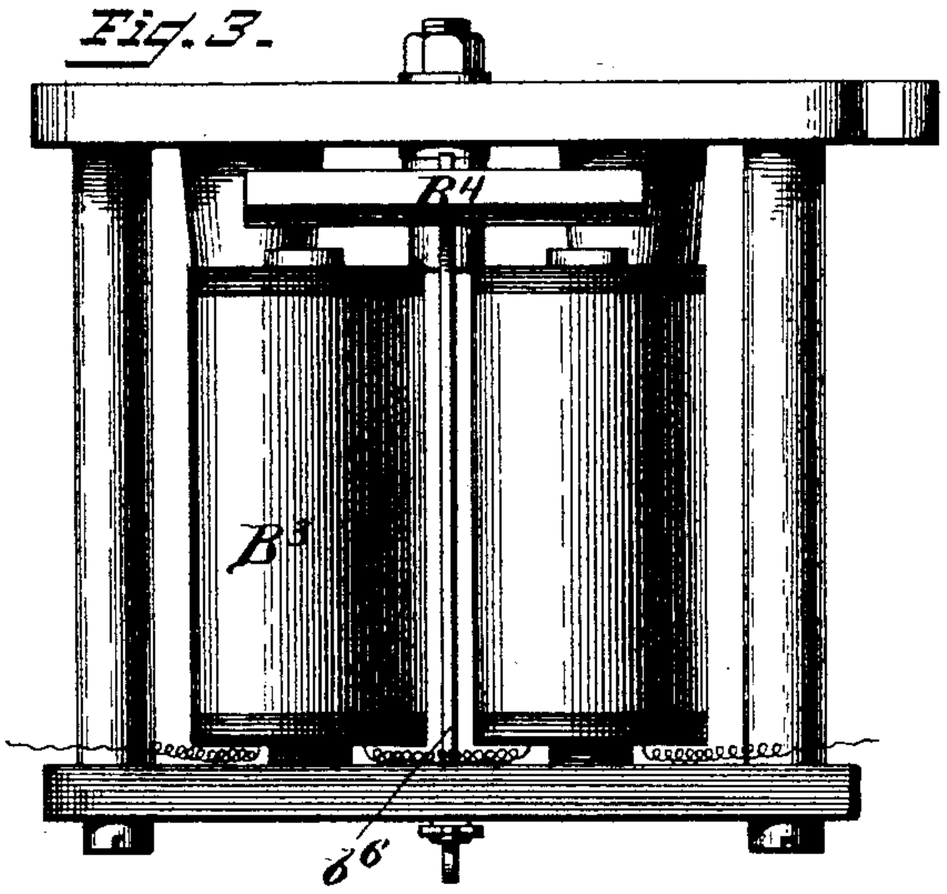
(No Model.) 4 Sheets—Sheet 2.

W. F. GARDNER.

CLOCK SYNCHRONIZING DEVICE AND SYSTEM.

No. 480,577. Patented Aug. 9, 1892.

Fig. 3.



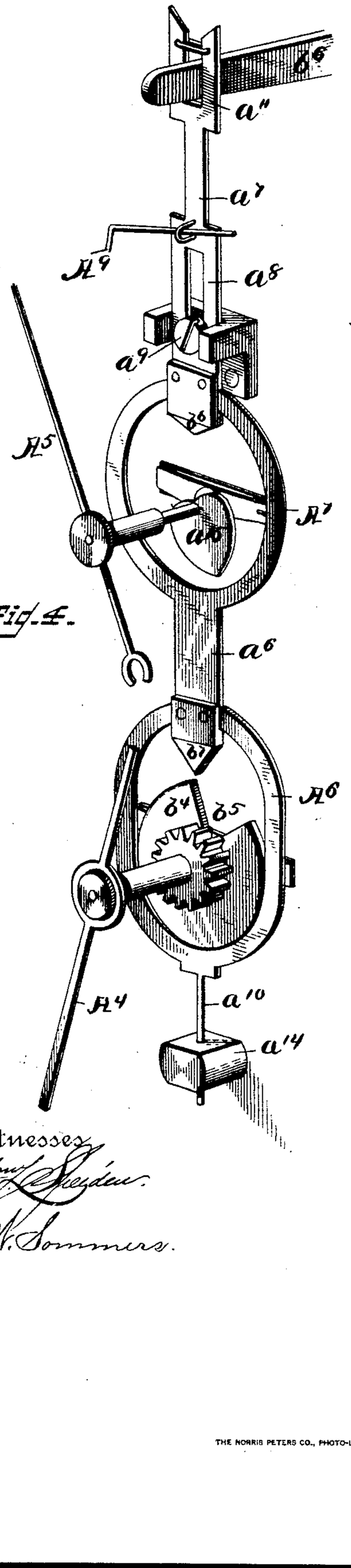
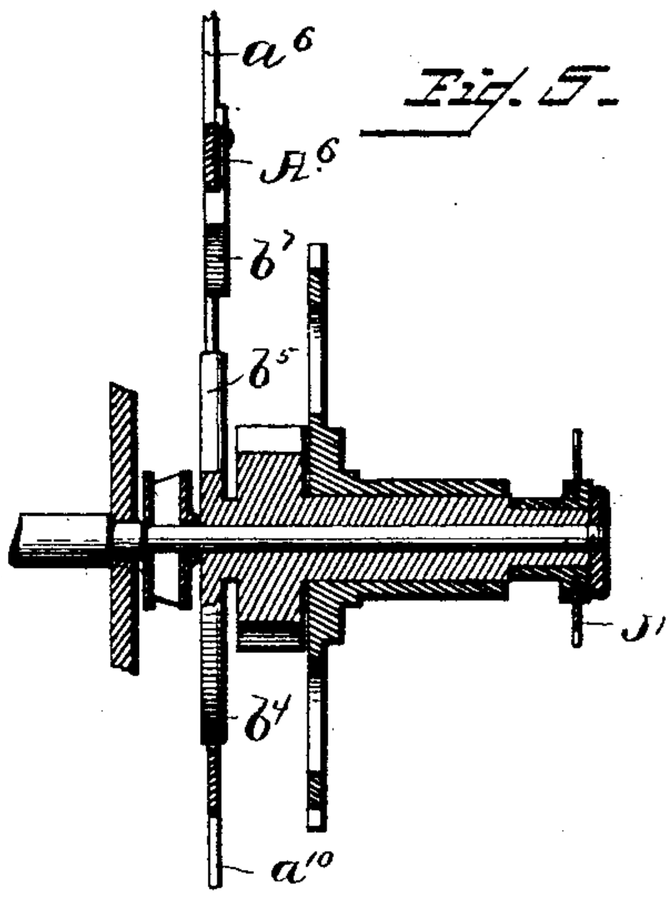


Fig. 4.

Fig. 5.



Witnesses
W. F. Gardner.
B. W. Sommers.

Inventor
William F. Gardner
By his Attorneys
Doubleday & Bliss

(No Model.) 4 Sheets—Sheet 3.

W. F. GARDNER.

CLOCK SYNCHRONIZING DEVICE AND SYSTEM.

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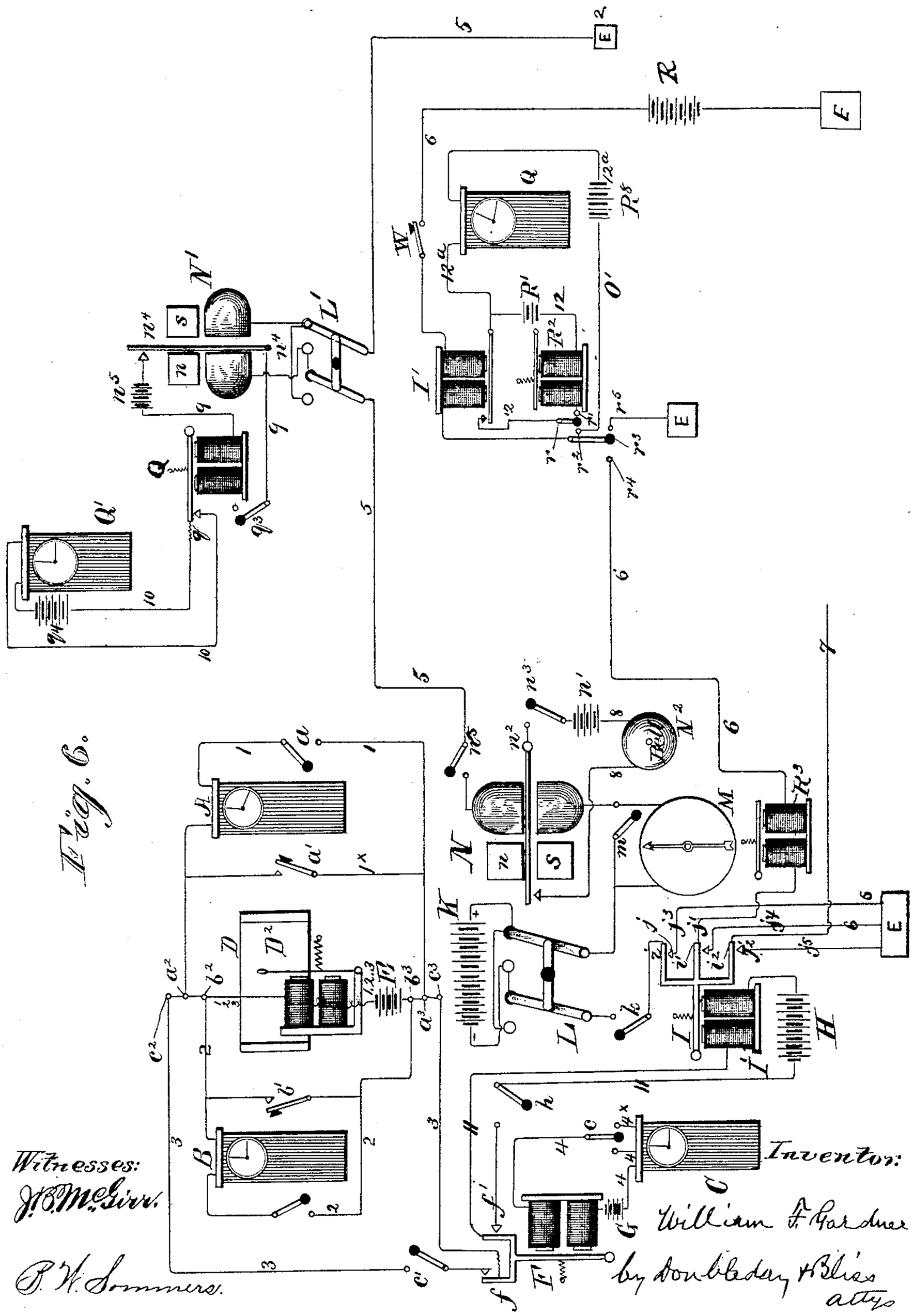

Fig. 6.

Witnesses:
J. B. McGirr.
P. H. Sommers.

Inventor:
William F. Gardner
by Doolittle & Bliss
attys

(No Model.) 4 Sheets—Sheet 4.

W. F. GARDNER.

CLOCK SYNCHRONIZING DEVICE AND SYSTEM.

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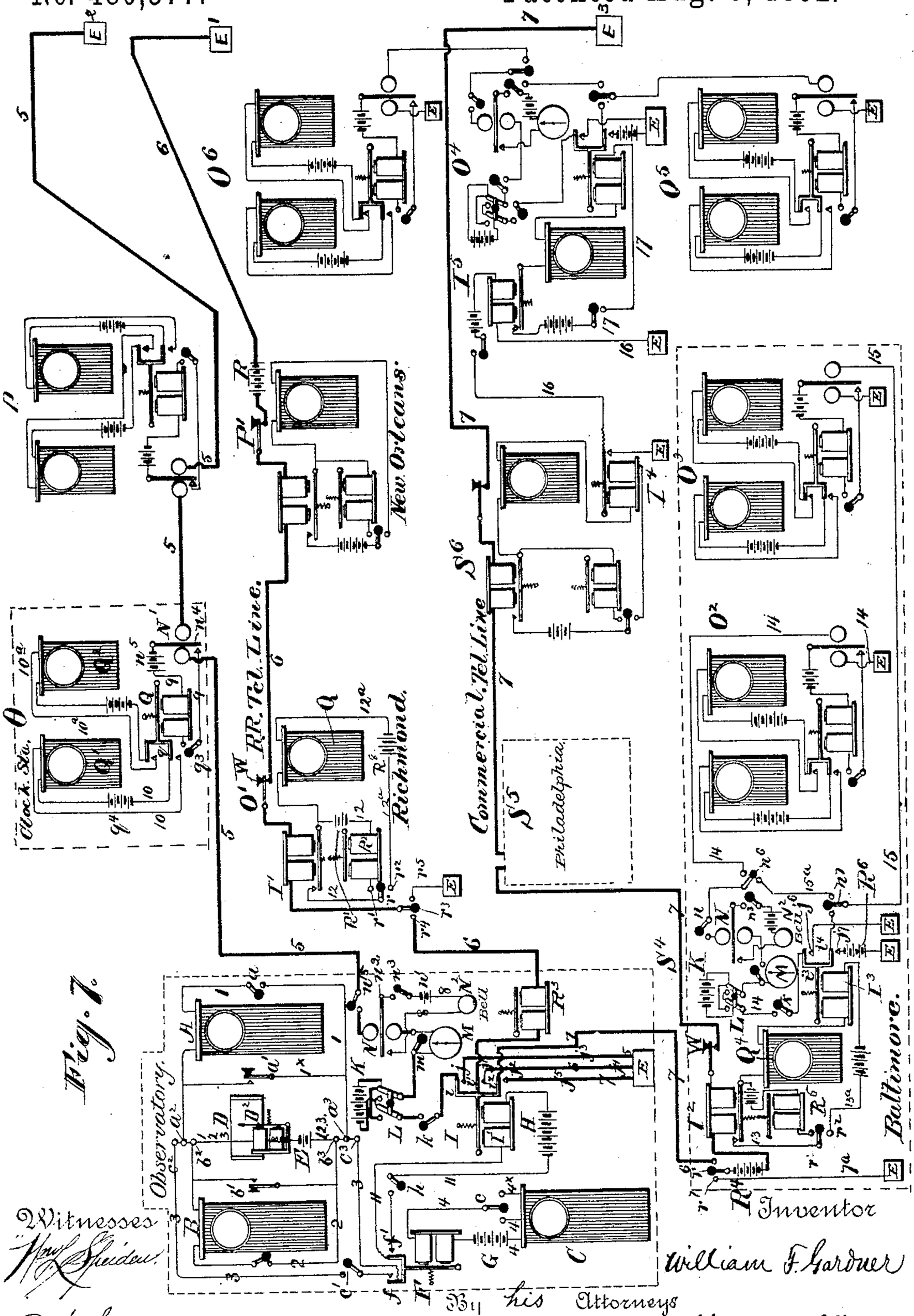

Fig. 1.

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

UNITED STATES PATENT OFFICE.

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

CLOCK-SYNCHRONIZING DEVICE AND SYSTEM.

SPECIFICATION forming part of Letters Patent No. 480,577, dated August 9, 1892.

Application filed December 13, 1888. Renewed July 8, 1892. Serial No. 439,421. (No model.)

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 Clock-Synchronizing Devices and Systems, of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates to improvements in devices for controlling or synchronizing clocks, it pertaining more especially to devices of the class used for controlling or synchronizing clocks whose time-measuring movements are effected by one or the other of the ordinary trains of gearing actuated by springs or weights in contradistinction to those clocks whose movements are caused by electrically-actuated mechanism. However, I wish it to be understood that there are numerous features of the present invention which can be applied to the systems and devices for controlling or synchronizing clocks of any of the now well-known forms.

The invention relates not only to the devices which are directly connected with or form part of the clocks proper, but also to the devices which are used for transmitting electric impulse to the controlled or synchronized clocks from points at a distance therefrom—that is to say, the apparatus herein presented, when regarded as a whole, may be treated as a system for attaining the ends above referred to, including the appliances of a central or observatory station, the appliances at various sub-stations of several sorts, and the appliances immediately incident to the clocks themselves, which it is the main purpose to reach, whether they be near to or distant from the central observatory or transmitting station.

Among other things, also, the invention relates to a novel method of testing the wires and other metallic parts in a clock-circuit on which clocks may be arranged for regulation, control, or synchronizing.

Figure 1 is a face view of a clock-movement having applied thereto synchronizing mechanism embodying my improvements. Fig. 2 is a side view of the same. Fig. 3 is a top plan view. Fig. 4 is a perspective of a part of the synchronizing devices. Fig. 5 is a sectional view of part of the mechanism, taken along the axis of the arbor. Fig. 6 is a diagrammatic station and some of the parts included in outside stations. Fig. 7 is a similar view showing somewhat more extensively some of the ways of applying my improved system.

First, referring to what I herein term the "observatory station," I have represented in Fig. 6 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 3 3 4 4, 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 the 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 a key a' in a cross-circuit $1^\times$, adapted to short-circuit or cut out the clock A. The switch a being closed, it will be seen that the impulse 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 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. The clock B being in operation, its impulses will be indicated by the marking-instrument at D^2 of the chronograph. Both the clocks A and B being in operation, their impulses will be both 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 4 and the other the parts $4\ 4\ 4^\times$, there being a common battery G and repeater F. The first set of make-and-break devices in the clock is utilized to trans-

mit certain predetermined impulses or preliminary time-signals, and the second set transmits a final signal to 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 for that purpose. By turning the switch *c* to the left a current from battery G passes through the circuit having parts 4 4 4 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 4$^{\times}$ and the final signaling or synchronizing or controlling device.

The relay or repeater F has two points *f f'*. The point *f* is adapted to close the above-mentioned circuit 33 through the battery E, it being a circuit also including the marking-instrument of the chronograph at D and having the terminals of its 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 repeating-lever F closing the contacts 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. 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 B being allowed to remain unchanged or uncorrected, although its daily and other variations are carefully noted. Then after the comparison of these has been completed by means of the chronograph the mean-time clock B 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 4 for the other. If as a result of said comparison it is ascertained that the transmitting-clock C is slightly out of the 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 now 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 relay or repeater F, above referred to, is in a circuit 11 with a local battery at H, there being in this circuit 11 an electric magnet I^5 of a multiple-pointed repeater I. At *h* there is a switch whereby this local circuit 11 can be opened or closed, as desired. The relay or 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 relay or repeater has three contact-arms *i i' i*^{2} with three contacts-points *j j'* j^2. Each has an earth connection j^3 j^4 j^5 and is in a main-line circuit, one indicated by 5 5 5, another by 6 6 6, and a third by 7 7 7.

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 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 extends out from the said station for the purpose of transmitting similar signals and for regulating and controlling clocks along the line of a telegraph company extending to distant points, at each of which it is desired to take from the said main line the signals or correcting or synchronizing impulses. As just said, the main line or circuit 6 6 6 is indicated as passing out from the observatory-station to a series of railroad-stations. The latter are generally indicated in Fig. 7 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 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. As aforesaid, the said branch is in the observatory-station connected to the arm *i'* of the relay or repeater I, the corresponding contact *j'* running to earth. This line 6 6 at the railroad-station O' passes through the electro-magnet of a main-line relay or repeater at I', adapted to close one or more local circuits. In Figs. 6 and 7 two are shown, one at 12 12, including battery R' and sounder R^2, and the other at 12^a 12^a, including battery R^8 and clock Q, both including the switch *r* and the armature of relay or repeater I'. 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 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^8, 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 in the preliminary signal-circuit of transmitting-clock C, the preliminary signal impulses are through relay or repeater F felt in circuit 11 through the relay or repeater I in circuit 6 6, and through the relay or repeater I′ in circuit 12 12, where they are indicated to the operator by the sounder R^2, switch r 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 $4^\times$ and the operator at station O′ moves the switch r to point r^2. Thereby 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 P and at all others along the railway telegraph-line are affected 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 R^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, a switch at n^{15}, all within the observatory or central transmitting station, and then the outgoing line-wire 5 5, extending to the sub-stations 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 local 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 circuit 9 9, having battery n^5, magnet of relay or repeater Q, and switch q^3. Arms q of repeater Q close the circuits 10 10 10^a 10^a, &c., each including a signaling or clock controlling, actuating, or synchonizing 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 will (through relays or repeaters F, I, N′, and Q) 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 C, 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 contact at $4^\times$ the switch k is closed, so that the final impulse in the circuit 4 4 $4^\times$ is experienced in the outgoing circuit 5 5. When so arranged, it is impossible to impart to the clocks Q′ Q^2 accidental impulse.

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

Still referring to the circuit 5 5 and the parts thereon, 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 any 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 central transmitting station; but that is not necessary.

Referring to Figs. 6 and 7, 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 relays N N′ are drawn toward the north poles n of the permanent magnets constituting part of the said relays, and the armatures n^4 at the distant stations are brought against the contacts which close the local circuits 9—that is to say, when a direct current is thrown to line 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 is idle the testing is accomplished as follows: First the 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 proper working order; but if from these indications or from any other source of knowledge a leakage or a 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 manipulations. Then at that station the terminals of the electro-magnets of the polarized relay are reversed either by changing the wires in the binding-posts or by a reversing-switch, as at L′. 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 traversing those in the other stations of the series. Therefore the armatures of all the other relays will remain away from their local-circuit contacts and their clocks are safe. The clock in the station that 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 the faulty point is discovered. In the meantime each and all the clocks have been continued in their normal movement without any interference of the electric impulse sent over the main line.

By means of the bell or indicator at N^2, battery *n′*, and the other part in circuit 8 8 in the observatory or transmitting station the attendant there can be informed as to when the local circuit is being closed and opened when the reverse currents from battery K is in line.

It will be seen that the relays or repeaters at Q are of the nature of "main-line" repeaters—that is to say, provided with electro-magnets of one polarity—although they are not arranged directly in the main line, and, further, that they are operated by the polarized repeater or relay which is in the main line. Some of the ends which I attain can be reached if relays or repeaters differing from that at N′ and at Q be used, although I prefer the devices shown. Of course it will be seen that a circuit such as that at 5 5 can, when not being used to affect time-signal-receiving instruments, be utilized for other purposes than testing if a current of one polarity is used for time-signaling and one of opposite polarity be used for the other operations.

Another advantage incident to the use of a current-changing switch, as at L, in connection with polarized relays at the receiving-stations, lies in the fact that after the circuit has been used for the desired purpose the battery can be so connected to the line that if from accident or inadvertence the switch k n^{15} should be closed a current sent to line would not influence the clocks or receiving-instruments, as it would throw the armatures n^4 away from their local contacts. 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 in Fig. 7 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 with the main-line battery R^4 by means of a switch at 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 includes the main-line relay I^2, adapted to close the local circuit 13 13, including a sounder R^5 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 those 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 and multiple relay or repeater. That shown at I^3 has two points j^6 j^7, against which the arms i^3 i^4 can impinge. From the relay or repeater arm i^3 there passes a circuit (indicated generally by 14 14) 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^3, 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 O^3, 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 relay or 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.

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 at 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^3 in such way as to accommodate all of the lines desired or to employ the system of repetition herein set forth by means of 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 distributing signals is illustrated. The station S^6 is an ordinary central 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 station 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 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.

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 having a testing apparatus located therein.

I will here describe more in detail the mechanism which is attached to each of such clocks, as those at O′ O^2, reference being had to Figs. 1 to 5. The train of wheels, the arbors, and other parts constituting the mechanism of each clock proper are indicated at A^2, these as a whole being substantially similar to clock mechanisms now in use. The hour-hand is indicated by A^3, the minute-hand by A^4, and the seconds-hand by A^5. The hour-hand and the minute-hand are mounted upon the same axis, and there is a dial-train of gearing which connects the arbors of the several hands in such way that any rotation or part of rotation of one is transmitted to the other. The hands are so supported upon their arbors, respectively, that they can be turned irrespectively thereof if sufficient force be applied.

A^6 represents a loop surrounding the arbors of the hour and minute hands, and A^7 one around the arbor of the seconds-hand. These loops are joined by a bar a^6, and above that at A^7 there projects a bar a^7. The latter is slotted at a^8 and in the slot fits a set-screw a^9. Below the loop A^6 there is an extension a^{10} fitted into a guide a^{14}, which, together with the slotted bar a^7 and set-screw a^9 holds all of the parts last described in proper position in relation to the arbor. At the upper end the bar a^7 is slotted or forked, as shown at a^{11}, and at A^9 there is a spring which bears against the bar a^7 in such way as to always tend to force it upward.

B^3 indicates an electro-magnet, the two parts of which are horizontal and situated on lines at right angles to the face of the clock. The armature B^4 lies behind the electro-magnet, it being secured to a bell-crank lever B^5, pivoted at b^5 to the clock-frame. The longer arm of this lever b^6 extends forward and is passed through the forked part a^{11} of the sliding parts a^6 a^7 A^6 A^7. When the electro-magnet B^3 is energized, the armature B^4

is drawn forward and the arm b^6 is thrust downward, it carrying with it the last said sliding parts.

On the arbor of the seconds-hand there is a heart-shaped cam a^{15}, and on the arbor of the hour-hand A^3 there is a disk b^4 with a circular outline, except where a section b^5 of a few degrees is removed. The bar a^7 has at its lower end a cam projection b^6, and the bar a^6 has a more or less similar projection b^7. The part b^6 lies in the plane of the cam a^{15} and the part b^7 in the plane of the mutilated disk at b^4.

It will be seen that during a period of a few moments in each day—namely, that period when the mutilated part of the disk b^4 lies below the cam b^7—it is possible for the above-described sliding devices to descend far enough to have the said cam b^7 engage with the inward-extending edges of the recessed part of the disk and to have the cam at b^6 engage with the edges of the recess in the cam a^5, and that when such motion occurs the cams b^6 and b^7 will act to turn the seconds-hand to a predetermined point and also turn the hour-hand by engaging with the inclined edges of the disk b^4 and through the dial-train move the minute-hand.

It will be seen that the push-bar above described reciprocates rectilineally and on lines radial to the arbors of the hands A^4 A^5. This arrangement of the push-bar is superior to the one shown in my earlier patent above mentioned, wherein it is pivoted and rocks about its pivot, especially when it is combined with a stop-disk, as at b^4. When the push-bar is arranged to rock around a center, it cannot be made to move radially to the axis of the arbor, and there is not that precision of adjustment of the hands which is attainable when the bar moves rectilineally and radially.

While for the purpose of making the whole system understood the signal-receiving clocks and the devices for testing the circuits are shown and described, I do not herein claim these, having made them, respectively, the subjects of applications, Serial Nos. 377,023 and 377,024, filed January 7, 1891; nor do I herein make claim for the improvements in the art of transmitting and receiving time-signals, having presented such claims in another application, Serial No. 404,760, filed September 4, 1891, as a division of the present.

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 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-line—by devices such as are shown in the observatory-station, and in such case, while the railroad telegraph-line is on the 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 equivalents for these herein to receive time-signals, they being telephone-bells, electric call-bells, &c., depending for their action on an electric impulse.

I herein mention "telegraphic or telephonic circuits," "main-line repeaters," and "telegraphic sounders," &c., and 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 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 W, 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 mitting apparatus."

What I claim is—

1. In a time-signaling system, signal-transmitting devices in an observatory or transmitting station, a telegraphic or telephonic main-line circuit, a branch circuit adapted to intermittingly connect the said signal-transmitting devices with the main-line circuit, a receiving-station, a main-line relay or repeater in said main-line circuit at said receiving-station, a local circuit opened and closed by said relay or repeater, said local circuit having two loops or branches with a battery in each loop, a sounder or equivalent receiving mechanism in one of said loops, a clock or time-signal-receiving apparatus in the other of said loops, and a hand-switch whereby the local circuit can be closed at will either through the said clock or through the said sounder, substantially as set forth.

2. In a time-signaling system, signal-transmitting devices in an observatory or transmitting station, a telegraphic or telephonic main-line circuit, a branch circuit adapted to intermittingly connect the said signal-transmitting devices with the main-line circuit, a receiving-station, a main-line relay or repeater in said main-line circuit at said receiving-station, a local circuit opened and closed by said relay or repeater and having two loops or branches, a sounder or equivalent receiving apparatus in one of said loops, a clock or time-signal-receiving apparatus in the other of said loops, a hand-switch whereby the local circuit can be closed at will either through the said clock or through the said sounder, and a switch or equivalent in the said main-line circuit and distant from the observatory or transmitting station for disconnecting said main line from the aforesaid branch, which extends to the observatory or signal-transmitting station, substantially as set forth.

3. In a time-signaling system, a telegraphic or telephonic main-line circuit, devices for automatically transmitting time-signals adapted to be connected therewith, a series of main-line relays or repeaters all in said circuit, a series of telegraph or telephone stations respectively containing said relays or repeaters, telegraph-signal-receiving devices in said station, a primary local electric circuit at each of said stations opened and closed by one of said relays or repeaters, a second repeater in said primary local circuit, one or more secondary local circuits extending out from the said secondary repeater, and one or more clocks or equivalents in said secondary circuits, substantially as set forth.

4. In a time-signaling system, the telegraphic or telephonic main-line circuit, devices for transmitting time-signals adapted to be connected therewith, a series of main-line relays or repeaters in said circuit, a series of telegraph or telephone stations respectively containing said relays or repeaters, a primary local circuit closed and opened by each of said relays or repeaters, a second repeater in said primary local circuit, a series of two or more successively-arranged secondary local electric circuits extending from the aforesaid secondary repeater, and each secondary circuit, except the last, being arranged to open and close a succeeding circuit, and one or more clocks or equivalents in the said series of secondary circuits, substantially as set forth.

5. In a time-distributing system, a receiving-station having a series of two or more electric circuits, as at 10 10 10^a 10^a, one or more clocks or signal-receiving devices in each of said circuits, a multiple relay or repeater opening and closing all of said circuits simultaneously, and an electric circuit, including said multiple relay or repeater and independent of the aforesaid circuit, a main electric circuit, as at 5 5, electro-magnetic devices in said main circuit for opening and closing the aforesaid relay or repeater circuit, and automatic time-signal-transmitting devices at a transmitting-station and which open and close the aforesaid main line, substantially as set forth.

6. In an observatory or time-signal-transmitting station, an automatic time-signal transmitter, a primary local electric circuit opened and closed by said transmitter, a repeater in said circuit, a secondary local electric circuit opened and closed by the said repeater, a second multiple repeater in said secondary circuit, and a series of several outgoing main lines adapted to be simultaneously opened and closed by said multiple repeater, substantially as set forth.

7. In a time-signaling system, an automatic signal-transmitting apparatus in an observatory or central transmitting station, a series of two or more main lines extending out from the said station and adapted to transmit time-signals therefrom, an electro-magnetic indicator, as at N^2, in the observatory or central station, adapted to be connected to said circuits, whereby the observatory-attendant is informed of the transmission of the signals over said circuits, substantially as set forth.

8. The combination of the clock Q, the electric circuit 12 12^a, the sounder R^2 or equivalent instrument in the said circuit or a part thereof, a main line, as at 6 6, the relay or repeater I′ in said main line, and the time-signal-transmitting apparatus at a transmitting-station, adapted to be connected by the main line with the relay or repeater I′, substantially as set forth.

9. The combination of the clock Q, the circuit 12^a 12^a and 12 12, the sounder R^2, the battery R′, the battery R^8, the switch *r*, a main line, as at 6 6, adapted to receive time-signals, and the relay or repeater I′ in the main line, substantially as set forth.

10. The combination of the clock Q, the circuits 12 and 12^a, the sounder R^2, the switch *r*, a main line, as at 6 6, the relay or repeater I′, and the telegraphing-key in the said main-line circuit, substantially as set forth.

11. The combination of the clock Q, the

sounder R^2, the circuit 12^a 12^a through the clock, the relay or repeater I′, having its armature adapted to open and close the circuit through the clock, a main-line circuit through the relay or repeater, and the switch for opening the circuit through the clock, substantially as set forth.

12. The combination of the clock Q, the sounder R^2 or equivalent instrument, an electric circuit through the clock, a battery R^8 therein, the electric circuit through the sounder, a main line, as at 6 6, a relay or repeater, as at I′, in said main line, having an armature adapted to open and close the circuit through the clock, and the switch for cutting out the clock, substantially as set forth.

13. The combination of the clock Q, the sounder R^2, an electric circuit through the clock, an electric circuit through the sounder, a main-line circuit, as at 6 6, and a relay or repeater I′ in said circuit, adapted to open and close the circuits through the clock and the circuit through the sounder, substantially as set forth.

14. The combination of the clock Q, the sounder R^2, the electric circuit through the clock, the electric circuit through the sounder, the relay or repeater I′, adapted to open and close either or both of the aforesaid circuits, the switch r for opening the clock-circuit, the time-signal-transmitting devices at the transmitting-station, a main line, as at 6 6, running through the said relay or repeater I′ and having two earth connections, one at the transmitting-station and one outside thereof, and a switch, as at r^3, for joining the main line to either of said earth connections, substantially as set forth.

15. The combination of the time-signal-transmitting apparatus in the observatory or central station, including a multiple-pointed relay or repeater I, a series of two or more main electric circuits, as at 5 5, 6 6, 7 7, extending from said multiple-pointed relay or repeater I out from the observatory or transmitting station, a time-signal-receiving station, as at S^4, a local electric circuit at the said station, a multiple-pointed relay or repeater in the said local circuit, and a series of two or more electric circuits extending out from the last said multiple-pointed relay or repeater to a series of clock-stations, as at O^2 O^3, substantially as set forth.

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

WILLIAM F. GARDNER.

Witnesses:
ALEX. S. STEUART,
H. H. BLISS.