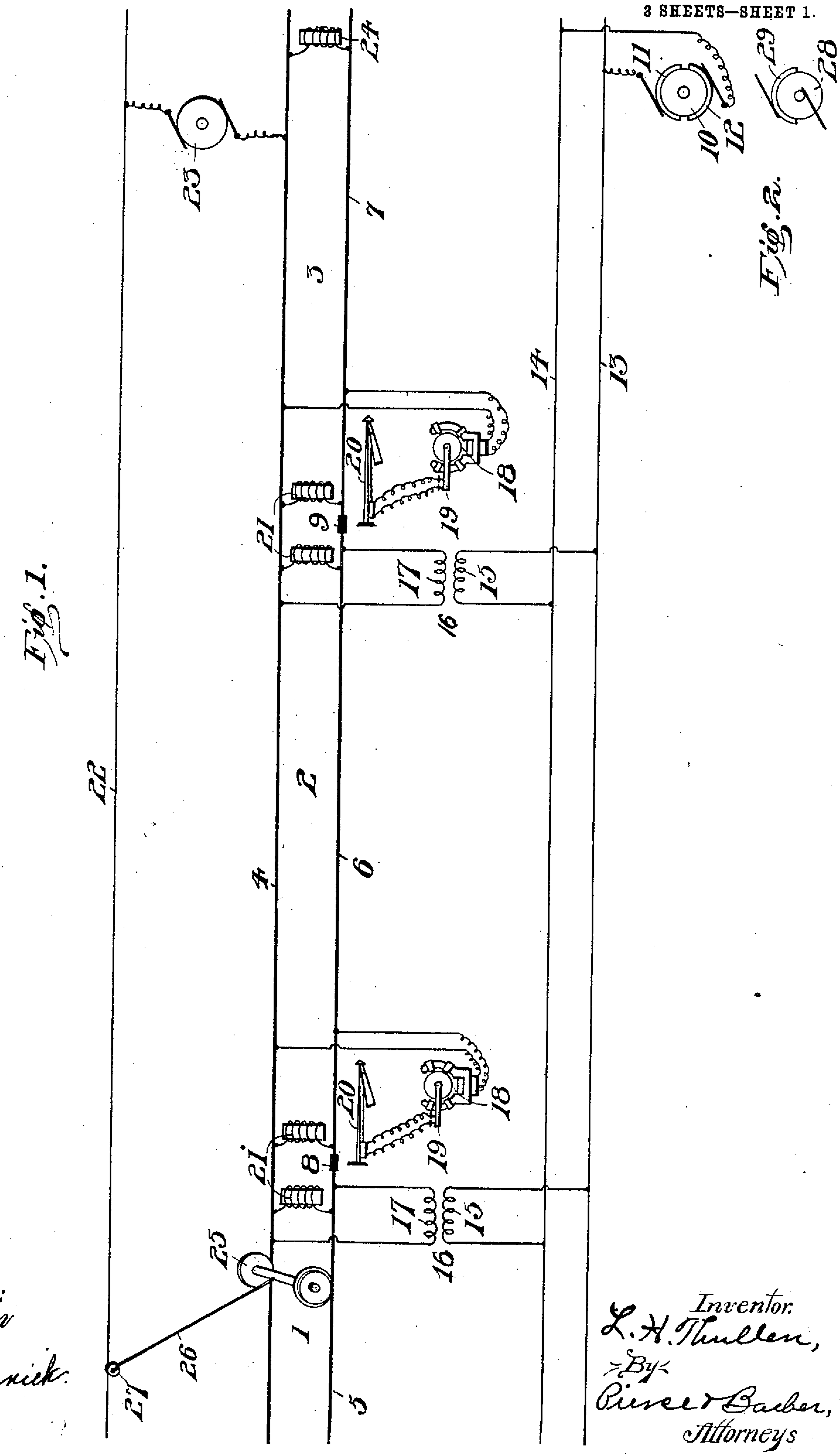
No. 837,154. PATENTED NOV. 27, 1906.

L. H. THULLEN.

RAILWAY SIGNALING SYSTEM.

APPLICATION FILED MAY 22, 1905.

3 SHEETS—SHEET 1.

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3 SHEETS—SHEET 2.

Fig. 3.

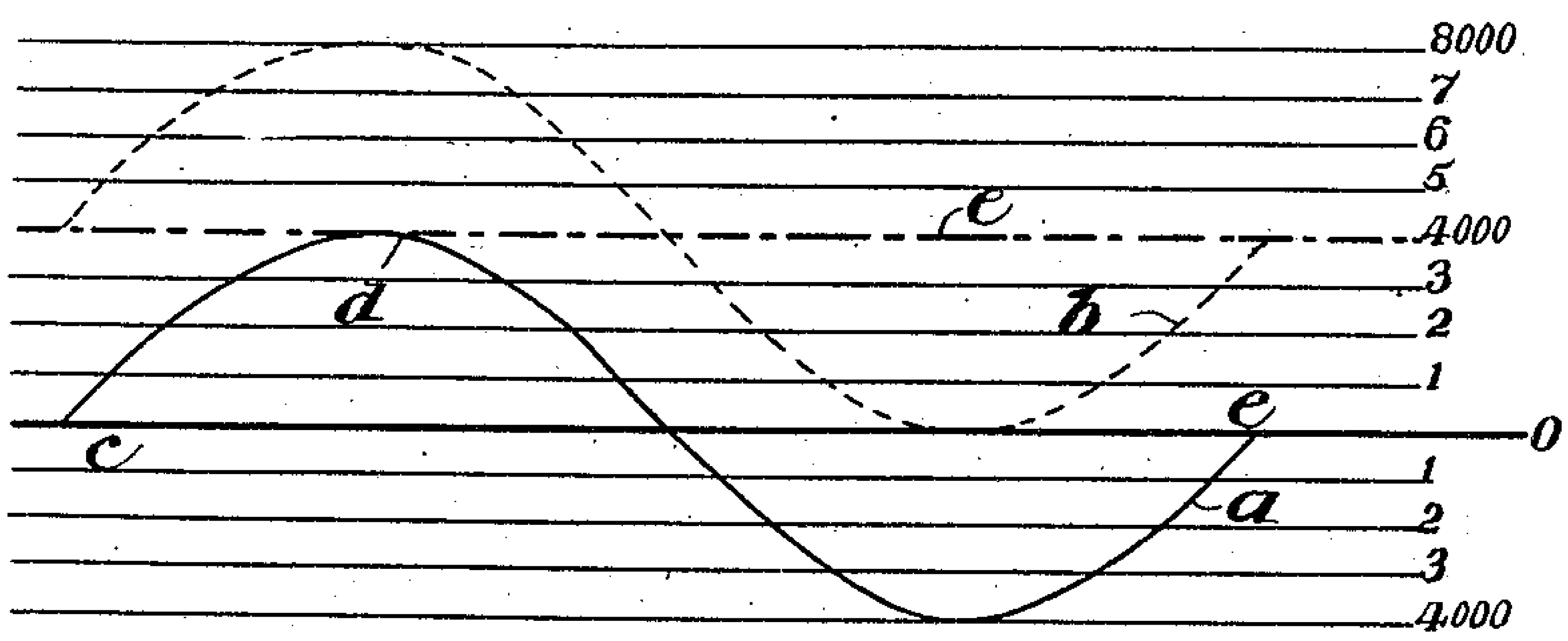



Fig. 4.

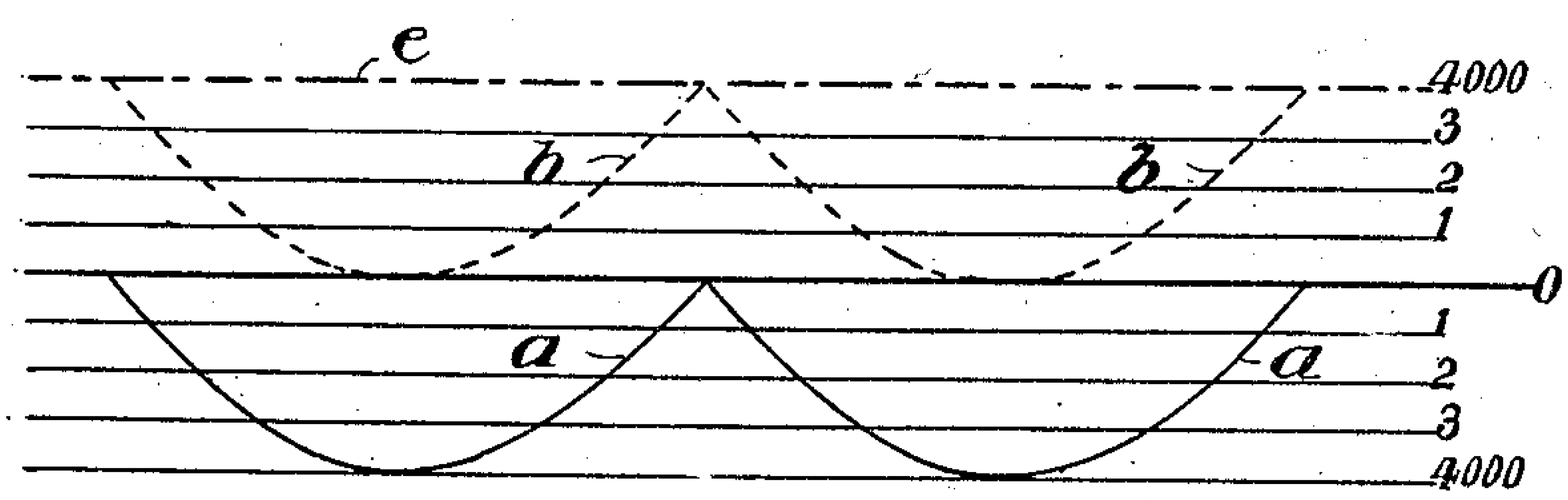
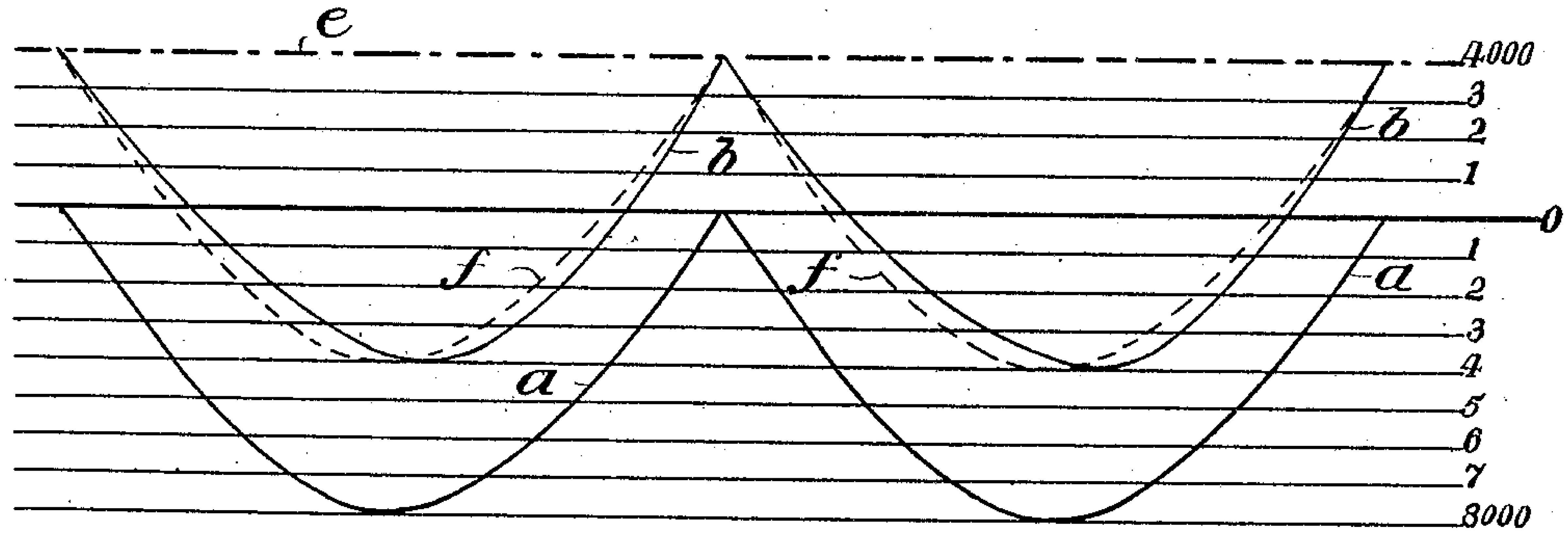



Fig. 5.

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8 SHEETS—SHEET 3.

Fig. 6.

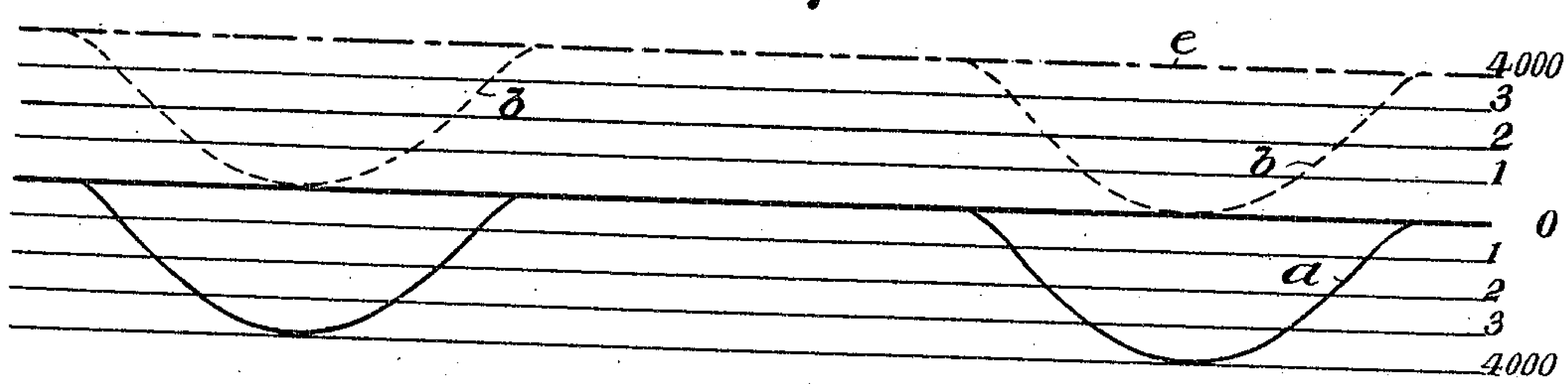



Fig. 7.

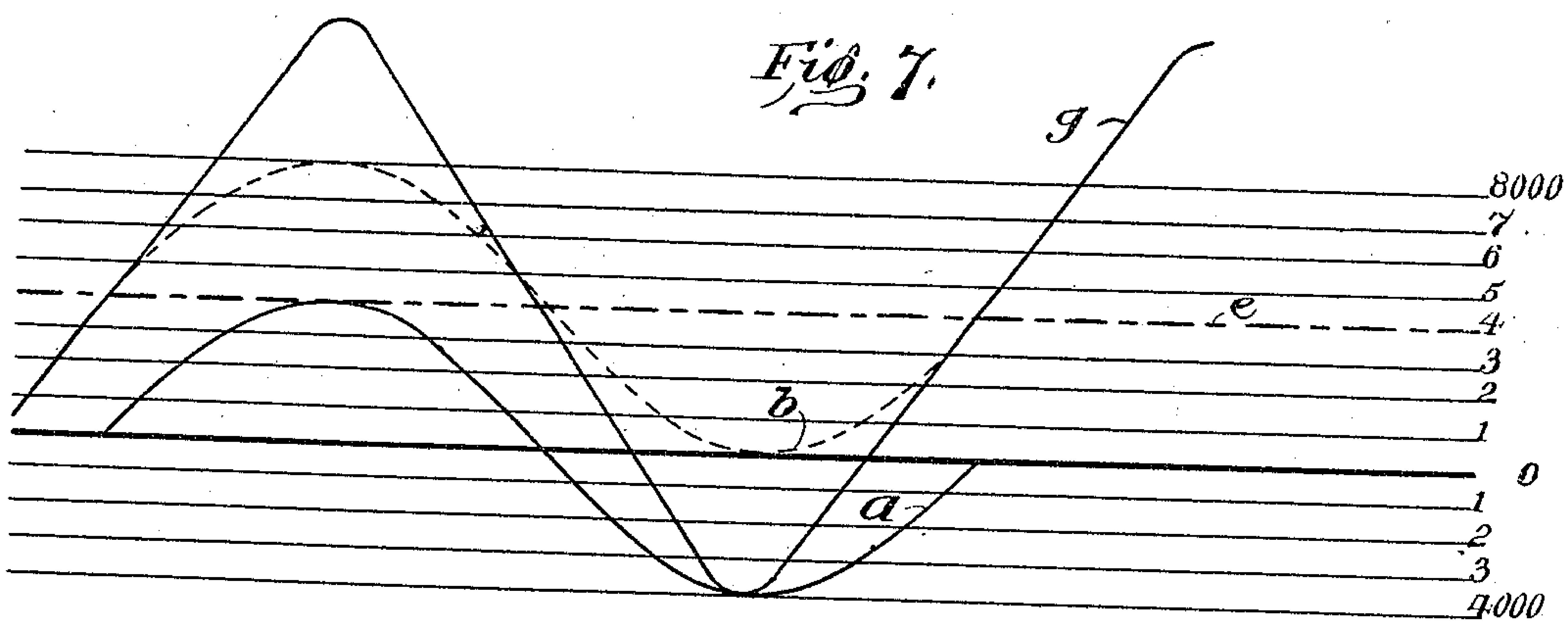
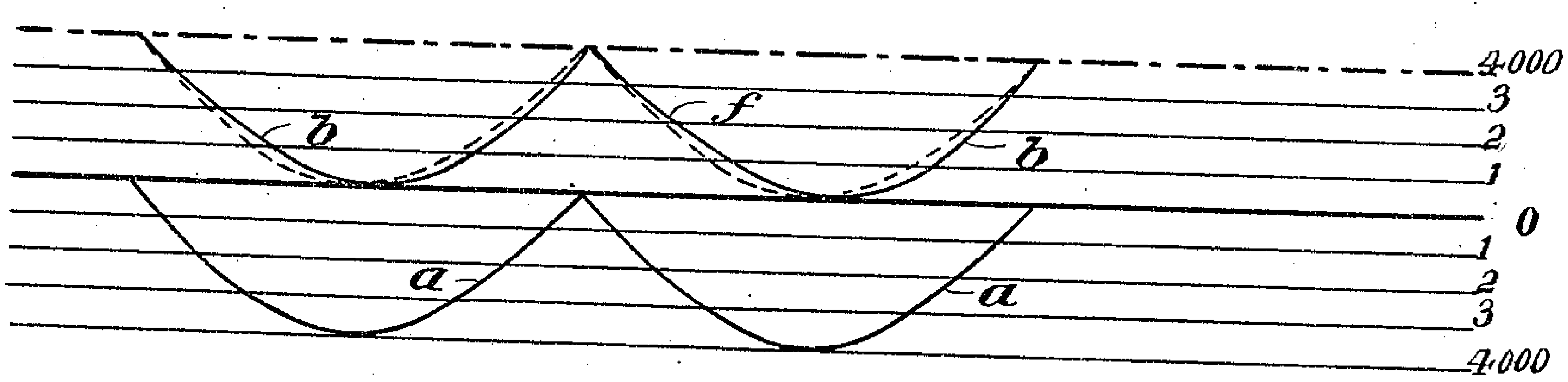



Fig. 8.

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# UNITED STATES PATENT OFFICE.

LOUIS H. THULLEN, OF EDGEWOOD PARK, PENNSYLVANIA.

## RAILWAY SIGNALING SYSTEM.

No. 837,154. Specification of Letters Patent. Patented Nov. 27, 1906.

Application filed May 22, 1905. Serial No. 261,509.

*To all whom it may concern:*

Be it known that I, LOUIS H. THULLEN, a citizen of the United States of America, residing at Edgewood Park, in the county of Allegheny and State of Pennsylvania, have invented or discovered new and useful Improvements in Railway Signaling Systems, of which the following is a specification.

Referring to the drawings, which form a part of this specification, Figure 1 is a diagrammatic view of my invention; Fig. 2, a diagrammatic view of a second form of generator of pulsating current; Fig. 3, diagrammatic representations on the magnetization of the core of a coil when traversed by both an alternating and a direct current; Fig. 4, a view showing the same thing as Fig. 3 when a pulsating and a direct current are used. Fig. 5 is a representation of the value of a pulsating current that is used so that the combined values of pulsating and direct currents would equal the combined values of the direct and alternating currents; Fig. 6, a view similar to Fig. 4 with the generator of Fig. 2 as the originator of pulsating current; Fig. 7, a diagram showing the value of an alternating current necessary to produce the counter electromotive force shown by the curve *a* when the core is acted on by direct current; and Fig. 8, a view similar to Fig. 4, showing in dotted lines a displacement of phase that might exist.

My invention relates to a system of railway signaling which employs an alternating or direct current for driving the railway-vehicle and a pulsating current for the track or signaling current. A pulsating current has a character widely different from an alternating or a direct current and can be generated in different ways. It can be produced by such generators as are shown on Figs. 1 or 2, or by the mercury-vapor arc, or by other means.

An alternating current has a wave form of sinusoidal character, and each wave length rises and falls between a maximum and a minimum, one above zero and the other below it, as shown by the line *a*, Fig. 3. A pulsating current has an entirely different wave form, which is shown by the line *a*, Fig. 4, where the wave form lies wholly on one side of zero. A direct or continuous current is represented by the horizontal dotted lines on Figs. 3 to 8, in which the horizontal lines represent different current strength, magnetomotive force, or electromotive force, as the case may be.

Referring for the present to Fig. 1, 1, 2, and 3 represent block-sections of a railway, the rail 4 being in this instance shown as continuous, while the opposite rail is divided into the sections 5, 6, and 7 by insulated joints 8 and 9 or otherwise. However, both rails may be divided into insulated sections, if desired. 10 represents a rotary generator of pulsating current and has the two segments 11 and 12 to indicate diagrammatically that there will be two pulsations at each revolution of the generator. The two brushes of the generator are respectively connected to the mains 13 and 14, across which are connected the primary coils 15 of the transformers 16, there being one of the latter for each block. The secondaries 17 of the transformers are connected across the rails, one end of the secondary being connected to the rail 4 and the other to its respective section of the other rail. 18 represents diagrammatically relays of the motor or other type bridged across the rails of the respective block-sections. These relays are not operative by the vehicle-propulsion current, whether it be direct or alternating, but only by a pulsating current. The relays have the current-closers 19, which control the signals 20 in a well-known manner. So long as the local circuits in which the signals are located are closed the signals indicate a clear track; but if this local circuit is for any reason opened the signal in such circuit at once indicates "danger." Inductive windings 21 connect the rails at each end of each section; but they may be differently arranged and may be constructed as shown in my application Serial No. 214,744. 22 represents the trolley-wire, third rail, or other means of distributing motive current, which is supplied by the generator 23 of direct or alternating current, one brush being connected to the feeder 22 and the other to the rail 4. 25 represents the vehicle provided with the trolley-pole 26, carrying the trolley 27.

The operation is as follows: The generator 10 is supposed to be supplying the transformers 16 with pulsating current, which the secondaries 17 impress on the rails of the block-sections, whence it passes through the relays, causing them to hold their armatures so as to close the local circuits, including the signals. This is the condition of each section when there is no train on that section.

When, however, a train enters a section, the trucks short-circuit the relay for that section, whereupon the local circuit is broken and the signal indicates "danger." As soon as the rails of the section are cleared the transformer-circuit again enters the relays and the local circuit is again closed, causing the signal to indicate "safety."

I will now explain the advantages which a pulsating signaling current offers in systems involving the principles of the present invention

If a direct current be impressed on a winding having an iron core, the latter will become magnetized to an extent depending on the strength of the current and the reluctance of the magnetic circuit. If an alternating current be simultaneously impressed upon the winding, the impedance of the winding to the alternating current will be inversely as the total magnetization of the core produced by the combined action of both currents.

Referring to Fig. 3, let the horizontal lines represent the total magnetization of an iron core traversed by a direct and an alternating current. Each line represents a density of one thousand magnetic lines of force per square centimeter. The line *a* represents the value of the magnetization at any point of the cycle when the winding is traversed by an alternating current only. The dotted horizontal line shows the magnetization of the core, if traversed by a direct current of some known value. The line *b* shows the magnetization of the core when the winding is traversed by both an alternating current and a direct current. As will be seen, the value of the magnetization will reach a high value at one part of the cycle and go down to zero at another part.

In Fig. 4 is shown by the curve *a* the magnetization of the core, due to a pulsating current of the same strength as the alternating current in Fig. 3, and by the dotted curve *b* the magnetization of the core when the winding also carries a direct current of the same strength as the direct current in Fig. 3. The maximum value of the magnetization, with the combined alternating and direct current, is eight thousand lines, (see Fig. 3,) while the maximum value of the magnetization with the combined pulsating and direct current is but four thousand lines. (See Fig. 4.) Therefore with the combination of the pulsating and direct currents the maximum magnetization of the core is far less than with the combined action of the alternating and direct currents. The unit of time on all these curves is measured on the horizontal lines. For instance, the distance from *c* to *e* may be considered a unit of time and for convenience in this case may be considered to equal one second. The value of the magnetization, the electromotive force, or the current strength is measured on a perpendicular to said lines. Therefore the magnetization, the electromotive force, or the current strength at any instant is equal to the distance at that instant on said perpendicular by any common scale.

Referring to Fig. 3, at any one instant, as at *c*, the strength of the alternating current, and therefore the magnetization thereby on the core, is zero. At the same instant the direct-current strength, and therefore the magnetization thereby on the core, is four thousand, and the sum of the two magnetizations is four thousand. At another instant, as at *d*, the alternating current produces a magnetization of four thousand and the direct current a magnetization of four thousand; or the two currents producing a total magnetization of eight thousand lines, and as this is measured at the maximum point of the magnetization due to the alternating current it is also at the point of total magnetization from the combined currents.

In Fig. 4 and in practice the direction of the pulsating current is made to traverse the windings 21 in opposition to the direct current. Therefore the total magnetization or the current strength is equal to the difference between the direct and the pulsating currents. This is plainly shown by Figs. 4 and 5, in which *a* represents the magnetization due to the pulsating current, the dotted line *e* the value of the direct current, (in all cases shown constant,) and *b* the resultant magnetization due to the two currents.

Fig. 5 shows the value of a pulsating current that could be used so that the maximum value of the combined direct and pulsating currents would be equal to the combined maximum value of the direct and alternating currents. This shows that a pulsating current having twice the strength of the alternating current could be used with the same direct current and still have the total maximum values equal. This figure is self-explanatory and needs no further comment.

Fig. 6 shows the characteristic of a pulsating current produced by the generator 28 of pulsating current, Fig. 2. In this case the pulsating current attains its maximum value but once in a revolution, as the current is produced only when the strip 29 is in contact with a brush. In Figs. 4, 5, and 8 the pulsating current attains its maximum value twice in a revolution. In Fig. 6 the pulsating current is zero for half a revolution; but I do not restrict myself to any particular form of pulsating current or to any means of generating same, as my invention broadly is any way of using a pulsating current in connection with a closed track-circuit of any description for railroads, both steam and electrical.

The dotted curves *f* in Figs. 5 and 8 show the relation of the current and electromotive force that could exist; but the displacement in phase indicated by the curves could be far more or less than shown. It depends entirely upon the capacity on inductance of the circuit.

By Fig. 7 I show how a high saturation is objectionable in an impedance-coil. In an impedance-coil the counter electromotive force equals the impressed electromotive force. To establish this counter electromotive force, it is a well-known fact that a certain number of magnetic lines of force per second must be looped within the winding. Should the core become nearly saturated by the direct current, it can then be readily seen that but few more lines could be forced through the core by the alternating current and that it would require a strong current to force these lines through the core, as the greater the density of the lines in the core the less the permeability of the iron, and therefore the greater the magnetic reluctance of the magnetic circuit.

In Fig. 7 the dotted line *e* represents the electromotive force necessary to produce the desired direct current and the desired magnetization due thereto. In this instance it is shown constant. The curve *a* shows the value of the counter electromotive force necessary to equal the impressed electromotive-force resistance of the coil being neglected. The curve *g* shows the value of the alternating current necessary to produce the counter electromotive force shown by the curve *a* when the core is acted upon by the direct current. The curve *b* shows the magnetization of the core due to the combined action of the direct and alternating currents.

If the magnetization of the core is not carried very high—say to four thousand lines per square inch—the current required to magnetize the core would be quite small and could be represented by the curve *a*. The higher the magnetization by the direct current the greater the flow of alternating current when coil is also subjected to an alternating electromotive force, and if the magnetization is carried very high by the direct current the value of the alternating current is therefore nearly infinitely great. As it is desirable to keep the alternating current at its lowest value, it can be readily seen that the magnetization of the core must be kept quite low, in the vicinity of four thousand lines per square inch, at ordinary frequencies.

It is desirable that the inductive bond 21 farthest from the transformer should take but little current. In this bond the pulsating current traverses the winding in the opposite direction to the direct or propulsion current. The reason less current is desirable at this point is on account of the drop due to the impedance of the rail to current of a large amount and low voltage, as it is very desirable that as high a voltage as possible should exist at the relay end with a minimum voltage at the transformer end.

The pulsating current in the inductive bond is in the same direction at the transformer end as the propulsion-current, and therefore takes more energy; but at this point the additional energy is not objectionable, as it is applied at a lower voltage than would be possible with an alternating current, and the consuming of energy at this point is not objectionable, as the apparatus can be designed to meet this condition

Having described my invention, I claim—

1. In railway signaling wherein a closed track-circuit is normally preserved, the motor-return current traverses the rails and the track and car-propulsion currents traverse the same inductive devices, means for impressing upon the track-circuit a signal-operating pulsating current and means for impressing upon the motor-circuit a current return of different character.

2. In railway signaling wherein a closed track-circuit is normally preserved, the motor-return current traverses the rails and the track and car-propulsion currents traverse the same inductive devices, means for impressing upon the track-circuit a signal-operating pulsating current and upon the motor-return circuit a current of different character, and causing the signal and motor-return currents to traverse the inductive device in opposite directions.

3. In a railway signaling system employing a closed track-circuit, a generator of pulsating current therefor, a car-propulsion motor operative by a direct or an alternating current having a track-return, and inductive device traversed by both currents.

4. In a railway signaling system employing a closed track-circuit, a generator of pulsating current therefor, a car-propulsion motor operative by a direct or an alternating current having a track-return, and inductive devices traversed in opposite directions by both currents.

5. In a railway signaling system employing a closed track-circuit, a generator of pulsating current therefor, a car-propulsion motor operative by a direct or an alternating current having a track-return, inductive devices and signal-actuating mechanism bridged in the rails of each block-section and means for permitting the flow of the return-circuit from one section to an adjacent section.

6. In combination in a signaling system, a closed track-circuit, a source of current pulsating in character, and a signal operative by such current.

7. In combination in a signaling system, a track-circuit permanently connected to the rails, means for producing a pulsating current for said circuit, and a signal operative by such current.

8. In combination in a signaling system, a

closed track-circuit, a source of current for propelling a car on the track, a source of pulsating current, and means whereby the signal is controlled by the latter current.

9. In a signaling system for electric railways, the combination of a plurality of block-sections, both rails of which are used for the return propulsion-current, a track-circuit for each block-section, a source of pulsating current for each track-circuit, a source of current for propelling cars on the track, means between adjacent block-sections for permitting the propulsion-current to pass from one block-section to another, but forming a path of high impedance to the pulsating current.

10. In an electric-railway signaling system having a closed track-circuit, a plurality of block-sections, a source of pulsating current for supplying the rails of each section, a signal for each block-section controlled by said current, a source of direct current for propelling the cars, and means for permitting the propulsion-current to traverse both rails of the block-sections.

11. A track-circuit for railway signaling systems comprising a source of unidirectional current-supply, automatically-operated means between it and the track-rails of the track-circuit for changing one of its characteristics, and a translating device responsive only to the operating-current in the track-rails.

12. A track-circuit for railway signaling systems comprising a source of unidirectional current-supply, a charging-circuit for said source, means between the source of continuous supply and the track-rails for changing one of its characteristics, and a translating device responsive to its operating-current in the track-rails.

13. A track-circuit for railway signaling systems comprising a source of unidirectional current-supply, a charging-circuit for said source, means between it and the track-rails for altering a characteristic of the unidirectional current, and a translating device responsive to the altered current.

14. A track-circuit for railway signaling systems comprising a source of unidirectional current-supply, an interrupter located in a connection of the source of supply with the track-rails whereby its character of unidirection is changed, and a translating device.

Signed at Pittsburg this 16th day of May, 1905.

LOUIS H. THULLEN.

Witnesses:
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