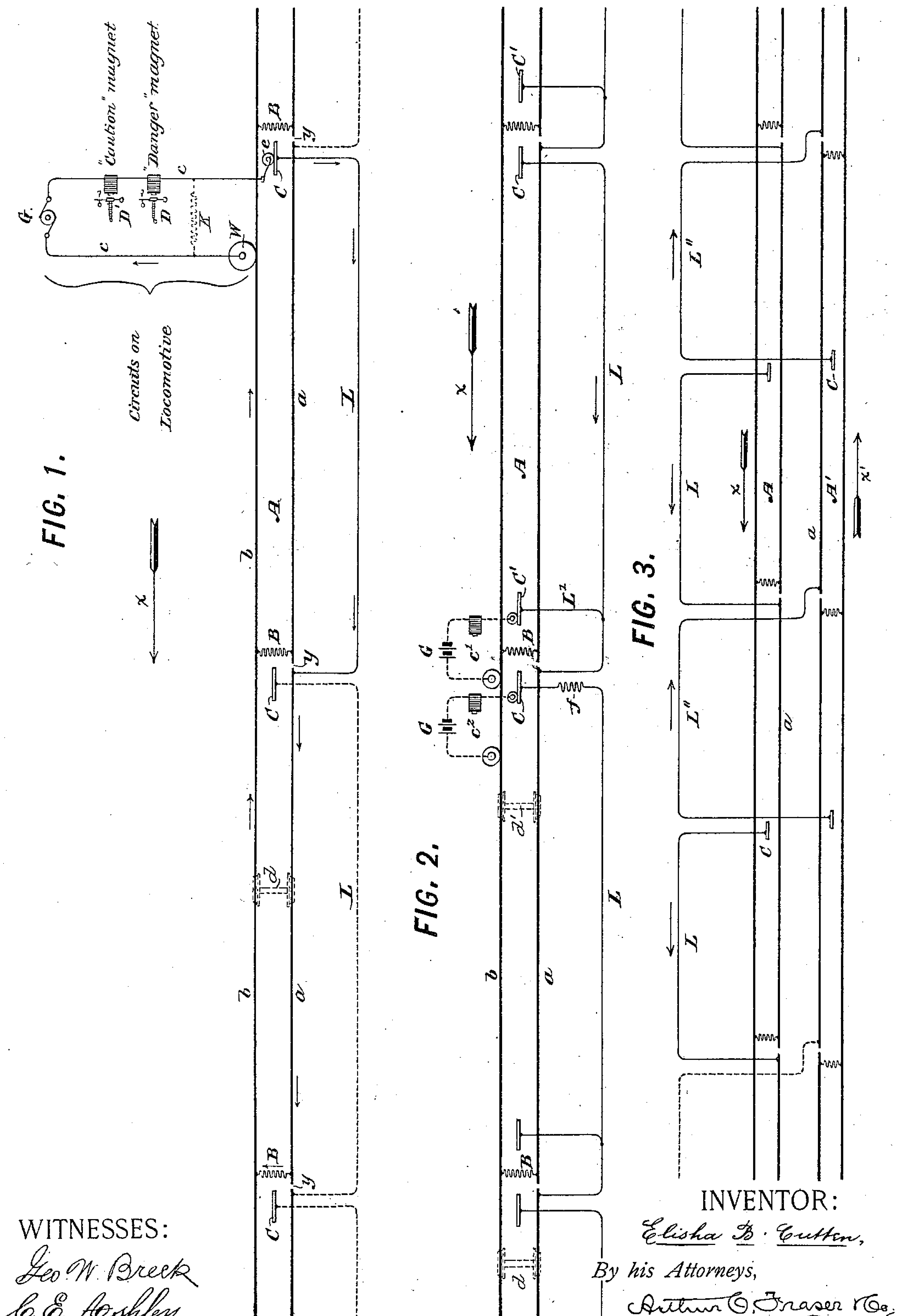
(No Model.)

5 Sheets—Sheet 1.

E. B. CUTTEN.

ELECTRIC SIGNAL FOR RAILWAYS.

No. 552,279. Patented Dec. 31, 1895.



WITNESSES:

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By his Attorneys,

Arthur C. Fraser & Co.

(No Model.)

5 Sheets—Sheet 2.

E. B. CUTTEN.

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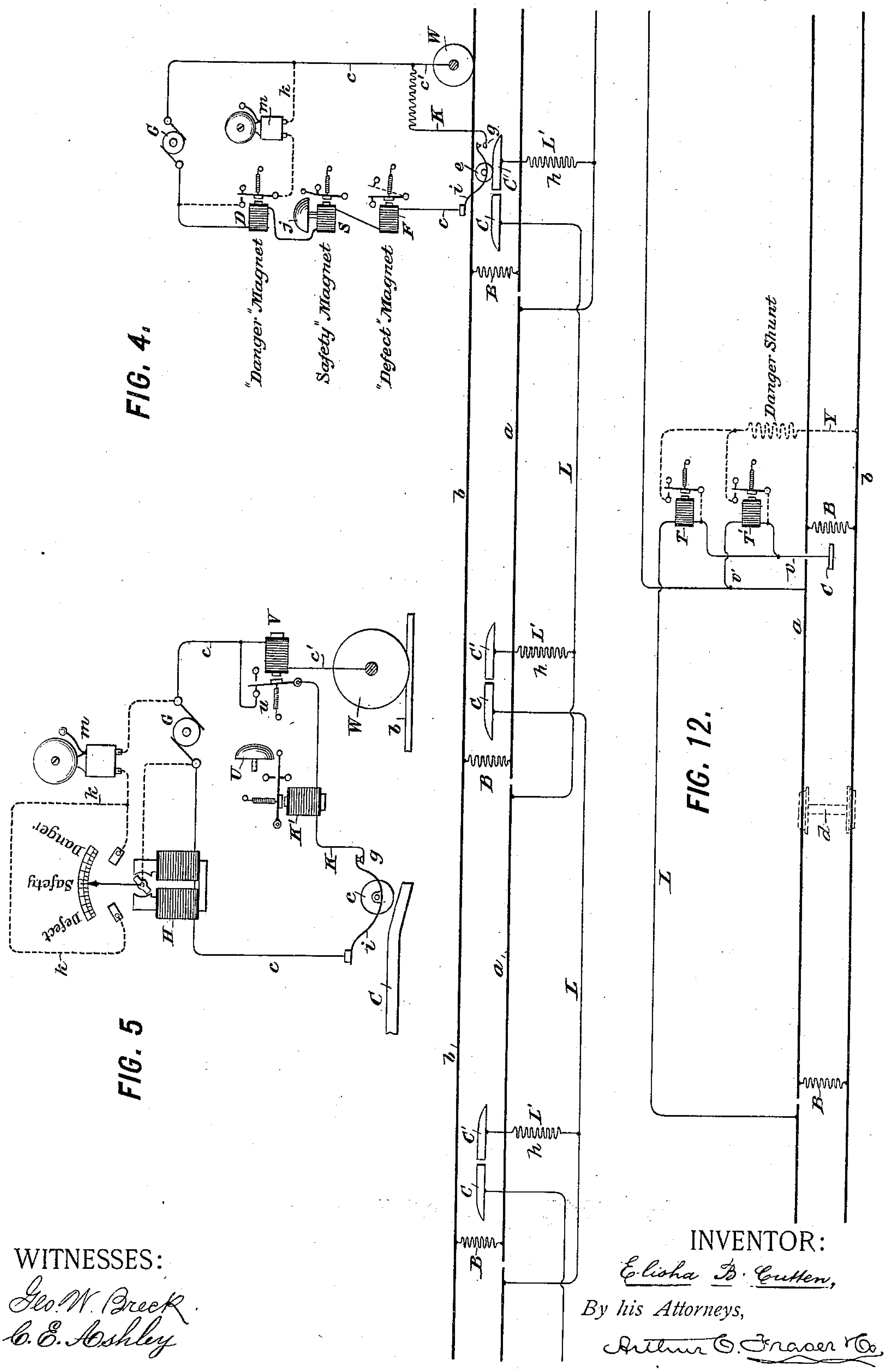

WITNESSES:

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(No Model.) 5 Sheets—Sheet 3.

E. B. CUTTEN.

ELECTRIC SIGNAL FOR RAILWAYS.

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FIG. 6.

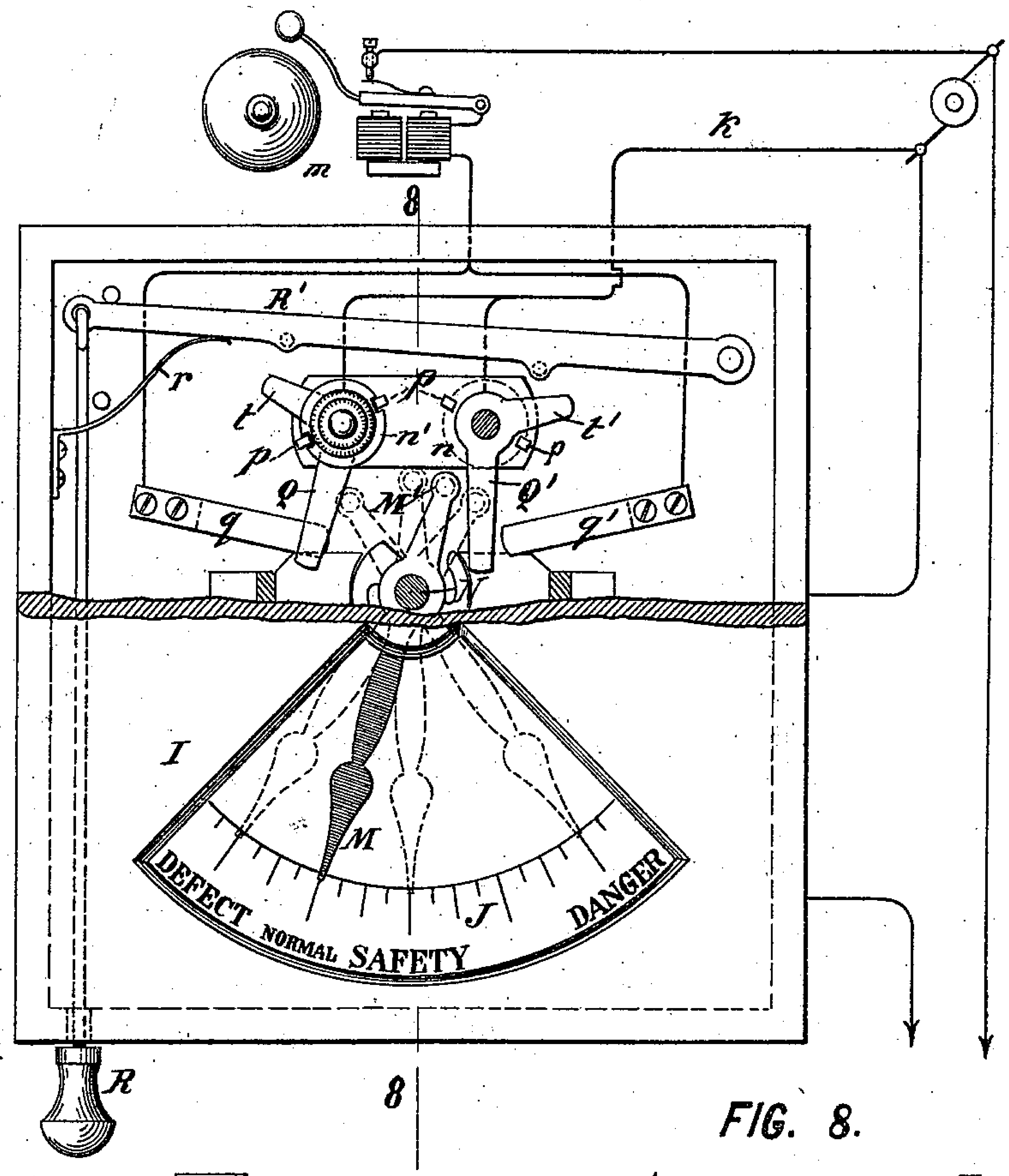


FIG. 7.

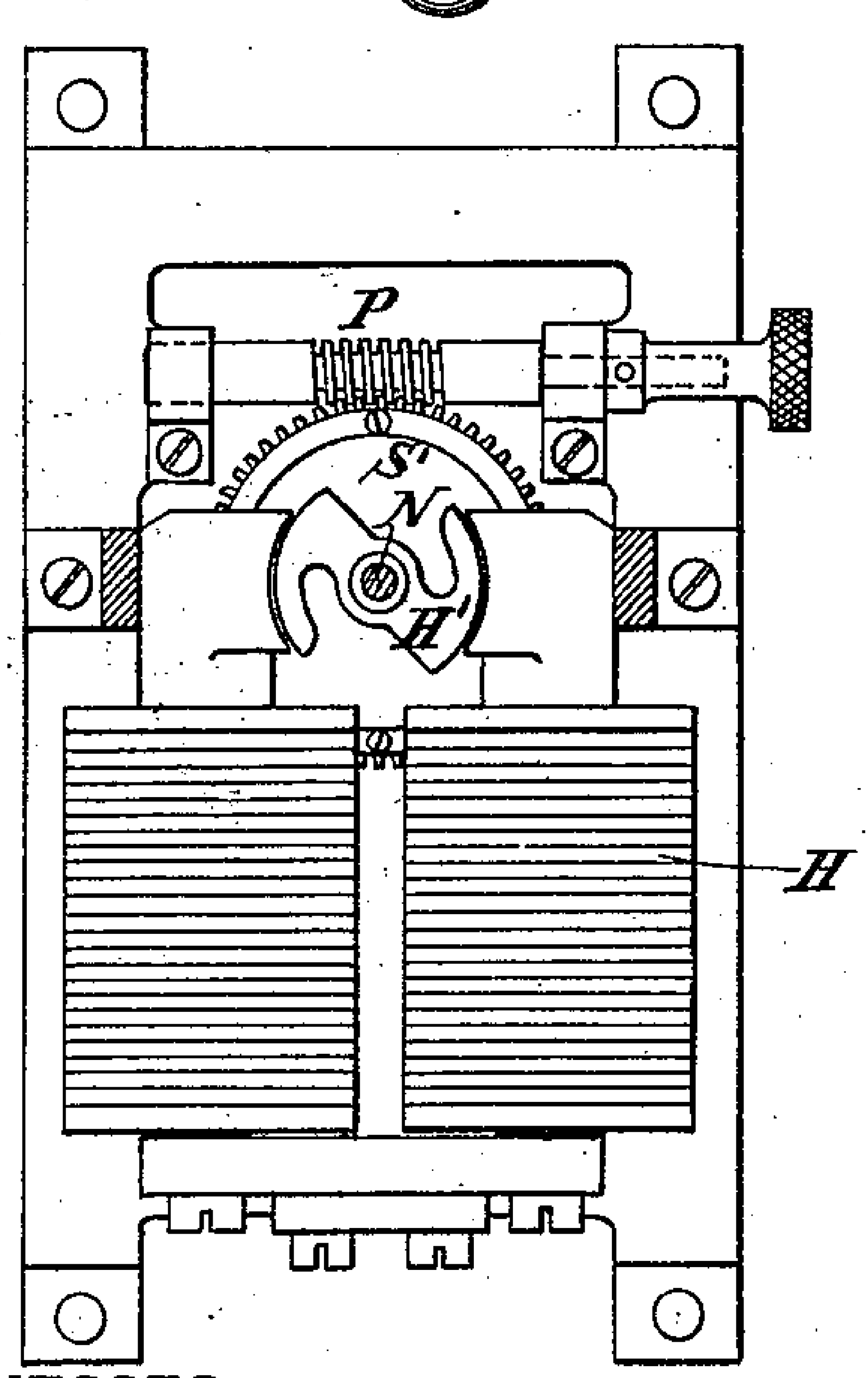
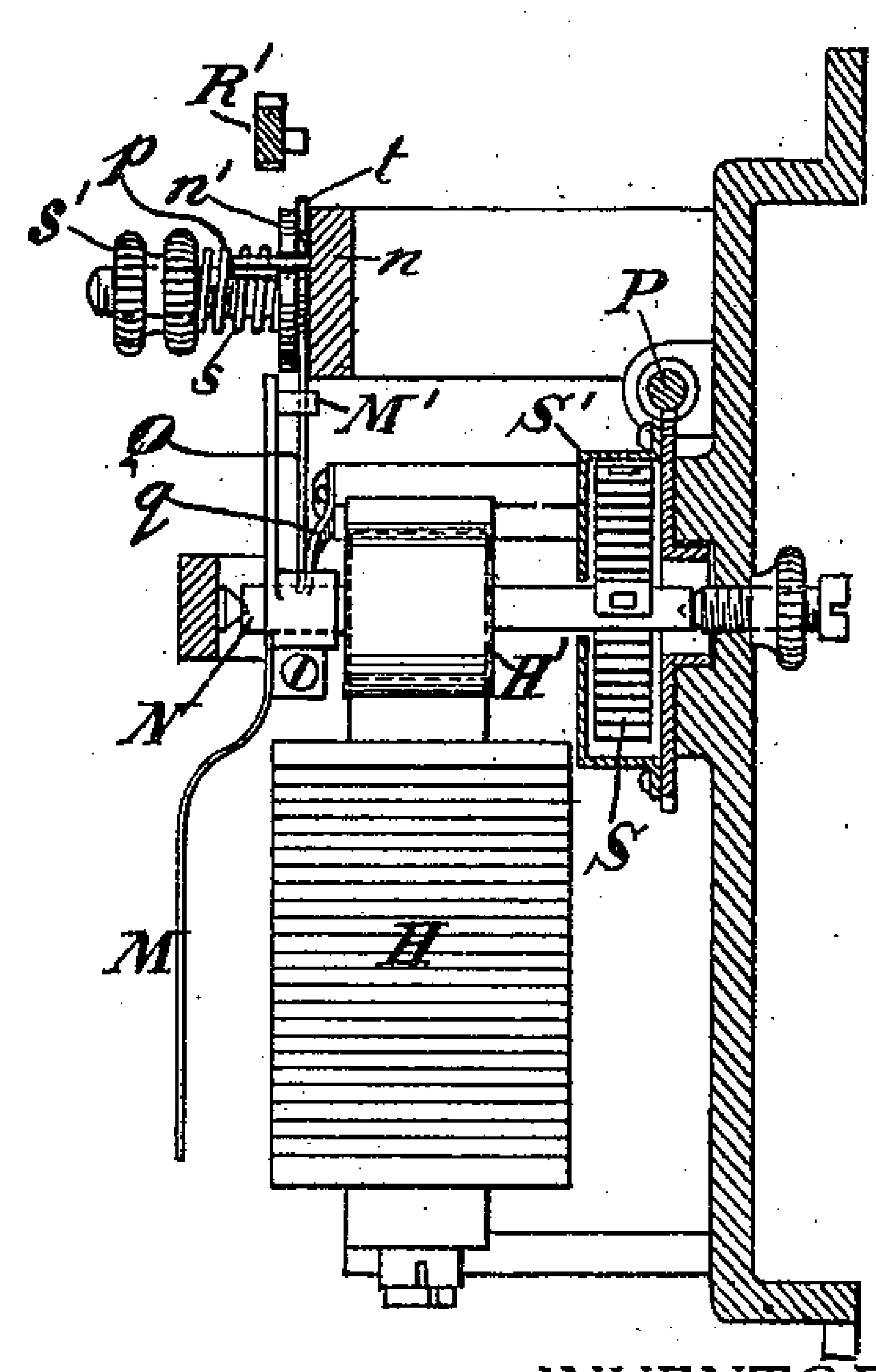


FIG. 8.



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(No Model.) 5 Sheets—Sheet 4.

E. B. CUTTEN.

ELECTRIC SIGNAL FOR RAILWAYS.

No. 552,279. Patented Dec. 31, 1895.

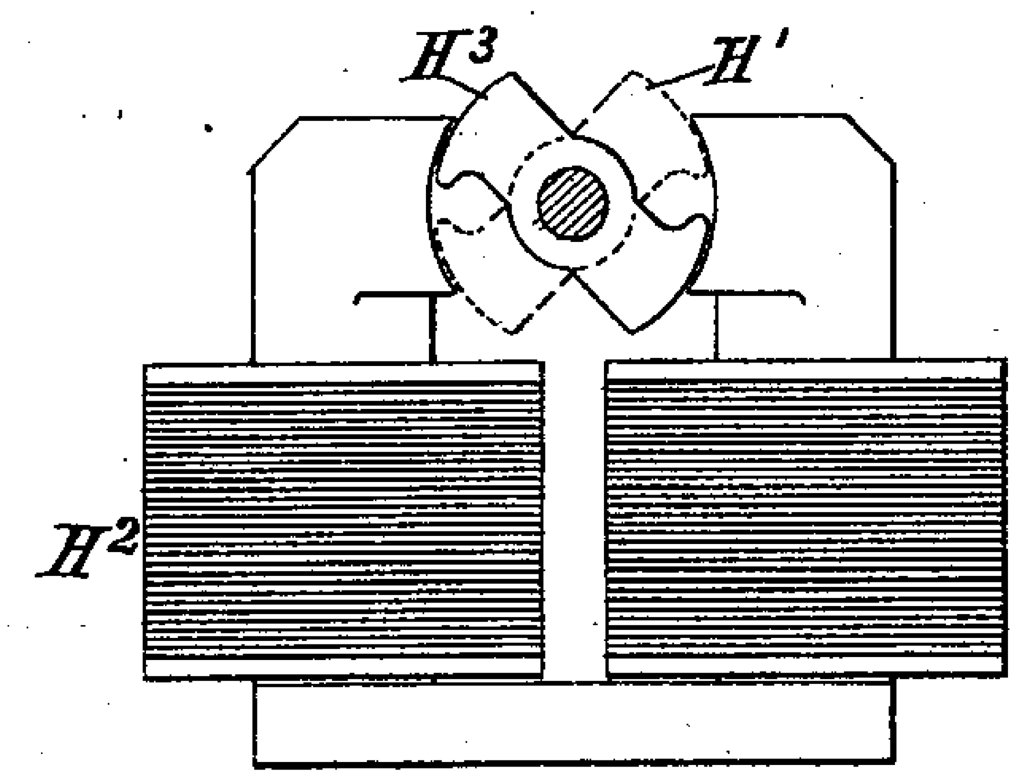

FIG. 9.

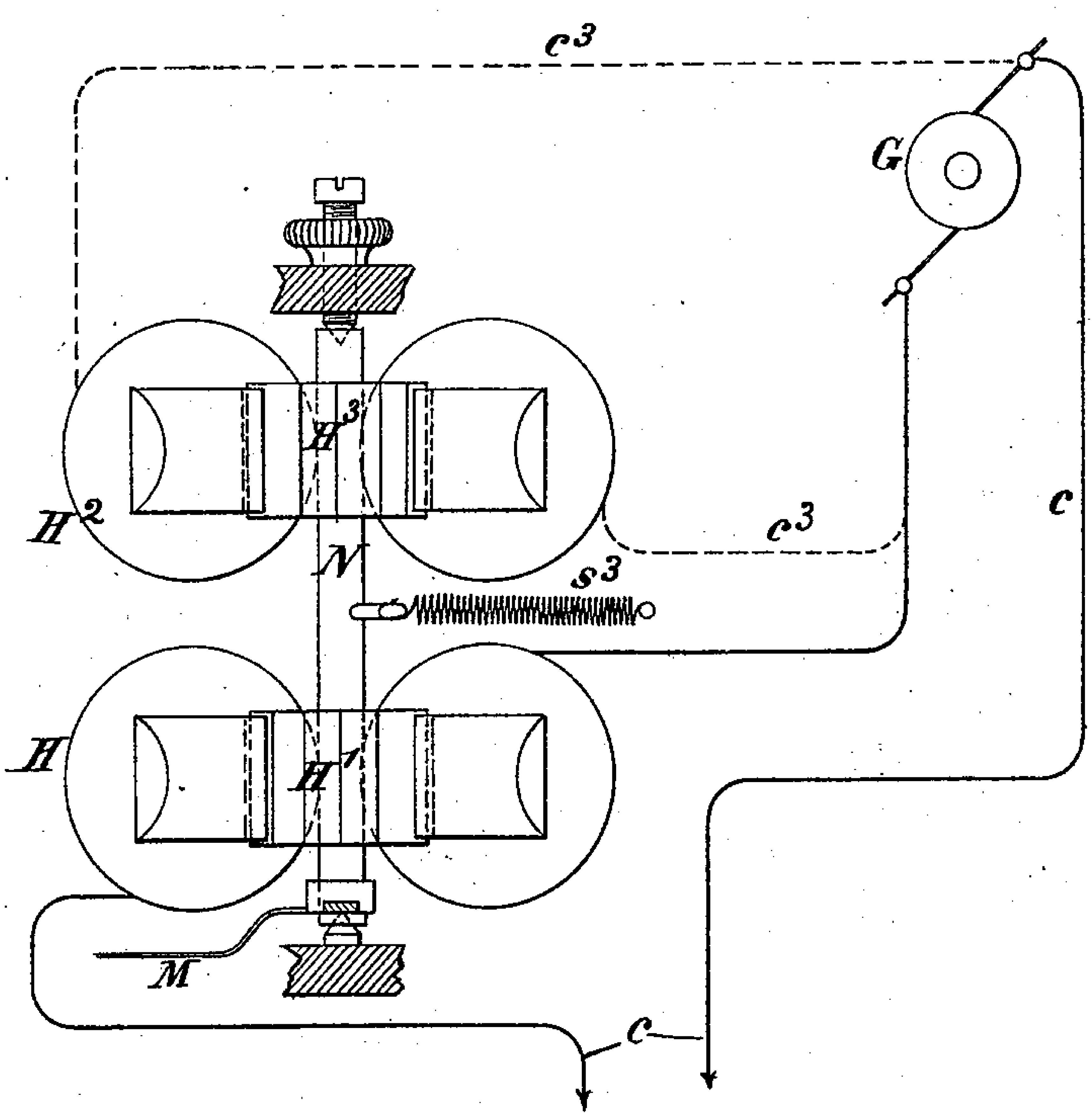

FIG. 10.

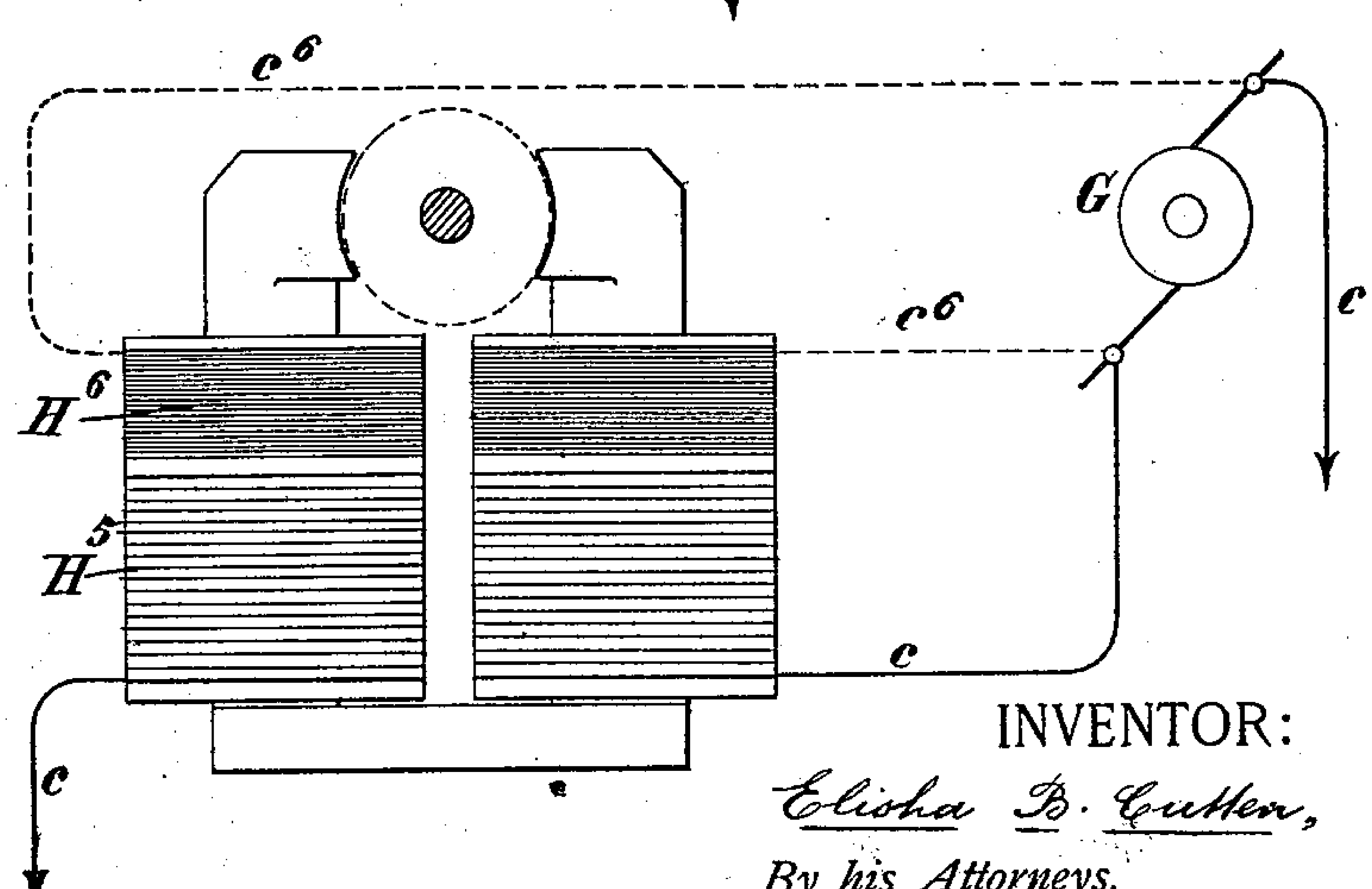

FIG. 11.

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(No Model.) 5 Sheets—Sheet 5.

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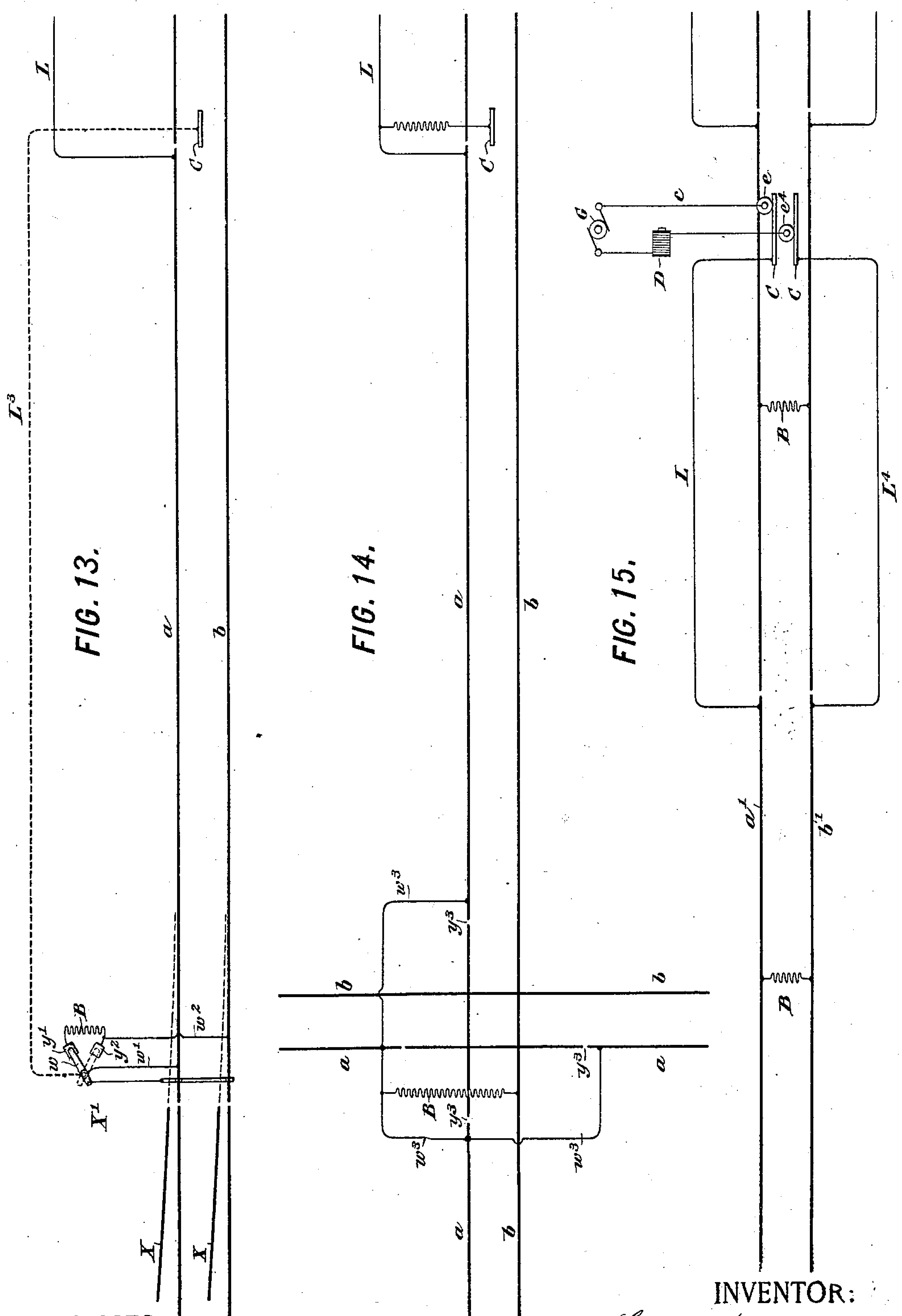

WITNESSES:

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UNITED STATES PATENT OFFICE.

ELISHA B. CUTTEN, OF NEW YORK, ASSIGNOR TO ARTHUR C. FRASER AND GEORGE H. FRASER, OF BROOKLYN, NEW YORK.

ELECTRIC SIGNAL FOR RAILWAYS.

SPECIFICATION forming part of Letters Patent No. 552,279, dated December 31, 1895.

Application filed April 1, 1891. Serial No. 387,215. (No model.)

To all whom it may concern:

Be it known that I, ELISHA B. CUTTEN, residing in the city, county, and State of New York, have invented certain new and useful Improvements in Electric Signals for Railways, of which the following is a specification.

This invention relates to electric signals designed to give warning to an engineer whenever he is running within a predetermined distance of a train ahead, an open switch, or other source of danger.

It has heretofore been proposed to operate block-signals by constituting the rails of the track a portion of an electric circuit on which a current is maintained constantly by means of a battery located alongside the track and whereby a relay is normally excited, but in case any of the wheels of a train rest upon the rails of the section or block thus protected the current from the battery is short-circuited through the wheels and axles and the relay is consequently demagnetized, so that by dropping off its armature it operates in some manner to give a danger-signal, usually by the breaking or closing of the circuit of an electromagnet which operates the signal, or which operates a pneumatic or hydraulic valve controlling a fluid-pressure which supplies the power necessary for operating the signal. Such systems as heretofore proposed have been applied to visual signals or semaphores located alongside the track at the entrance to the blocks. Such systems have proved objectionable by reason of the necessity for galvanic batteries located along the track, which require frequent recharging, are liable to freeze, and are a source of considerable expense. Notwithstanding these disadvantages such signals have met with considerable favor because of their capability, possessed by no other type of signals, of affording an indication of the existence of a train or any part thereof on the section or block of track in advance of an approaching train. In this respect such signals are greatly superior to those which depend wholly upon the setting of a signal to "danger" by mechanical or electrical means upon the passage of a train and its restoration to "safety" when the train passes off the block or section protected by the signal, or, in other words, when the train reaches a certain distance in advance, since with signals of this latter type no indication is afforded in case a train which has passed beyond and cleared the signal backs again onto the section, or in case a train breaks in two leaving a car or cars standing on the section or block.

My invention has a twofold object: first, to utilize the advantages of the rail-circuit system of signals while wholly dispensing with the objectionable batteries located alongside the track, and, second, to adapt such system to the giving of a warning-signal in the cab of the locomotive instead of or in addition to a signal displayed alongside the track.

To this end I provide the locomotive, and preferably each locomotive of a road, with a partial electric circuit including a dynamo or other suitable generator of electric energy, this partial circuit terminating on the one hand in the wheels of the locomotive and on the other in a contact device by means of which electric connection may be made with a contact rail or plate suitably provided at each signaling-point along the track. The track is provided with such a rail or plate at each point, and one rail of the track is divided by insulating breaks or spaces into sections or blocks of suitable length—say, for example, one mile. The contact rail or plate at each signaling-point is connected by means of a conducting wire or line with the insulated rail of a block in advance, either the one immediately in advance or the one next beyond, or with any insulated section of rail in advance, in order to conduct a current from the locomotive into the insulated section of rail traversing the block of track the condition of which is to be tested. Such insulated rail is connected through a suitable electrical resistance with the other rail of the track, which is undivided by insulations, and which constitutes a return-circuit. Whenever a locomotive thus equipped reaches a signaling-point, it sends a current through its contact device into the contact rail or plate along the track, thence through the conducting-wire to one end of the insulated section of rails, thence through these rails to the electrical resistance or bridge connecting them with the opposite rail, and back through the latter to the wheels of the locomotive, and thence back to the dynamo. In case there be no train on the section of track in advance the current must necessarily follow the path just indicated, and must traverse the resistance-bridge between the rails, so that only such current can pass under a given electromotive force as is proportional to the electrical resistance of the circuit thus formed. If, however, a train or part thereof be standing or in motion on the section or block in advance, the wheels and axles thereof form a short circuit between the track-rails of practically no resistance, thereby cutting out or short-circuiting the resistance-bridge, so that the current having no longer to encounter the resistance thereof traverses a circuit of much lower resistance than in the case first described, and according to the well-known law a much greater volume of current traverses the circuit. The proportions of the electrical resistances of the circuit may be such that the current in the former and in the latter case varies as one to two or as one to three, or in any other proportion within the limits of practicability. In order to utilize the variations of the current thus sent through the locomotive at the instant of passing a signaling-point, it is only necessary to introduce in the portion of the circuit carried by the locomotive an electromagnet which shall be insensible to the minimum current indicative of a condition of safety, but which shall respond and attract its armature when traversed by the augmented current indicative of danger. By the proper proportioning and adjustment of such a magnet it may be caused to give with great accuracy and reliability a perfect indication of the existence of danger ahead.

One important advantage of the rail-circuit system of signals first referred to wherein a constant current from the battery is maintained over a closed circuit is that in the event of any defect or break in the circuit the relay will be demagnetized and will give a signal of danger. My invention is susceptible of the same advantage, but instead of giving the same danger-signal to indicate both the existence of danger ahead and the existence of a defect in the circuit I provide for giving a separate and special indication of the existence of such defect. To this end I arrange the circuit carried by the locomotive to be normally closed so that a current is continually flowing, and in this circuit I introduce a magnet which I call the "defect-magnet," which normally holds its armature attracted, and I provide a circuit-breaker whereby whenever the contact device in connection with the locomotive-circuit makes contact with the contact rail or plate on the track this normal circuit is broken. It results from this that if the external or track circuit is complete, as it will normally be, the current on the locomotive-circuit will be maintained by this circuit being cut serially into the circuit along the track; but if the external circuit be incomplete or broken by reason of any defect the action of the circuit-breaker will be effective to break the locomotive-circuit and the current through the defect-magnet will be interrupted, thereby causing it to release its armature and thereby give a defect-signal. I consider such a separate defect-signal to be preferable to the employment of a single signal to indicate either absolute danger (denoting the presence of a train on the block ahead) or possible danger due to the fact that the signaling-circuits are inoperative.

My invention is also readily applicable for indicating in the cab of the locomotive the condition of a switch or drawbridge that a train is approaching. To this end I provide at a suitable distance in advance thereof a contact-rail along the track connected by a wire leading to the switch or drawbridge, where it connects with the return circuit rail of the track through the medium of an electric resistance, preferably the same as that of the resistance-bridge between the track-rails in the former instance. When the switch or drawbridge is properly set this resistance is included in the circuit; but in case the switch or draw is open this resistance is short-circuited by means of a suitable circuit-closer operated by the switch or by the locking-bolt of the drawbridge.

My invention is equally applicable to the indication of other sources of danger on railroads—such as grade-crossings, &c.

Having now stated the general nature of my invention, I will proceed to describe particularly how it may be applied in practice, with reference to the accompanying drawings, wherein—

Figure 1 is a diagrammatic plan of one track of a double-track railway, showing also diagrammatically the circuits on the locomotive according to one arrangement. Fig. 2 is a similar diagrammatic view showing a further development of my invention. Fig. 3 is a diagrammatic view showing both tracks of a double-track road equipped for signaling by my system by an arrangement which admits of the use of a single line-wire for giving the signals for both tracks. Fig. 4 is a diagram showing the track-rails of one track in plan and indicating in elevation the contact-rails and the wheels and contact device of the locomotive, and showing the several circuits diagrammatically. Fig. 5 is an elevation showing diagrammatically the preferred arrangement of circuits on the locomotive. Fig. 6 is a front elevation of one suitable form of signaling-box or dial-instrument to be placed in the cab of the locomotive. Fig. 7 is a front elevation showing the preferred construction of this instrument. Fig. 8 is a vertical midsection on the line 8 8 in Fig. 6. Fig. 9 is an elevation answering to Fig. 7, partly in vertical section and showing a further addition to the dial-instrument shown in Figs. 6 to 8. Fig. 10 is a plan of the instrument shown in

Fig. 9. Fig. 11 is a sectional front elevation answering to Figs. 7 and 9, and showing a modified construction. Fig. 12 is a diagrammatic view of a track and track-circuits, showing a modified means for applying my invention in connection with relays located alongside the track, whereby a single contact-rail may be used for testing both the block immediately in advance and the one beyond it. Fig. 13 is a diagrammatic plan of a track, showing the application of my invention to a switch. Fig. 14 is a plan of a track, showing the application of my invention to a grade-crossing. Fig. 15 is a track-plan showing a modification of my invention.

Fig. 1 shows my invention in one of its simplest forms. The track A, on which trains run in the direction of the arrow *x*, has one of its rails *a* divided by insulating-breaks at *y y* into blocks or sections of any desirable length—say, for example, one mile—while the other or return-circuit rail *b* is undivided, forming a complete electric conductor over its whole length. The insulations *y y* are made by means of insulated joints in any suitable known manner. An electric conducting-bridge B of suitable resistance is arranged to connect each of the rails *a* and the rail *b*, this bridge being arranged preferably at one end of each block or section. A conducting line or wire L is connected preferably to the opposite end of each section of rail *a*, and leads back for a suitable distance along the track, being connected to a contact rail or plate C at a signaling-point. The signaling-points are preferably arranged at the entrance to each block or a few hundred feet in advance. They may be constructed of an ordinary track-rail turned bottom upward and mounted somewhat above the level of the rails of the track with its ends bent downwardly to form gradual inclines.

The locomotive carries a circuit *c* fed by a dynamo or other generator G, and connected on the one hand to a contact-wheel or other suitable contacting device *e*, such as a metallic brush for sweeping over the rail C, and on the other hand it is connected to the frame and wheels of the locomotive, (designated by the wheel W.) In this circuit is introduced a danger-magnet D, and preferably also one or more other magnets. In Fig. 1 a caution-magnet D′ is shown. The full lines in Fig. 1 show the locomotive-circuit open or incomplete; but in practice a closed circuit is preferable. The circuit may be closed by introducing a conducting branch K containing a resistance. At the instant of the locomotive's passage past a signaling-point and while its contact device *e* is in contact with the rail C a current passes from the dynamo G through the circuit *c*, contacts *e* C, over line-wire L to the block in advance, through the insulated rail-section *a* thereof to the farther end, then through the resistance-bridge B, and back through the rail *b* to the locomotive, which it enters by its wheels W, and returns by the circuit *c* to the dynamo. The path of the current is shown in Fig. 1 by the small arrows. Let us assume the joint resistance of the line L and locomotive-circuit *c* to be three ohms and that of the bridge B to be six ohms, the resistance of the rails being so slight as to be inconsiderable. The total resistance then under the conditions stated being nine ohms, if the electromotive force of the generator G is nine volts, the current which will normally traverse the circuit will be one ampère. If, however, the rails *a b* are short-circuited by the presence on the block of the wheels and axles of a car, as denoted at *d*, the six ohms resistance of B is practically cut out, since practically all of the current will pass directly from rail *a* to rail *b* through the wheels and axles, thereby reducing the resistance of the whole circuit approximately to three ohms. With the electromotive force stated a current flowing under these circumstances will be augmented to three ampères instead of one. In order properly to give the danger-signal, then, it is only necessary to so adjust the retracting-spring of the danger-magnet D that the magnet will not be able to attract its armature with a current of one ampère, but requires a current of (say) two ampères to energize it sufficiently to overcome the resistance of the retracting-spring, so that with a current of three ampères, which will flow whenever the resistance B is short-circuited, the danger-magnet will inevitably act and give some suitable alarm to the engineer.

Since the rails *a b* are laid in the usual manner upon wooden ties, it is apparent that in wet weather there will be some leakage of current between them, which leakage will increase the current flowing under normal conditions when the rails are not short-circuited. Thus in the example given this leakage may perhaps amount to sufficient to increase the current from one ampère to one and one-half ampères. It is, however, obvious that the greatest possible leakage will afford much less conductivity than the absolute short circuit due to the presence of wheels and their axles bridging the rails.

To reduce the extent of leakage in wet weather, a much lower electromotive force may be provided for the dynamo G. It may be even as low as two volts, for example; but as this would necessitate a considerable increase in the expense of the conducting-wires, since the latter must be made of large size, I prefer a somewhat higher electromotive force, there being no difficulty in adjusting the magnet by which the signal is received to make it wholly insensible to the effect of the greatest current due to leakage and yet cause it to respond with certainty to the larger current due to the short-circuiting of the rails. I believe that an electromotive force of anywhere from four or five to ten volts, or even more, will be admissible.

Fig. 2 shows a further amplification of my invention. In the construction shown in Fig.

the locomotive receives at each signaling-point a signal indicative of the condition of the block in advance of the one which it is just entering. Under these circumstances it is possible that a train might have backed onto the block immediately in advance, or have run thereonto from a siding, since the time when the condition of that block was tested by the locomotive at the preceding signaling-point, and in such case, as the engineer received signals of safety (or absence of danger) both at the preceding signaling-point and at the one it has just passed, it would have no indication of danger, and would be apt to run into the train which has occupied the section or block it is entering. To avoid this possibility, I provide for taking an indication of the condition not only of the second block in advance, but also of the first block or the one which the locomotive is just about to enter. This may be done in the manner shown in Fig. 2, where two contact-rails C C′ are laid at each signal-point, the rail C′ being connected by a wire L′ with the line-wire L, or otherwise connected directly with the rail a of the block immediately in advance. When a train reaches the position indicated at c', it sends a current through contact-rail C′, wire L′, insulated rail a, conducting-bridge B and return-rail b, and if there be on this section any train or part thereof, as indicated at d', the short-circuiting of the insulation thereby will augment the current and cause a danger-alarm to be given. Immediately thereafter the locomotive on reaching the position indicated at c^2 will send a current through the rail C and line L to the second block ahead in order to receive the signal if that block is occupied. If it is desired to indicate to the engineer otherwise than by the successive order in which these two signals are received whether the source of danger is in the block immediately in advance or in the second block beyond, provision may be made for this by means of differentiating the signals. To this end the locomotive should be equipped in the manner shown in Fig. 1 with the danger-magnet D and a caution-magnet D′. The retracting-spring of the danger-magnet should be so adjusted that it will respond only to a current so augmented as to amount practically to a short circuit—that is to say, to a current corresponding to the resistance of the connecting-wire L′, added to the locomotive-resistance and the very slight resistances of the rails a b, so that this magnet will respond only in case the source of danger is in the block immediately in advance. The caution-magnet may be adjusted to respond to a current corresponding to the resistance of the entire line L plus that of the locomotive-circuit and the trifling resistances of the rails and short-circuiting wheels and axles, being in fact of the same adjustment as that of the danger-magnet first described. Under these circumstances the caution-magnet will be excited when the source of danger is in the second block ahead, and both magnets will be excited when the source of danger is in the block immediately ahead. To increase the range or difference of resistances between the circuits under these two conditions, an extra resistance may be introduced in the line, as indicated graphically at f, it being understood that in practice such extra resistance will be imparted by using a line-wire L of suitably smaller diameter. I would remark that I suggest this differential means of signaling merely to show the adaptation of my invention and not because I recommend it for practical use, as I consider a single danger-signal to be sufficient.

Fig. 3 shows an arrangement by which a single line-wire may be used for block-signaling on both tracks of a double-track railway. The two tracks A A′, on which trains run in the directions of the arrows x x', respectively, are divided into sections or blocks by the insulation of one rail a of each track, as before, and in the middle of each block is laid the contact-rail C. A line-wire L connects each contact-rail C with the insulated rail a of the section in the rear on the track A, and a line-wire L″ connects each contact-rail C on the track A′ with the insulated rail of the section in the rear. Assuming the sections or blocks to be one mile long, the line-wire from its contact-rail to the next section will be only one-half mile in length, so that each train receives a danger-warning one-half mile in advance of entering a section if that section be occupied by any car of a preceding train. This is suggested as an economical arrangement for wiring a road.

Fig. 4 shows the preferred equipment of the track according to my invention, and shows also a suitable locomotive-circuit for operating in connection therewith embodying the principle of my complete invention. By means of this apparatus a safety-signal is given if the track ahead is clear and the circuits working properly, or if the track ahead is blocked a danger-signal is given, or if any circuit-wire is broken or disconnected a defect-signal is given.

The track is divided into sections of suitable length, and at each section or signaling-point are laid two contact-rails C C′ arranged preferably end to end and with a space or insulation between their adjoining ends. Their remote ends are bent or beveled downwardly to form respectively rising and falling inclines to act upon the contact-wheel e carried by the locomotive. Preferably these rails are ordinary railroad-rails inverted so that the base-flanges thereof form contact-plates, the rails being mounted on insulated supports with their bases about two inches above the tops of the track-rails, but inclined downwardly at their ends to about the same level as or slightly below the tops of the track-rails. The contact-wheel e is hung beneath the locomotive or tender in such manner that it projects ordinarily to about one inch above the tops of the track-rails so that it shall not encounter them in crossing tracks or switches. On striking the contact-rail it is lifted about an inch above its normal position, and it rolls along the contact-rails, running off the first and onto the second, and finally running down the falling incline at the end of the latter. In the normal position of this wheel two contact or circuit-breaking stops *g* are in contact, and by the lifting of the wheel they are separated, thereby breaking the branch K of the circuit traversing these stops.

The arrangement of the resistance-bridges B B, the insulations between the rail-sections *a a*, and the connections of the line-wires L L are the same as in Fig. 1. Each rail C′ is connected by a wire L′ with the line L, or otherwise directly with the rail *a* of the block immediately in advance, in substantially the manner shown in Fig. 2, with one exception, however, that in this connection is introduced a resistance *h* equal to that of the line-wire L in order that when a current is sent through the rail C′ and connection L′ to test the block immediately in advance it shall traverse exactly the same normal resistance as if it be sent through the rail C over the line L to test the second block in advance.

The locomotive-circuit *c* fed by a dynamo G is a normally-closed circuit traversing the supporting spring or arm *i* of the contact-wheel *e* (or other suitable mounting for this wheel) and the contact *g* and branch K with its resistance. The circuit has a branch connection *c′* with the frame of the locomotive, and thence through the wheels thereof (designated diagrammatically by the wheels W) to the rail *b*. In this normally-closed circuit are included three magnets—the danger-magnet D, the safety-magnet S, and the defect-magnet F. The danger and safety magnets have their armatures normally retracted, while the defect-magnet normally holds its armature attracted. The only difference is in the tensions of the retracting-springs of the several armatures, that of the magnet F being so weak that the normal current will cause magnet F to attract its armature, that of the magnet S being somewhat stronger so that a current to a certain extent in excess of the normal current is required to energize the magnet S sufficiently to attract the armature, while the spring of the magnet D is still stronger, requiring a certain further augmentation of current to cause the magnet D to attract its armature. The armature of the magnet S carries a hammer which when attracted strikes a single blow on a bell *j*, or in lieu thereof some other means may be provided for giving a safety-signal. The armature of the magnet D is included in the circuit *k* of a rheotomic bell *m*, so that whenever the magnet D attracts its armature the circuit to this bell is closed and the bell will continue to ring until its circuit is broken, thereby affording an unmistakable warning to apprise the engineer of danger. Other means, however, of giving a danger-signal may be provided.

The operation is as follows: On the contact-wheel *e* being lifted by the first contact-rail, the normal circuit is broken at *g*, and if there be any break also in the outside circuit connections the current normally flowing through the magnets ceases, so that the defect-magnet F drops off its armature, thereby giving in any suitable manner a special alarm or signal indicative of the existence of a defect. If, however, the external circuits are complete, the current will flow through the contact-wheel *e* and whichever of the contact-rails it touches, through the line-wire or other connection, through the insulated section of rail *a*, through the resistance-bridge B, and back through the rail *b* to the wheel W and connection *c′* back into the locomotive-circuit. The resistance of the circuit thus traversed is less than that of the resistance in the branch K, so that upon the current thus flowing it is augmented to a degree proportionate to the greater conductivity, and this augmentation is sufficient to actuate the magnet S, the armature of which strikes a single blow on the gong *j*, thereby apprising the engineer both that the current has passed properly over the circuit ahead and that the block of track in advance is clear. If, however, the block ahead is occupied, the resistance B will be short-circuited by the wheels and axles, and the greater conductivity thereby afforded will cause an augmented current to flow, which will be sufficient to cause the magnet D to attract its armature and give the danger-alarm, thereby apprising the engineer of the existence of danger in advance. To accomplish these results it is only necessary to properly proportion the electromotive force, the respective resistances, and the tensions of the respective retracting-springs. For example, let us assume that six volts is the electromotive force, the resistance of the locomotive-circuit, including the branch K, is twelve ohms, the line-resistance, including the trifling resistance of the locomotive-circuit exclusive of K, is two ohms, and the bridge B is four ohms. Then during normal running the current on the closed locomotive-circuit will be one-half ampère, the current over the block in advance when unoccupied will be one ampère, which will be sufficient to operate the safety-magnet, and when the resistance-bridge is short-circuited by a train on the block in advance will be three ampères, which will be sufficient to operate the danger-magnet. The safety-signal is desirable because it gives the engineer a positive assurance of safety in advance and gives him confidence to proceed at full speed.

Fig. 5 shows another construction which embodies my complete invention in its preferred form. In this connection I use the dial-instrument shown in Figs. 6, 7 and 8 in lieu of the magnets D, S and F shown in Fig. 4.

The locomotive-circuit c is provided with circuit-breaking contacts g operated by the displacement of the contact-wheel e for breaking connection with the branch K, as before described. The resistance of this branch is here shown in the form of a coil K'. In the main circuit c is included the coil of the receiving-instrument, here lettered H. This instrument is made on the principle of an ammeter, having an oscillatory armature acting against a spring and moving in a polar gap of a horseshoe magnet, the attraction of which varies proportionately to the variations of current traversing it. This armature carries a hand which traverses a dial for showing the several indications of safety, defect, or danger. The same instrument also serves as a relay for closing the circuit k of the alarm-bell m. With the normal current the hand occupies one position, but in case the current is augmented to give a danger-signal the hand flies to the position marked "Danger," or in case the circuit is broken or the current considerably reduced it flies to the opposite extreme marked "Defect." This receiving-instrument H is preferably constructed in the manner shown in Figs. 6, 7 and 8. It is inclosed in a box or case I, in the front of which is an opening provided with a graduated scale J, over which moves a hand M. This hand is fixed on a spindle N, which carries the armature H' of the instrument. This may be a common **S**-armature, as shown in Fig. 7, or any other suitable form. To the spindle is also attached one end of a spring S, the other end of which is attached to its barrel S', and its tension is adjustable by turning this barrel by means of a screw or worm P. With every change in current the armature moves to a new position where the magnetic attraction is balanced by the retractive pull of the spring, and in so doing moves the hand to different positions on the dial corresponding to the different currents. To cause the instrument to act as a relay to close the circuit to the alarm-bell m, a pin M' is connected to the hand M or spindle N so that it moves therewith through a certain arc. As it approaches either extreme of its movement indicative of either defect or danger, this pin encounters one or other of two light sheet-metal arms or plates Q and Q' and displaces it sufficiently to bring it into contact with a spring or plate q or q'. The arms Q Q' are connected with one terminal of the bell-circuit k, and plates q q' with the other terminal thereof, so that when either arm is pushed onto its plate it closes the bell-circuit and causes the bell to ring. In order to cause the bell to continue ringing until it is stopped by an act of the engineer, I provide means for causing the arms Q Q' to frictionally retain any position in which they are placed, which may be done in the manner shown—namely, by clamping the pivotal portion of the arm by a light frictional pressure between a supporting-plate n and a frictional plate n', both stationary, the latter being pressed toward the former by a spring s regulated by nuts s' to exert more or less tension. The plate n' may be held stationary by pins p p fixed in the plate n. In order to restore the arms Q Q' and break the circuit, a knob R is provided, by pulling down on which either of the arms Q or Q' is brought back to its normal position. This knob is connected by means of a rod with a lever R' normally pressed up by a spring r and having projections which when it is drawn down encounter laterally-projecting arms t or t' formed on the respective arms Q Q'. In the drawings the hand M has just swung to "danger" and back, and in doing so has displaced the arm Q from its normal position and into contact with the strip q, thereby closing the circuit to the bell, which is ringing and will continue to ring until the knob R is pulled down. This dial instrument may be operated in either of two ways. According to the first method the hand may normally stand in the mid-position, indicating "safety," as shown in Fig. 5, and may be deflected to one side by an augmented current to indicate "danger" or "caution," and to the other side by a broken or materially-reduced current indicative of "defect." According to the other method the hand may normally occupy a position between "safety" and "defect," as shown in Fig. 6, so that on reaching a signal-point it is bound to assume one of three positions—namely, either that marked "Defect" in Fig. 6, (corresponding to the operation of the defect-magnet in Fig. 4,) or that marked "Safety," (corresponding to the operation of the safety-magnet in Fig. 4,) or that marked "Danger," (corresponding to the operation of the danger-magnet in Fig. 4.)

One advantage of the dial-instrument thus described is that it enables an allowance to be made for the different operations of the signals due to leakage of current in wet weather. With a magnet-instrument reliance must be placed on the graduation of the retracting-springs relatively to the varying strength of the magnets under different currents. Such adjustment once correctly made may be relied upon if proper margin be allowed under any ordinary circumstances. It is, however, desirable to provide for indicating to the engineer the exact magnetic strain upon the signal-receiving instrument, and this the dial-instrument provides. So long as the hand habitually stands at the graduation indicating its correct normal position, the engineer knows that all adjustments are correct. In ordinary weather the hand should move exactly to the graduations indicative of "safety," "caution," or "danger," as the case may be. In wet weather the leakage will proportionally augment the current, and the hand should move a certain distance beyond these graduations. An engineer will quickly learn what extent of such excessive movement is to be expected for each different condition of weather or track—for example, a certain extent for snow, a certain other extent for slush, and a certain other extent for a rain where the ties have become soaked. He will instinctively make a proper allowance for this excessive movement proportionally to his knowledge of the effect of different conditions, thereby performing an unconscious mental calibration of the signaling-instrument. Obviously the correct operation of this dial-instrument, or in fact of any magnetic receiving instrument under my system, is dependent upon the proper or standard electromotive force being maintained. An excessive electromotive force would tend to increase the current and tend to give delusive danger-signals, while too low an electromotive force would have the contrary effect. In practice I provide means for accurately controlling the electromotive force generated by the dynamo through the medium of a magnetic governor controlling the admission of steam to the engine or motor which drives the dynamo, and so long as this governor does its work properly the signaling system will be reliable. To provide, however, for the possible contingency that the governor should become deranged, I have devised a further addition to the dial-instrument, by means of which any fluctuation of potential above or below the normal will exert a compensating effect upon the instrument and thereby cause it to give the correct indication notwithstanding such fluctuations. To this end, instead of using the invariable retractile force of a spring for retracting the armature of the instrument, I employ an electromagnetic retractile force which rises and falls in proportion to the fluctuations of electromotive force. This is readily accomplished by providing a special retracting-electromagnet which acts upon either the same armature as the attracting-magnet H or upon a separate armature connected thereto. This retracting-magnet may act to attract or to repel the armature, the only essential being that its action shall be contrary to that of the attracting-magnet and shall fluctuate proportionally to the fluctuations in electromotive force. Figs. 9 and 10 show an addition to the instrument for carrying out this principle. Fig. 10 is a plan showing two electromagnets H and H^2 acting both on armatures H' and H^3, respectively, both fixed on the same spindle N. Their relative arrangement is shown in Fig. 9, where the armature H' of the attracting or signal-receiving magnet H is shown in dotted lines, and the armature H^3 of the retractile magnet H^2 is shown in full lines. The magnet H^2 has its coils introduced in a shunt c^3 between the dynamo-terminals, so that its magnetism rises and falls proportionally to any rise or fall of potential. The proportions should be such that any fluctuation of potential will affect the two magnets equally, so that each will increase or decrease its attraction for its armature in the same ratio as the other, which attracts it oppositely, thereby causing the pointer to remain stationary, or, if at the instant of receiving a signal, causing the pointer to assume the same position that it would have assumed had the electromotive force continued unchanged. In order to cause the instrument to indicate a defect in the event of an entire cessation of current, a light retracting-spring s^3 is provided having sufficient power to throw the needle to the position of "defect," when substantially all magnetic strain ceases. Fig. 11 shows a modification wherein substantially the same compensating effect is produced by the use of a single magnet, the mechanical construction of the instrument being the same as in Figs. 6 to 8. The magnet is one with two coils—a main coil H^5, included in the locomotive-circuit c, and a supplemental coil H^6, included in the shunt c^6, between the dynamo terminals. This supplemental coil is inversely connected, so that with any increase of potential the increased current acts to demagnetize the magnet to the same extent as the increased current through the coil H^5 tends to increase its magnetization. The armature-lever carries a hammer, which on its retractile stroke strikes a bell U, which may be located in the cab. On hearing this bell the engineer will instantly glance at the dial and notice what movement is executed by the hand. He should do this quickly, because the hand returns in a very short time, depending on the speed of the locomotive and the length of the contact-rail, to its normal position. If, however, he fails to glance at the dial in time, he may rely on the audible signal—that is to say, if only the bell U is struck it means "safety," but in case of either danger or defect the continuously-ringing bell m is started. In depending solely on the audible signals the engineer cannot tell whether the bell rings for actual danger or for a defect; but the difference is not important, as he should regard a defect-signal as being practically a signal of danger. If preferred, however, two different bells may be provided, one to be rung for danger and the other for defect, so that the engineer may distinguish by the difference in tone or rapidity of ringing of these bells whether the signal was of defect or danger.

It will be understood that the breaking of the circuit at g does not occur instantly, but that an appreciable time intervenes between the instant when the wheel e first reaches the contact-rail and the instant when, by having traveled up the inclined end of this rail a sufficient distance, it separates the contacts g and breaks the circuit K. During this interval the current on the normal circuit will, except in the case of a defect in the external circuit, be somewhat excessive, being the sum of the current over the line plus the normal current. Thus in case of a safety-current over the line of one ampère and a normal current of one-half ampère, the current on the circuit will for a moment be increased, not to one ampère, as it should be, but to one and one-half ampères. In the case of a separate safety-magnet, as shown in Fig. 4, set to respond to one ampère and a danger-magnet set to respond to considerably above one and one-half ampères, (say, to three ampères, as hereinabove described,) this abnormal current, however prolonged, will not derange the signals. In the case of a dial-instrument its only effect will be to carry the hand somewhat beyond the "safety" point; but in case of a rapidly-moving train its duration will be so brief that this effect will be ordinarily imperceptible; but in case the train is moving very slowly this extra current will have the effect of carrying the hand too far and might lead to some doubt on the part of the engineer whether the signal intended was not a danger-signal. Sometimes, also, in the case of a magnet-instrument, as shown in Fig. 4, it may be desirable to allow so little margin between the volume of current acting on the safety and danger magnets as to render it desirable to eliminate this extra current. For this purpose I provide a special circuit-breaking magnet V, as shown in Fig. 5, which acts instantly to break the circuit-branch K as soon as a current is instituted over the external circuit. This magnet V has its coil included in the branch c' leading to the earth connection—that is, the frame and wheels of the locomotive—so that it is over this branch that the connection is made with the external circuit. As soon as the wheel e touches the rail C, a current will flow if the external circuit be complete, and the magnet V will instantly respond thereto, thereby attracting its armature, the lever of which is included in the circuit-branch K, and drawing it out of contact with the stop u. This action will occur so quickly as to break the branch K to all effect simultaneously with the passage of the current over the external circuit and far more rapidly than the mechanical circuit-breaker g can possibly act, so that the augmentation of current due to the super-position of the normal current upon the current over the external circuit can have no effect upon the indicating magnets or instruments, since the magnet V by reason of its greater sensitiveness, the less inertia of its armature, and the lighter tension of its retracting-spring will act far more quickly than the indicating magnets or instrument can act. The function of the mechanical circuit-breaker g is consequently reduced to the breaking of the circuit-branch K to give a defect-signal in case no current is passed over the external circuit.

In the modification shown in Fig. 12 only one contact-rail C is employed at each signaling-point for testing both the block immediately in advance and the second in advance. Two relay-magnets T and T' are arranged in two branches or derivations of the circuit-wire v leading from this rail. One of these branches after traversing the coil of the magnet T extends forward as the line L to the signaling-block in advance, while the other branch (lettered v') after traversing the coil of the relay T' connects with the rail a of the block immediately in advance. The armature-levers of the relays T and T' are drawn off by springs adjusted so that the normal or safety current traversing the relay and the resistance or bridge B will not be sufficient to enable the relay to attract its armature; but in case the bridge B is short-circuited by a wheel and axle, as at d, the augmented current consequently flowing through the relay-coils excites the relay sufficiently to cause it to attract its armature. The armature-levers of both relays are included in two derivations of a local circuit or danger-shunt lettered Y, extending from the contact-rail C to the return-circuit rail b. The conductivity of this shunt is such that when it is introduced in circuit it gives a signal of "danger." Consequently if either of the relays is strongly excited by the current due to the short-circuiting of either bridge B, and consequently attracts its armature, it closes the danger-shunt and thereby opens a path of greater conductivity than that through either relay and line, thereby insuring the giving of a danger-signal. This construction is not my sole invention, but is here introduced as a modification to illustrate one of the applications of which my invention is susceptible. It is chiefly advantageous in case a relatively high potential is used, which, if sent directly over a line of low resistance, would create so great a difference of potential between the rails a and b as to give rise to a greatly increased volume of leakage between them in wet weather, so that this leakage might become sufficient to give of itself delusive danger-signals. In such case it is necessary to reduce the difference of potential between the rails by interposing a sufficiently high resistance to cut down the initial electromotive force to the required limit. For example, if fifteen volts is used, and the desirable difference at the rails is three volts, a resistance of twelve ohms must be introduced between the rail a and the contact-rail C; but this proportionately reduces the margin of current flowing under the respective conditions of safety and danger, so that, assuming that the bridge B is three ohms and making no allowance for leakage, the safety-current will be one ampère, while the danger-current, instead of being two or three times as great, will be increased only to one and one-quarter ampères. This margin of difference might not be safely relied upon for operating an instrument carried by the locomotive and subjected to the violent shocks and jars thereof, but is amply sufficient to operate a relay alongside the track, where it can be mounted on a foundation free from vibration, and which admits, also, of a nice adjustment. By the construction shown, the operation of such a relay is utilized to throw in a sufficiently greater conductivity to operate a receiving-magnet on the locomotive capable only of a coarse adjustment. It is also an advantage of this arrangement that it dispenses with one of the contact-rails C C′ for making a test of two blocks at once. A defect-signal can be given by adjusting the defect-magnet F, in Fig. 4, to drop off its armature, in case the current falls below that equal to the combined currents flowing through both relays when both blocks are at "safety," so that in case any defect exists which prevents the passage of a current through either relay the current will thereby be reduced one-half, and this reduction will actuate the defect-magnet.

Fig. 13 shows the application of my invention to signaling the condition of a switch. I have shown an ordinary stub-switch leading from the main track to a siding lettered X and operated by a switch-post X′. This post carries a circuit-closing arm or spring w, which may be connected by a wire w' with the rail a, or by a line-wire L^3 with a contact-rail C at any suitable distance. In the closed and open positions of the switch the circuit-closing arm w touches contact-plates y' y^2, respectively, between which is introduced the resistance B. This resistance is connected between the rails a and b by the wires w' w^2. In the normal position of the switch the current will pass either from the contact-rail C over the line L^3 to the switch-post, or from a more remote contact-plate over the line L and rail a and wire w' to the switch-post, and from the switch-post by the arm w, plate y', resistance B, and wire w^2 to the rail b, and back through this rail to the signal-point whence it comes. If, however, the switch is misplaced, the arm w rests on the plate y^2, so that it short-circuits the resistance B and will thereby give a danger-signal. If by accident or through breakage the switch or post should stand in any intermediate position, the arm w would touch neither plate y' nor plate y^2, thereby leaving the circuit open and giving a defect-signal.

Fig. 14 shows one suitable arrangement for signaling by my invention in the case of tracks crossing at grade, so that if a train is on either of the tracks within a certain predetermined distance of the crossing a train approaching on either of the tracks will receive the danger-signal. To render the figure simple I have shown only one track of each of the crossing roads, which are supposed to be double-track roads. All of the rails a are insulated at y^3, adjacent to the crossing, and all are connected together by intervening wires w^3, so that a current sent over either rail a may pass into any of the other rails a, and thence through any axle and wheels which may short-circuit them, to any of the rails b, all of the latter being in metallic contact to form a return-circuit. The normal resistance of the bridge B may be introduced between any of the rails a and any rail b, or between any of the wires w^3 and any rail b. The arrangement for a double track is the same, except that there are more rails a a to be connected together by wires w^3.

My present invention provides a means for carrying out the principle or generic means for signaling described and claimed in an application filed by myself and Arthur C. Fraser February 6, 1891, Serial No. 380,444. Nearly any one of the modifications described therein may be used in connection with my present invention.

The contact device for making connection with the contact-rail C may be variously constructed, it being immaterial to my present invention what means is employed for this purpose. I prefer the contact device claimed in an application about to be filed by Arthur C. Fraser and myself, and to which reference may be made for a full description and illustration of the particular construction preferred.

I have referred to the rail b as the "return-conductor." It is preferable to use this rail as such conductor because it saves laying a return-wire, and also because it is preferable to utilize the frame and wheels of the locomotive as the means of effecting the return or ground connection with the locomotive-circuit. These arrangements, however, are not essential, since a return-wire may be employed and may connect with a contact-rail instead of using the track-rail for this purpose. This modification is shown in Fig. 15, where a' and b' are the respective rails, both divided by insulations into sections or blocks, the former connected by the line L with contact-rail C, as before described, and the latter connected by the line L^4 with the contact-rail C^4. The rails C C^4 are touched simultaneously by contact-wheels e e^4 carried by the locomotive, and forming the respective terminals of the locomotive-circuit c.

My invention is not limited to signaling from a locomotive to a section of track in advance, as it is equally applicable to signaling from a stationary point along the line to ascertain whether a section of track is occupied or clear. In the latter case the same circuits are employed, the only difference being that the contact connections e C on the one hand and W on the other, which are necessary in connecting the moving with the stationary circuit, may be omitted.

I have herein referred to the audible signal or alarm as being given by an electrically-operated bell. This is, however, not essential, as any other alarm device may be substituted—such, for example, as a whistle—or a visual signal alone may be relied upon.

The dial receiving-instrument, as described, is not necessarily limited in its application to locomotive-cab signals for sending a testing-current through the rails of the track, but may be operated by other means—as, for example, by means of a current through the increased conductivity of a danger-shunt—such as the shunt Y in Fig 12.

I claim as my invention the following-defined novel features or improvements, substantially as hereinbefore specified, namely:

1. The combination with a railway track divided by rail insulations into conducting sections or blocks, a resistance bridge introduced between the opposite rails of a block, and an electric generator and signal-receiving magnet adapted to be introduced at a signaling point between the opposite rails of a block, said magnet constructed to give a signal upon reaching a certain excitation, whereby on sending a current over said section it normally excites said magnet to a predetermined extent, but if said interposed resistance be short-circuited by the presence of a car or train on said section the consequent augmentation of current will increase the excitation of said magnet and give a danger signal.

2. A railway track divided by rail insulations into conducting sections or blocks, a resistance bridge introduced between the opposite rails of a block, and a contact rail electrically connected to an insulated rail section, in combination with a locomotive provided with an electric circuit in connection with a contact device adapted to make contact with said contact rail, a generator in said circuit, and a signal-receiving magnet or instrument insensible to a current traversing said rails and interposed resistance but actuated by an augmented current flowing when said resistance is short-circuited by the presence of a car or train on the insulated section.

3. A railway track divided by rail insulations into conducting sections or blocks with a signaling point preceding each section, a resistance bridge introduced between the opposite rails of a section, a contact rail or rails at each signaling-point, and an electric connection between the one insulated rail of each section or block and a contact rail at an adjacent signaling-point and between said insulated rail and a contact rail at a more remote signaling-point, whereby an approaching train will first make connection with the last named contact rail to test the section or block in advance of reaching it, and will subsequently make contact with the first named contact rail and again test the section or block as it is about to enter it.

4. A railway track one rail of which is divided by insulations into conducting sections or blocks, resistance bridges introduced between the insulated sections and the opposite rail, two contact rails at each signaling-point, an electric connection between one of said rails and the insulated rail of the block next in advance, and a line wire constituting an electrical connection between the other of said rails and the second section or block in advance.

5. A railway track divided by rail insulations into conducting sections or blocks, a resistance bridge introduced between the opposite rails of a section, a contact rail or rails at a signaling-point, and an electric connection between one insulated rail of each section or block and a contact rail at an adjacent signaling-point and between said insulated rail and a contact rail at a more remote sinnaling point, and a resistance interposed in said former connection equal to the resistance of the longer connection between said rail and the contact rail at said remote point, whereby a current sent under a given electromotive force from either of said rails will be of equal volume under the same condition of the block.

6. A railway track divided by rail insulations into conducting sections or blocks, a resistance bridge introduced between the opposite rails of a section, and contact rails each electrically connected with one of said insulated rail sections, in combination with a locomotive provided with an electric circuit in connection with a contact device adapted to make contact with said contact rails in passing, a generator for feeding said circuit, and a signal-receiving instrument or instruments in said circuit controlled by the volume of current therein and adapted to give an indication of safety upon an augmentation of current due to the current traversing the resistance of the circuit connection to an insulated rail section and the resistance between it and the opposite rail, and adapted to give an indication of danger when the current is augmented by the short-circuiting of said interposed resistance as by the presence of a car or train on the section or block.

7. A railway track divided by rail insulations into conducting sections or blocks, a resistance bridge introduced between the opposite rails of a section, and contact rails each electrically connected with one of said insulated rail sections, in combination with a locomotive provided with a normally-closed electric circuit, a circuit-breaking contact device in said circuit adapted in passing over a contact rail to make contact therewith and be displaced thereby and by such displacement to break the normal locomotive circuit, an electric generator for feeding said circuit, and a signaling instrument or instruments controlled by said circuit and comprising means for giving a defect signal by a certain diminution in the volume of current in said circuit, and a danger signal by a certain augmentation of such volume.

8. A locomotive provided with a normally-closed electric circuit, an electric generator feeding said circuit, a signaling instrument therein, a contact device in connection with said circuit, an earth or return connection joining said circuit through a branch, an electro-magnet in said branch, and a circuit-breaker operated by the excitation of said magnet to break said normally-closed circuit.

9. A locomotive provided with a normally-closed electric circuit, an electric generator feeding said circuit, a signaling instrument therein, a circuit-breaking contact device in connection with said circuit, an earth or re-

turn connection joining said circuit through a branch, an electro-magnet in said branch, and a circuit-breaker operated by the excitation of said magnet to break the portion of said circuit between said contact device and the junction of said earth or return connection.

10. A locomotive provided with a normally-closed electric circuit, an electric generator feeding said circuit, a signaling instrument therein, a circuit-breaking contact device in connection with said circuit, an earth or return connection joining said circuit through a branch, an electro-magnet in the portion of said circuit cut out by said circuit-breaker, and a bell operated by the demagnetization of said magnet consequent upon the breaking of said branch by the circuit-breaker, whereby said bell rings whenever said circuit-breaking contact device is operated by passing over a contact rail.

11. The combination with a locomotive provided with a normally-closed electric circuit, an electric generator feeding said circuit, and a circuit-breaking contact device in connection with said circuit, of a signal-receiving instrument in said circuit consisting of a dial or scale, a hand or pointer traversing it, an electro-motive device exerting a strain to move said hand or pointer in one direction proportionally to the volume of current flowing, and a retractile force tending to move said hand or pointer in the contrary direction.

12. The combination with a locomotive provided with a normally-closed electric circuit, an electric generator feeding said circuit, and a circuit-breaking contact device in connection with said circuit, of a signal-receiving instrument in said circuit consisting of a dial or scale, a hand or pointer traversing it, an electro-motive device exerting a strain to move said hand or pointer in one direction proportionally to the volume of current flowing, a retractile force tending to move said hand or pointer in the contrary direction, an electro-magnetic alarm, and a circuit-closer therefor adapted to be moved to close the circuit to said alarm in consequence of an abnormal movement of said hand.

13. A signal-receiving instrument for a signaling circuit carried by a locomotive, consisting of a dial or scale, a hand or pointer traversing it, an electro-motive device exerting a strain to move said hand or pointer in one direction proportionally to the volume of current flowing, a retractile force tending to move said hand or pointer in the contrary direction, an electro-magnetic alarm, and a circuit-closer therefor in the path of said hand adapted to be moved to close the circuit to said alarm by an abnormal movement of said hand, and adapted frictionally to retain its position when displaced, and a restoring device adapted to be manually operated and by its operation to restore said circuit-closer to its normal position and thereby break the alarm circuit and stop the alarm.

14. A signal-receiving instrument for a signaling circuit carried by a locomotive, consisting of a dial or scale, a hand or pointer traversing it, an electro-motive device exerting a strain to move said hand or pointer in one direction proportionally to the volume of current flowing, a retractile force tending to move said hand or pointer in the contrary direction, an electro-magnetic bell or alarm, and two circuit-closers therefor in the path of said hand and held frictionally in place, one adapted to be moved to close its alarm circuit in consequence of the abnormal movement of said hand in one direction and the other to be moved by the abnormal movement of said hand in the other direction, whereby an abnormal movement of the hand indicative of either defect or danger will cause the giving of an alarm.

15. A signal-receiving instrument for a signaling circuit carried by a locomotive consisting of a dial or scale, a hand or pointer traversing it, an electro-motive device exerting a strain to move said hand or pointer in one direction proportionally to the volume of current flowing, and electro-magnetic means acting on the pointer in opposition thereto, influenced by any variations of the electro-motive force to which said electro-motive device is subject, but in a different circuit from the latter so as to be uninfluenced by the variations of volume of current in said circuit, whereby any disturbing effect due to fluctuations of electro-motive force is compensated for.

16. A signal-receiving instrument for a signaling circuit carried by a locomotive consisting of a dial or scale, a hand or pointer traversing it, a signal receiving electro-motive device exerting a strain to move said hand or pointer in one direction proportionally to the volume of current flowing, and a retractile electro-motive device tending to move said hand or pointer in the contrary direction with a force varying proportionally to any variations in the electro-motive force affecting said signal-receiving electro-motive device, whereby such variations of electro-motive force are compensated for.

17. The combination with a railway track and switch, of a contact device at a signaling point remote from said switch, an electric conductor extending thence to said switch, a return conductor extending from said switch, and a resistance bridge at said switch arranged in connection therewith to be introduced serially between said conductors when the switch is properly set and to be short-circuited when the switch is open, whereby the condition of said switch may be ascertained from said signaling point by measuring the resistance of a circuit including said conductors.

18. The combination of two railway tracks crossing at grade, one rail of each track divided by insulations to constitute an insulating block adjacent to said crossing, a contact

device at a signaling point remote from said crossing, an electric connection between said insulated sections of rail, and a resistance bridge introduced between said insulated sections of rail and the opposite or return circuit rail of either track, whereby the presence of a car or train on either insulated section adjacent to said crossing may be ascertained from said signaling point by measuring the resistance of a circuit including said insulated and return circuit rails.

In witness whereof I have hereunto signed my name in the presence of two subscribing witnesses.

ELISHA B. CUTTEN.

Witnesses:
FRED WHITE,
GEORGE H. FRASER.