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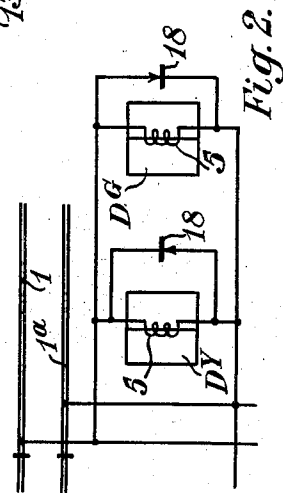
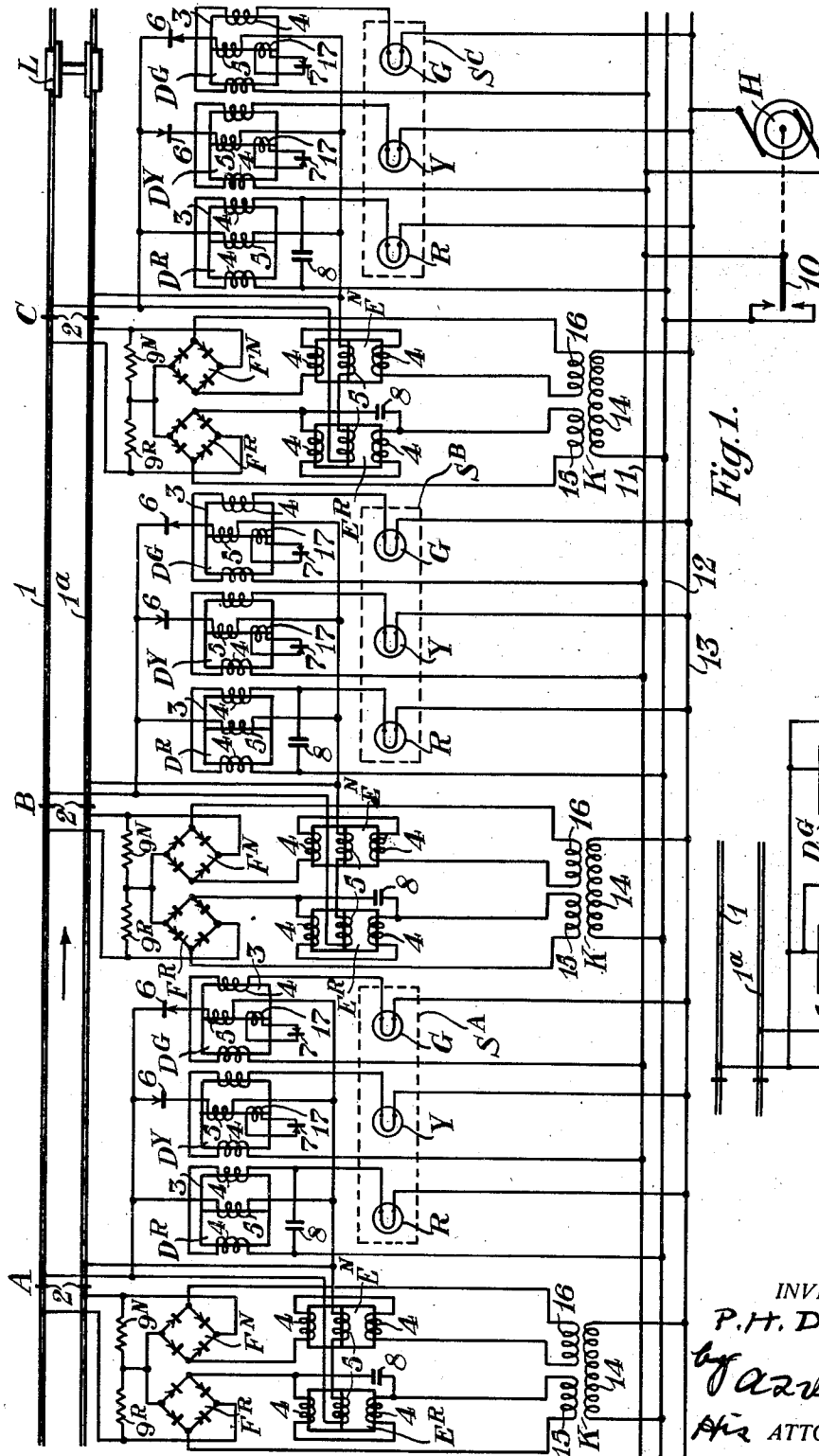
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2,171,784

RAILWAY SIGNALING SYSTEM

Original Filed April 22, 1931

3 Sheets-Sheet 1



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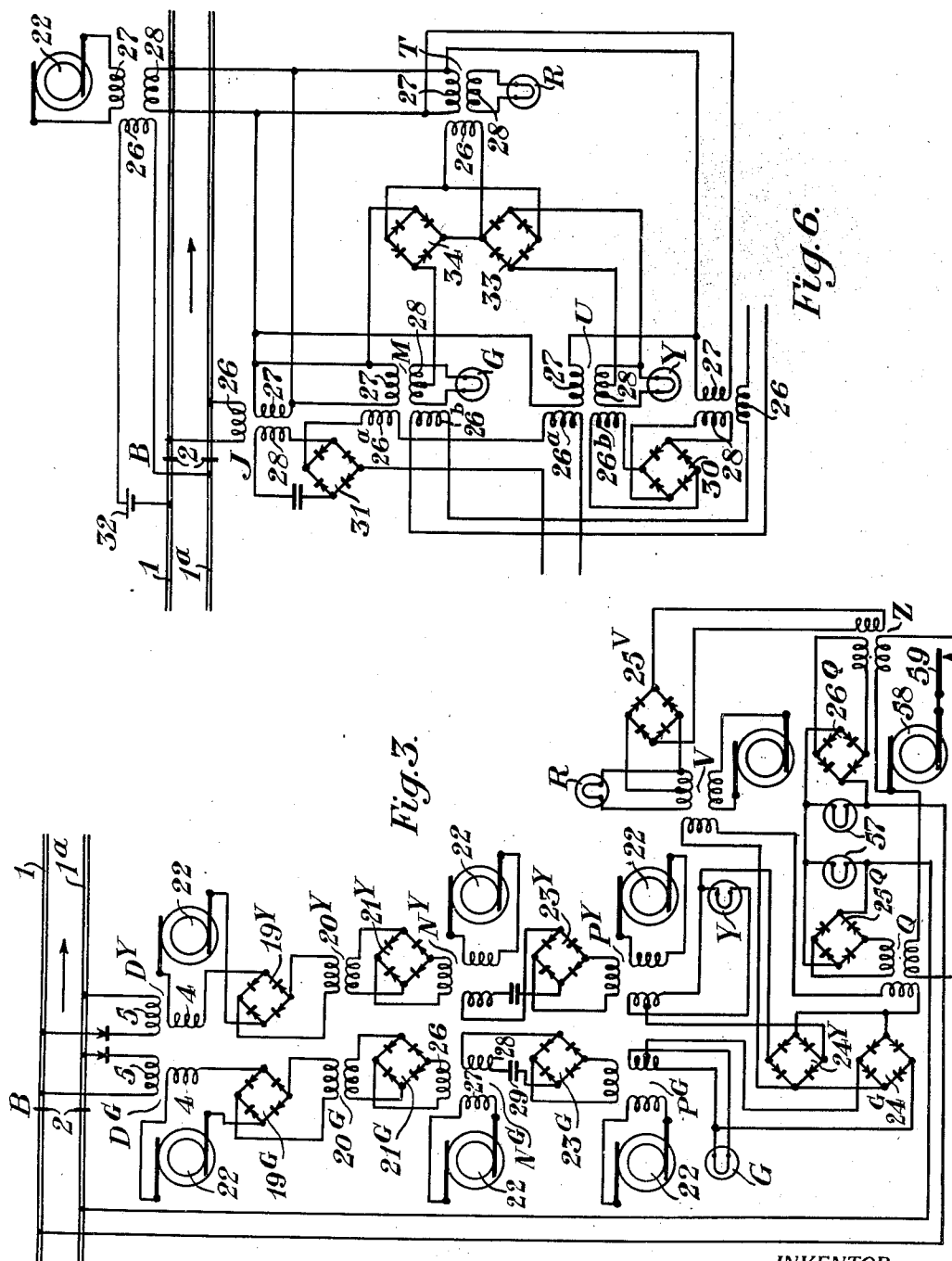
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P. H. DOWLING

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RAILWAY SIGNALING SYSTEM

Original Filed April 22, 1931 3 Sheets-Sheet 2



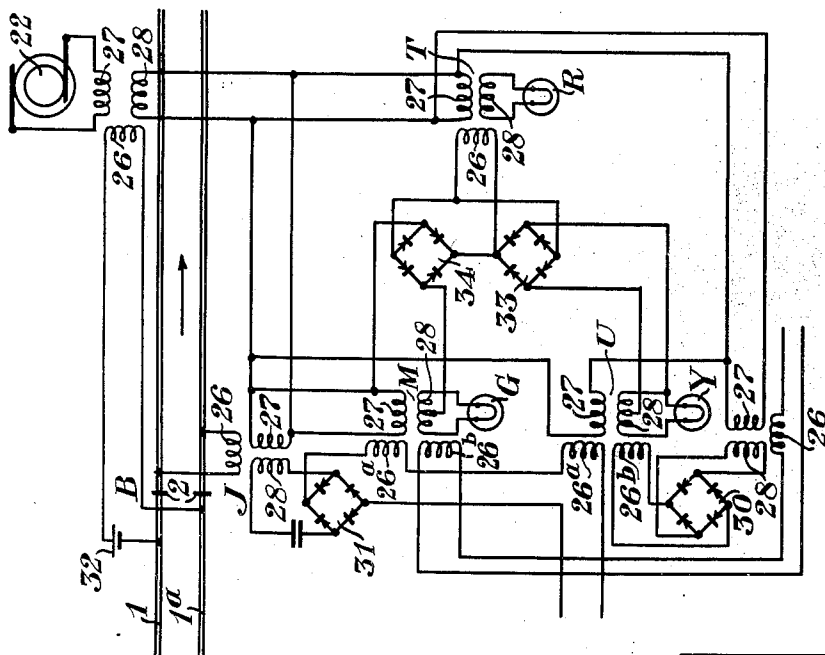
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2,171,784

RAILWAY SIGNALING SYSTEM

Original Filed April 22, 1931 3 Sheets-Sheet 3

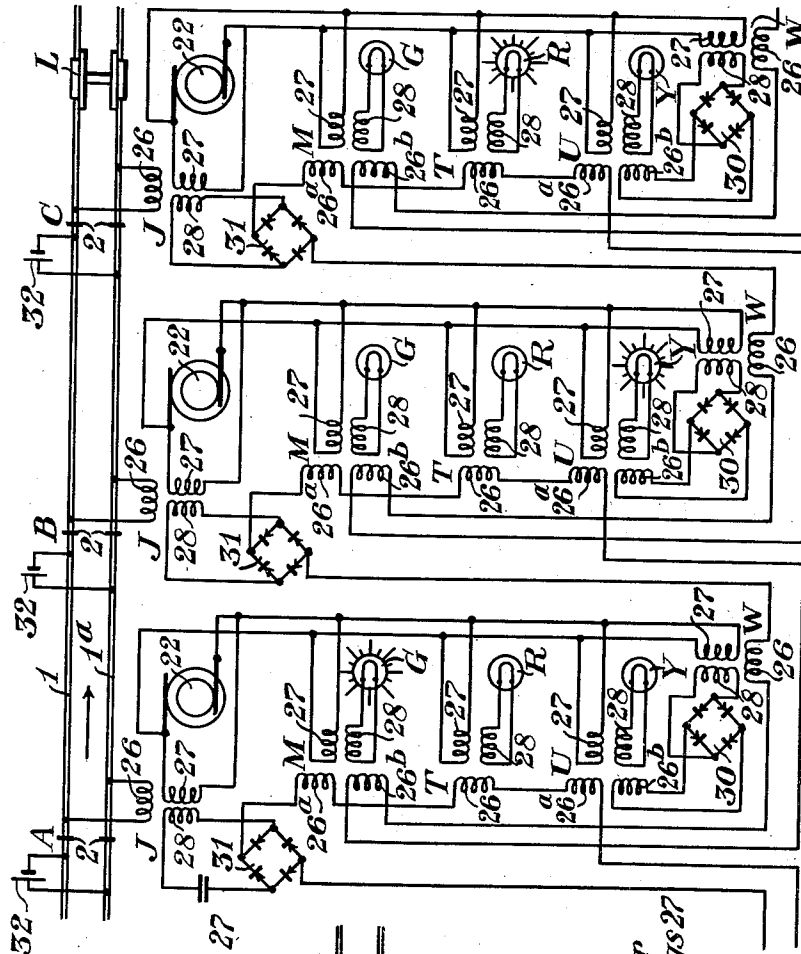


Fig. 4.

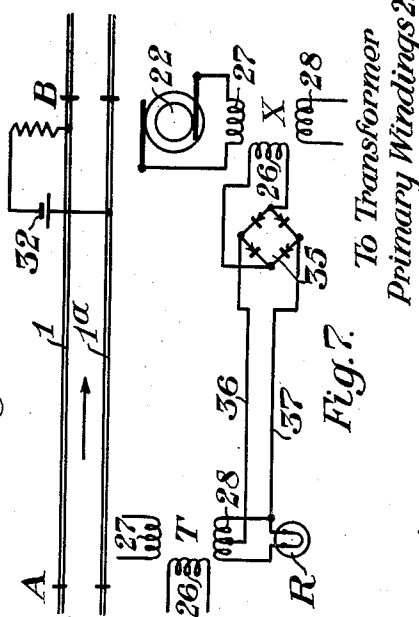
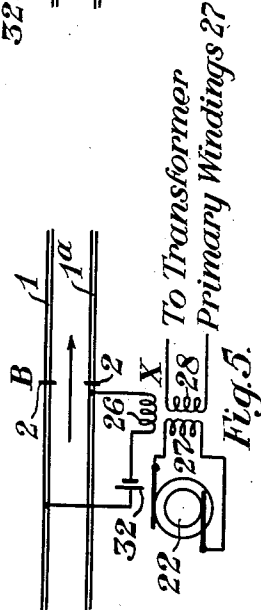


Fig. 7.

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2,171,784

RAILWAY SIGNALING SYSTEM

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Application April 22, 1931, Serial No. 532,028
Renewed July 2, 1938

64 Claims. (Cl. 246—34)

My invention relates to railway signaling systems, and has for an object the provision of novel and improved systems for the control of signals by relays having no moving parts. More specifically, the present invention is directed to systems involving relays of the magnetic amplifier type, that is, relays wherein the output is controlled by varying the reactance of the output winding or by varying the magnetic coupling between a primary winding and a secondary or output winding.

I will describe several forms of systems embodying my invention, and will then point out the novel features thereof in claims.

In the accompanying drawings, Fig. 1 is a diagrammatic view showing one form of signaling system embodying my invention. Fig. 2 is a fragmental view showing a modification of a portion of the system shown in Fig. 1. Fig. 3 is a view showing another form of signaling system embodying my invention. Fig. 4 is a view showing still another form of signaling system embodying my invention. Fig. 5 is a diagrammatic view showing a modification of a portion of the system shown in Fig. 4. Fig. 6 is a view showing another modification of part of the system shown in Fig. 4. Fig. 7 is a view showing a modified means for the approach control of the amplifiers and transformers shown in the preceding views.

Similar reference characters refer to similar parts in each of the views.

Referring first to Fig. 1, the reference characters 1 and 1^a designate the rails of a railway track along which traffic normally moves in the direction indicated by the arrow. These rails are divided by insulated joints 2 to form a series of track sections, of which only two complete sections, A—B and B—C, are shown in the drawings.

Each section is provided with three magnetic amplifiers D^G, D^Y and D^R. Each of these amplifiers comprises a magnetizable core 3 having three parallel legs. The middle leg is provided with an input winding 5, which is connected across the rails of the associated section adjacent the entrance end thereof. The two outer legs of the core are provided with coils 4, which are connected in series to form an output winding, and this output winding is supplied with alternating current in the manner explained hereinafter. A rectifier 6 is included in series with the input winding 5 of amplifier D^G and is poled to permit current to flow through the winding when and only when the lower rail 1^a is positive; this current is of what I will hereinafter term "normal" polarity. The input winding 5 of amplifier

D^Y is provided with a similar rectifier 6, which is poled to permit current to flow through the winding when and only when the upper rail 1 is positive; this current is of what I will term "reverse" polarity. No rectifier is included in the circuit for winding 5 of amplifier D^R, but a condenser 8 is connected across the output winding of this amplifier to tune the winding of resonance at the frequency of the alternating current which is supplied thereto when the input winding 5 is deenergized. The result of this tuning is that a comparatively large current will flow in the output winding of amplifier D^R when the input winding is deenergized, but the current flowing in the output winding will be materially decreased when the reactance of the output winding 4 is changed due to the energization of the input winding 5. Amplifier D^R constitutes, then, what may be termed a "back contact" amplifier. Several types of magnetic amplifiers which operate in this manner are disclosed and claimed in an application for Letters Patent of the United States, filed by me on June 23, 1930, Serial No. 463,019, now Patent No. 1,835,209 granted December 8, 1931, for Electrical translating apparatus.

Each section is provided with a signal designated by the reference character S with a suitable exponent and comprising a proceed lamp G included in series with the output winding 4 of amplifier D^G, a caution lamp Y included in series with the output winding of amplifier D^Y, and a stop lamp R included in series with the output winding of amplifier D^R.

Current of normal or reverse polarity is supplied to the rails of each section by means of apparatus involving a transformer K, two magnetic amplifiers E^N and E^R, and two rectifiers F^N and F^R.

The primary 14 of transformer K is supplied with alternating current by means hereinafter explained. A secondary 16 of this transformer is connected with the input terminals of rectifier F^N, through the output winding 4 of amplifier E^N, and another secondary 15 of transformer K is connected with the input terminals of rectifier F^R through the output winding 4 of amplifier E^R. The input winding of each amplifier is connected across the rails of the section next in advance. A condenser 8 is connected across the output winding 4 of amplifier E^R, so that this amplifier is of the back contact variety. The output terminals of rectifier F^N are connected across the rails of the associated section in such manner that the current delivered by this rectifier to the rails is of normal polarity. The output

terminals of rectifier F^R are also connected across the rails of the associated section in such manner that the current delivered by this rectifier is of the reverse polarity. Preferably a resistance 9^N is connected across the output terminals of rectifier F^N , and a resistance 9^R is connected across the output terminals of rectifier F^R .

Assuming first that uninterrupted alternating current is continuously supplied to all transformers K and all amplifiers D , the operation of the system is as follows: The track section immediately to the right of point C is occupied by a car or train L , so that the input windings 5 of all the amplifiers D at location C are deenergized. It follows that lamps G and Y of signal S^C are extinguished, and that lamp R of this signal is lighted because the input winding 5 of amplifier D^R is deenergized. The input windings of both amplifiers E at location C being deenergized, it follows that the reactance of winding 4 of amplifier E^N is high, so that little or no current is delivered to rectifier F^N . Winding 4 of amplifier E^R is tuned to resonance at the frequency of the current supplied to this amplifier, however, so that this amplifier offers little or no impedance to the flow of current from secondary 15, with the result that rectifier F^R delivers current of reverse polarity to the rails of section $B-C$. At location B , amplifier D^Y is effectively energized so that the caution lamp Y is lighted. Amplifier D^G is deenergized by virtue of the associated rectifier 6, so that lamp G is extinguished. Amplifier D^R is energized, so that its output winding 4 is de-tuned, with the result that lamp R is extinguished.

The input windings 5 of the two amplifiers E at location B are energized, so that amplifier E^R is de-tuned, with the result that the supply of current to rectifier F^R is suppressed. The reactance of winding 4 of amplifier E^N is reduced, however, so that current is supplied to rectifier F^N , with the result that current of normal polarity is supplied to the rails of section $A-B$.

At location A , amplifier D^G is effectively energized to cause the proceed lamp G to be lighted. Amplifier D^Y is deenergized because of the associated rectifier 6, and so the caution lamp Y is extinguished. Back contact amplifier D^R is energized, so that the stop lamp R is extinguished.

Each amplifier D^G and D^Y may be provided with an additional winding 17 on the middle leg of the magnetic circuit, which winding is provided with a closed circuit including a rectifier 7. Each of these amplifiers, then, becomes a regenerative amplifier. Amplifiers of this type are disclosed and claimed in Letters Patent of the United States No. 1,739,579, granted to me on December 17, 1929, for Electrical translating apparatus. Rectifier 7 for amplifier D^G is connected in such manner that the regenerative effect aids the polarization accomplished by the rectifier 6 in the input circuit. That is to say, if the input current is of the proper polarity it is aided by the regeneration, whereas, if the input current is of the other polarity the regeneration opposes it.

It will be apparent from the foregoing, that if uninterrupted alternating current were supplied to the output circuits of the amplifiers D , and if uninterrupted direct current were supplied to the input circuits for these amplifiers, then a break down in the output winding of any amplifier D^G or D^Y would result in false energization of the associated lamp G or Y when the input winding for such amplifier is deenergized. In order to

indicate such a failure, the system shown in Fig. 1 involves means for supplying periodically interrupted current to the track rails, so that when the apparatus is operating properly a flashing indication will be given by each lamp. The alternating current for the operation of the system is furnished by a generator H , the terminals of which are connected with two line wires 11 and 13. A third line wire 12 is provided and is periodically connected with the line wire 11 by means of a contact 10 which may be operated in any suitable manner. The primary of each transformer K is connected across wires 12 and 13, so that this transformer is supplied with periodically interrupted alternating current, with the result that the current furnished to each track section is periodically interrupted unidirectional current. The output circuit for each amplifier D^G and D^Y is connected across wires 11 and 13, so that these circuits are supplied with uninterrupted alternating current, but when any amplifier D^G and D^Y is energized from the track rails, the associated lamp G or Y will flash, due to the periodic interruption of the current thus supplied to the amplifier from the track rails. The output circuit for each amplifier D^R is connected across wires 12 and 13, so that each of these circuits is supplied with periodically interrupted alternating current, the result being that when amplifier D^R is deenergized, the associated stop lamp R will flash at the same frequency as the proceed or caution lamp G or Y . It follows that the continuous lighting of any signal lamp G or Y will indicate that some portion of the apparatus associated with such lamp is not functioning properly.

Another characteristic of the regenerative action of the amplifiers shown in Fig. 1 is as follows: If rectifiers 6 associated with amplifier D^G should become shorted when the upper rail 1 is positive, current would flow through the input winding 5 of this amplifier, but it would give rise to a bucking regeneration, which would tend to keep the proceed lamp G extinguished. A similar action will occur if the rectifier 6, associated with amplifier D^Y , should become shorted when the lower rail 1^a is positive.

In Fig. 1 the rectifiers 6 are connected in series with the input windings 5. In Fig. 2 these series rectifiers are omitted, and a rectifier 18 is connected in multiple with the input winding 5 of each amplifier D^Y and D^G . When the upper rail 1 is positive, current will flow through the input winding 5 of amplifier D^Y and so will cause the caution lamp Y to be lighted. Similarly, when the lower rail is positive, the input winding 5 of amplifier D^G will receive current and so will cause the proceed lamp G to be lighted. Considering amplifier D^G , the rectifier 18 is not effective as a shunt, but it will serve for regeneration, because the pulsating direct current which appears in the input winding 5 of amplifier D^G as soon as track circuit current flows through it, will be poled in such a direction as to aid the action of the track current. If this rectifier should become short-circuited, the proceed lamp G will remain extinguished. If the rectifier associated with amplifier D^Y fails, that is, if it becomes open-circuited, track current will flow through the input winding 5 of this amplifier, but the major part of the regenerative action will be lost. It follows that the matter of safety merely requires enough margin between the amplifier acting regeneratively and not acting regeneratively.

Referring now to Fig. 3, the apparatus at each

signal location involves two magnetic amplifiers D^G and D^Y , as in Fig. 2, and these amplifiers are of the inherently polarized or regenerative type, so that when the lower rail 1^a is positive, amplifier D^G responds and amplifier D^Y does not, whereas when the upper rail 1 is positive, amplifier D^Y will respond and amplifier D^G will not. Each of these amplifiers involves an input winding 5, and an output winding 4 constantly supplied with alternating current from a source 22. The output circuit for amplifier D^G is connected with the input terminals of a full-wave rectifier 19^G , and the output terminals of this rectifier are connected with the primary of a transformer 20^G . It follows that the output voltage of this transformer pulsates at twice the frequency of the track current. Transformer 20^G is reactive, so that it will allow the pulsating or coded current to pass, but will prevent transmission of the high frequency alternating component of the output of rectifier 19^G in the event of a short circuit in the output winding 4 of amplifier D^G .

The secondary winding of transformer 20^G is connected with the input terminals of a rectifier 21^G , and the output terminals of this rectifier are connected with the input winding 26 of an amplifying transformer N^G . This transformer includes a primary winding 27 constantly supplied with alternating current from a source 22 and a secondary winding 28. The transformer N^G preferably is of what is known as the "discontinuous slow-acting" type, disclosed in my application, Serial No. 463,020, filed June 23, 1930, now Patent No. 1,862,212, granted June 7, 1932, for Electrical translating apparatus. When this transformer is effectively energized, it supplies uninterrupted alternating current to the input terminals of a rectifier 23^G through a condenser 29 and the output terminals of this rectifier are connected with the input winding of a balanced flux amplifying transformer P^G which may for example be of the type disclosed in my application, Serial No. 438,916, filed March 25, 1930, now Patent No. 1,891,044, granted December 13, 1932, for Electrical translating apparatus. The primary winding of transformer P^G is supplied with alternating current from a source 22, and the secondary winding is connected with the proceed lamp G. This secondary winding is also connected through a rectifier 24^G with the input winding of an amplifying transformer Q similar to transformer P^G and also with the input winding of a back contact amplifying transformer V.

The apparatus interposed between amplifier D^Y and the caution lamp Y is the same as that interposed between amplifier D^G and the proceed lamp G. The secondary winding of transformer P^Y is also connected with the input windings of both transformers Q and V, so that these transformers are effectively energized when either lamp G or Y is lighted.

When transformer V is deenergized, the stop lamp R will be lighted, and this, of course, occurs only when both the proceed lamp G and the caution lamp Y are extinguished.

When transformers Q and V are deenergized, transformer V is effective to supply current to a rectifier 25^V and thence to the input winding of an amplifying transformer Z, similar to transformers P^G and Q. When transformers Q and V are both energized, the supply of current from transformer V is suppressed, and transformer Q is then effective to supply current through a rectifier 25^Q to the rails of the section A—B. This current is of such polarity that the lower rail 1^a

is positive. When transformer Z is energized, its output winding supplies current to the rails of section A—B through a rectifier 26^Q , and this current is of reverse polarity so that the upper rail 1 is positive. Two lamps 57 each having a positive temperature coefficient are connected across the output windings of rectifiers 25^Q and 26^Q respectively, for the purpose which is set forth in an application for Letters Patent of the United States, filed by me on April 1, 1931, Serial No. 526,797, now Patent No. 1,852,704, granted April 5, 1932, for Electrical apparatus.

The primary windings of amplifying transformers Q and Z are furnished with alternating current from a source 58, through a periodically operated contact 59, so that the current which is supplied to the rails of section A—B is periodically interrupted unidirectional current.

The operation of the apparatus shown in Fig. 3 will be apparent from the foregoing description without detailed explanation.

Referring now to Fig. 4, the apparatus shown in this view employs line circuits instead of polarized track circuits for distinguishing between the proceed and the caution indication of each signal. Each track section is provided with a track circuit comprising a battery 32 connected across the rails at the exit end of the section, and an input winding 26 of an amplifying transformer J of the discontinuous type connected across the rails at the entrance end of the section. Each section is provided with two double input amplifying transformers M and U, and with two back contact amplifying transformers T and W. The double input transformers M and U may be similar to those shown and described in an application for Letters Patent of the United States filed by me on December 26, 1929, Serial No. 416,355, now Patent No. 1,910,381, granted May 23, 1933, for Electrical translating apparatus. The back contact transformers T and W may be similar to those shown and described in an application for Letters Patent of the United States filed by me on June 23, 1930, Serial No. 463,019, now Patent No. 1,835,209, granted December 8, 1931, for Electrical translating apparatus.

The primary winding of each of the transformers is constantly supplied with alternating current from a source 22.

Referring for example to the apparatus associated with section B—C, the secondary 28 of transformer J is connected with the input terminals of a rectifier 31 , and the output terminals of this rectifier are provided with a circuit which includes the first input winding 26^a of the associated transformer M, the input winding 26 of the associated transformer T, the first input winding 26^a of the associated transformer U, the second input winding 26^b of transformer M for section A—B, and the input winding 26 of transformer W for section A—B. The second input winding 26^b of transformer U is supplied with current from the secondary 28 of the associated transformer W through a full-wave rectifier 30. The proceed lamp G is connected with secondary 28 of transformer M, the caution lamp Y is connected with secondary 28 of transformer U, and the stop lamp R is connected with secondary 28 of transformer T.

As shown in the drawings, the section to the right of point C is occupied by a car or train L, so that the transformer J at point C is deenergized. It follows that the associated transformers M and U are, likewise, deenergized, so that lamps G and Y at point C are extinguished.

Transformer T being energized, however, the stop lamp R at this location is lighted. At location B, the first input winding 26^a of transformer M is energized, but the second input winding 26^b is deenergized, and inasmuch as both input windings must be energized in order to effectively energize the transformer, it follows that lamp G is extinguished. As for transformer U, the first input winding 26^a is energized, because transformer J at point B is energized. The second input winding 26^b is energized because transformer W, which is a back contact transformer, is deenergized. It follows that the caution lamp Y is lighted. The stop lamp R is extinguished because its back contact transformer T is deenergized.

At point A, both of the input windings for transformer M are energized, and so the lamp G is lighted. Stop lamp R is extinguished because the back contact transformer T is energized. The caution lamp Y is extinguished because the second input winding 26^b of transformer U is deenergized, due to the fact that the associated back contact transformer W is energized.

In apparatus of the character shown in Fig. 4, it may sometimes be desirable to have the amplifying transformers normally deenergized, and to energize them in response to the approach of a train. One form of apparatus for accomplishing this approach control is illustrated in Fig. 5, where the input winding 26 of an auxiliary amplifying transformer X is interposed between the track battery 32 and one of the track rails 1^a. The primary winding 27 of this transformer is connected with a source of alternating current 22, and the secondary winding 28 supplies current to the primary windings 27 of each transformer J, M, T, U and W, shown in Fig. 4. That is to say, the auxiliary transformer X at the exit end of section A—B in Fig. 5 will control the supply of current to all the transformers associated with section B—C, and the same thing will be true of each of the other locations. The apparatus is so proportioned that when section A—B, for example, is unoccupied, the current flowing in the input winding 26 of transformer X will be so low that only a very small alternating current will be delivered by the secondary winding 28 of this transformer; whereas, when a train occupies section A—B, the increased current from battery 32 flowing through winding 26 will increase the output of transformer X to such value that the other transformers associated therewith will be effectively energized.

Referring now to Fig. 6, the apparatus shown in this view involves a modification of the apparatus shown in Fig. 4, together with the approach control illustrated in Fig. 5. In Fig. 6 the transformer J controls transformers M and U as in Fig. 4, and the second winding 26^b of transformer U is supplied from transformer W in the same way as in Fig. 4. Transformer T, however, is controlled in a manner which differs from Fig. 4. In Fig. 6 the input winding 26 of transformer T is supplied with direct current from the output winding 28 of transformer M, through a rectifier 34, and also from the output winding 28 of transformer U through a rectifier 33. Transformer T being a back contact device, it follows that when either transformer M or transformer U is energized, that is, when either lamp G or lamp Y is lighted, transformer T will be energized to extinguish the stop lamp R. On

the other hand, when both transformers M and U are deenergized, transformer T will, likewise, be deenergized, so that the stop lamp R will be lighted. The input windings 27 of all transformers J, M, U, T and W, are controlled by an auxiliary transformer X, as in Fig. 5.

In the event that the variation in current drawn from the track battery 32 according to the presence and absence of trains is not sufficient to properly control the approach control transformer X, this transformer may be controlled from the next signal location in the rear in the manner indicated in Fig. 7. In this view, the approach control transformer X at location B is supplied with current from the secondary winding 28 of the transformer T at location A, through the medium of line wires 36 and 37 and a rectifier 35. It follows that when section A—B is unoccupied, so that transformer T is deenergized, little or no current will be supplied to the input winding 26 of transformer X, and so the other transformers at location B will be deenergized. When section A—B is occupied, however, transformer T will be energized to light the stop lamp R, so that current of considerable value will be supplied to the input winding 26 of transformer X, with the result that the other transformers at location B will be effectively energized.

Although I have herein shown and described only a few forms of signaling systems embodying my invention, it is understood that various changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. In combination, a section of railway track, means for supplying the rails of said section with unidirectional current of normal or reverse polarity, two magnetic amplifiers each having its input circuit connected with the rails of said section, an output winding for each amplifier, rectifiers included in said input circuits for permitting current of normal polarity to affect the first amplifier and current of reverse polarity to affect the second amplifier but preventing current of reverse polarity from affecting the first amplifier and current of normal polarity from affecting the second amplifier, and a circuit for said output winding of each amplifier including a source of alternating current and a signal.

2. In combination, a section of railway track, means for supplying the rails of said section with unidirectional current of normal or reverse polarity, two regenerative magnetic amplifiers each having its input circuit connected with the rails of said section, an output winding for each amplifier, rectifiers included in said input circuits for permitting current of normal polarity to affect the first amplifier and current of reverse polarity to affect the second amplifier but preventing current of reverse polarity from affecting the first amplifier and current of normal polarity from affecting the second amplifier, and a circuit for said output winding of each amplifier including a source of alternating current and a signal, each amplifier being so adjusted that the flux due to the regenerating is in the same direction as that which is due to the input current.

3. In combination, a section of railway track, a source of current connected with the rails of said section, a magnetic amplifier having an input winding connected with the rails of said

section, an output winding for said amplifier, a circuit for said output winding including a source of alternating current and a signal, and a condenser connected across said output winding for tuning such winding to resonance at the frequency of said source when said input winding is deenergized but not when it is energized, whereby said signal will receive more current when said section is occupied than when it is unoccupied.

4. In combination, a section of railway track, means controlled by traffic conditions in advance of such section for supplying the rails of the section with unidirectional current of normal or reverse polarity, three magnetic amplifiers each having its input circuit connected with the rails of said section, an output winding for each amplifier, a rectifier included in the input circuit of the first amplifier for permitting current of normal polarity but not of reverse polarity to affect the amplifier, a rectifier included in the input circuit of the second amplifier for permitting current of reverse polarity but not of normal polarity to affect the amplifier, a circuit for said output winding of each amplifier including a source of alternating current and a signal, and a condenser connected across the output winding of the third amplifier for tuning such winding of resonance at the frequency of said source when the associated input winding is deenergized but not when it is energized.

5. In combination, a section of railway track, means controlled by traffic conditions in advance of such section for supplying the rails of the section with unidirectional current of normal or reverse polarity, three magnetic amplifiers each having its input circuit connected with the rails of said section, an output winding for each amplifier, a rectifier included in the input circuit of the first amplifier for permitting current of normal polarity but not of reverse polarity to affect the amplifier, a rectifier included in the input circuit of the second amplifier for permitting current of reverse polarity but not of normal polarity to affect the amplifier, a circuit for said output winding of each amplifier including a source of alternating current, a condenser connected across the output winding of the third amplifier for tuning such winding to resonance at the frequency of said source when the associated input winding is deenergized but not when it is energized, a proceed signal included in the output circuit for said first amplifier, a caution signal included in the output circuit for the second amplifier, and a stop signal included in the output circuit for the third amplifier.

6. In combination, a section of railway track, two rectifiers each having its output terminals connected across the rails of said section in such manner that one rectifier delivers current of normal polarity and the other delivers current of reverse polarity to the rails, an input circuit for each rectifier including a source of alternating current and the output winding of a magnetic amplifier, means for energizing the input windings of both amplifiers when the section next in advance is unoccupied but not when it is occupied, and a condenser connected across the output winding of one amplifier but not the other for tuning such winding to resonance at the frequency of said source when the associated input winding is deenergized but not when it is energized.

7. In combination, a section of railway track, two rectifiers each having its output terminals

connected across the rails of said section in such manner that one rectifier delivers current of normal polarity and the other delivers current of reverse polarity to the rails, two resistances connected across the output terminals of said two rectifiers respectively, an input circuit for each rectifier including a source of alternating current and the output winding of a magnetic amplifier, means for energizing the input windings of both amplifiers when the section next in advance is unoccupied but not when it is occupied, and a condenser connected across the output winding of one amplifier but not the other for tuning such winding to resonance at the frequency of said source when the associated input winding is deenergized but not when it is energized.

8. In combination, a section of railway track, means for supplying the rails of said section with unidirectional current of normal or reverse polarity, two regenerative magnetic amplifiers each having its input winding connected with the rails of said section, an output winding for each amplifier, a circuit for said output winding of each amplifier including a source of alternating current, the parts being so connected that one amplifier responds to current of normal polarity but not to current of reverse polarity and that the other amplifier responds to current of reverse polarity but not to current of normal polarity, and signaling means controlled by said output circuits.

9. In combination, a stretch of railway track divided into sections, two regenerative magnetic amplifiers for each section each having its input winding connected with the rails of its section, an output winding for each amplifier, a circuit for said output winding of each amplifier including a source of alternating current, the parts being so connected that one amplifier responds to current of normal polarity but not to current of reverse polarity and that the other amplifier responds to current of reverse polarity but not to current of normal polarity, a proceed signal for each section energized by the response of the first associated amplifier, a caution signal for each section energized by the response of the second associated amplifier, a stop signal for each section energized when both of the associated amplifiers are deenergized, and means for supplying current of normal or reverse polarity to the rails of each section according as either amplifier for the section next in advance is energized or both such amplifiers are deenergized.

10. In combination, a section of railway track, means for supplying the rails of said section with periodically interrupted current of normal or reverse polarity, two regenerative magnetic amplifiers each having its input winding connected with the rails of said section, an output winding for each amplifier, a circuit for said output winding of each amplifier including a source of alternating current, the parts being so connected that one amplifier responds to current of normal polarity but not to current of reverse polarity and that the other amplifier responds to current of reverse polarity but not to current of normal polarity, and signaling means controlled by said output circuits.

11. In combination, a section of railway track, a source of current connected with the rails of said section, an amplifying transformer having its input winding connected with said rails and having its primary winding connected with a source of alternating current, a back contact am-

plifying transformer having its input winding connected with the secondary winding of said first transformer and its primary winding connected with a source of alternating current, and signaling means controlled by the secondary winding of said back contact transformer.

12. In combination, a section of railway track, a source of current connected with the rails of said section, means in the wayside associated with said section and governed by traffic conditions for controlling the current supplied to said rails, a back contact amplifying transformer having an input circuit controlled by the current flowing in said rails and having its primary winding connected with a source of alternating current, and signaling means controlled by current flowing in the secondary winding of said transformer.

13. In combination, a section of railway track, a source of current connected with the rails of said section, means in the wayside associated with said section and governed by traffic conditions for controlling the current supplied to said rails, a back contact magnetic amplifier having its input circuit controlled by the current flowing in said rails, an output circuit for said amplifier, and signaling means controlled by current flowing in said output circuit.

14. In combination, a stretch of railway track divided into sections, a source of current connected with the rails of each section, a master amplifying transformer for each section having its input winding connected with the rails of the section, a first and a second double input amplifying transformer for each section, a first and a second back contact amplifying transformer for each section, means for supplying the primary winding of each of said amplifying transformers with alternating current, a secondary circuit for each master transformer including one input winding of each of the double input transformers for the associated section and the input winding for the first back contact transformer of the associated section as well as the remaining input winding of the first double input transformer for the section next in the rear and the input winding for the second back contact transformer for such section next in the rear, a circuit for the second input winding of the second double input transformer for each section including the secondary of the associated second back contact transformer, and signaling means for the sections controlled by current in the secondary windings of said transformers.

15. In combination, a stretch of railway track divided into sections, a source of current connected with the rails of each section, a master amplifying transformer for each section having its input winding connected with the rails of the section, a first and a second double input amplifying transformer for each section, a first and a second back contact amplifying transformer for each section, means for supplying the primary winding of each of said amplifying transformers with alternating current, a secondary circuit for each master transformer including one input winding of each of the double input transformers for the associated section and the input winding for the first back contact transformer of the associated section as well as the remaining input winding of the first double input transformer for the section next in the rear and the input winding for the second back contact transformer for such section next in the rear, a circuit for the second input winding of the second double

input transformer for each section including the secondary of the associated second back contact transformer, a proceed lamp for each section connected with the secondary winding of the first double input transformer, a caution lamp for each section connected with the secondary winding of the second double input transformer, and a stop lamp for each section connected with the secondary winding of the first back contact transformer.

16. In combination, a stretch of railway track divided into sections, a source of current connected with the rails of each section, an amplifying transformer for each section having its input winding connected with the rails of the section and its primary winding connected with a source of alternating current, and signaling means for each section controlled in part by current in the secondary winding of the transformer for the associated section and in part by current in the secondary winding of the transformer for the next section in advance.

17. In combination, a stretch of railway track divided into sections, a source of current connected with the rails of each section, an amplifying transformer for each section having its input winding connected with the rails of the section, an output winding for each transformer, signaling means for said sections controlled by current in the output windings of said transformers, an approach control amplifying transformer for each section having its input winding interposed between the source of track circuit current and one rail of the section, and means for supplying the input winding of the first transformer for each section from the output winding of the approach control transformer for the section next in the rear.

18. In combination, a stretch of railway track divided into sections, a source of current connected with the rails of each section, amplifying transformers for each section, signals for the sections controlled by said transformers, an approach control amplifying transformer for each section having its input winding interposed between the source of track circuit current and one rail of the section, an output winding for each approach control amplifying transformer, and means for controlling the input windings of the first-mentioned transformers for each section by the output winding of the approach control transformer for the section next in the rear.

19. In combination, a stretch of railway track divided into sections, a source of current connected with the rails of each section, a master amplifying transformer for each section having its input winding connected with the rails of the section, a first and a second double input amplifying transformer for each section, a first and a second back contact amplifying transformer for each section, means for supplying the primary winding of each of said transformers with alternating current, a secondary circuit for each master transformer including one input winding of each of the double input transformers for the associated section and the remaining input winding of the first double input transformer for the section next in the rear as well as the input winding for the second back contact transformer for such section next in the rear, a circuit for the second input winding of the second double input transformer for each section including the secondary of the associated second back contact transformer, two circuits for the input winding of the first back contact transformer for each sec-

tion including the secondary winding of the associated first and second double input transformers respectively, a proceed lamp for each section connected with the secondary winding of the first double input transformer, a caution lamp for each section connected with the secondary winding of the second double input transformer, and a stop lamp for each section connected with the secondary winding of the first back contact transformer.

20. In combination, a rear and a forward section of railway track, a back contact amplifying transformer for the rear section, means for energizing said transformer when the rear section is unoccupied but not when it is occupied, a front contact amplifying transformer having its input winding connected with the secondary winding of said back contact transformer and having its primary winding connected with a source of alternating current, and signaling means for the forward section supplied with current from the secondary winding of said front contact amplifying transformer.

21. The combination in a railway signal system, of a translating device having a magnetizable core provided with an input and an output winding, means for supplying coded current to said input winding to vary the impedance of said output winding in step with the variations of said coded current, wayside means forming a part of said signal system and governed in accordance with the condition of a section of track of the system for controlling the coded current supplied to said input winding, a signal, and a control circuit for said signal including said output winding for causing said signal to display a distinctive indication when coded current is present in said input winding.

22. In combination, a section of railway track, a translating device having a magnetizable core provided with an input and an output winding, means for supplying coded current to said input winding for establishing a periodic flux condition in said core to thereby periodically change the impedance of said output winding, and means including a source of alternating current and said output winding for supplying current to the rails of said section having a corresponding code variation impressed thereon by virtue of said periodic change in impedance of said output winding.

23. In combination, a section of railway track, a translating device having a magnetizable core provided with an input and an output winding, means governed by traffic conditions in advance of said section for supplying current to said input winding for establishing a flux condition in said core to thereby change the impedance of said output winding, and means controlled by said output winding in accordance with the impedance thereof for supplying current to the rails of said section.

24. In combination, a first and a second section of railway track, means for supplying coded current to the rails of said first section, a signal for said first section capable of displaying one or another of a plurality of periodically recurrent indications corresponding with the code variations in said rail current, means governed in accordance with the occupied or unoccupied condition of said second section for controlling the current supplied to the rails of said first section, and signal control means receiving current from the rails of said first section and responsive to the code variations of said rail current for causing said signal to display said one or said other in-

dication according as said second section is occupied or unoccupied.

25. In combination, a first and a second section of railway track, means for supplying periodically interrupted current to the rails of said first section, a signal for said first section capable of displaying one or another flashing indication corresponding with the periodic interruptions in said rail current, means governed in accordance with the occupied or unoccupied condition of said second section for controlling the current supplied to the rails of said first section, and signal control means receiving current from the rails of said first section and responsive to the periodic interruptions in said rail current for causing said signal to display said one or said other flashing indication according as said second section is occupied or unoccupied.

26. In combination, a section of railway track, a source of current connected with the rails of said section, a magnetic amplifier having an input winding connected with the rails of said section, an output winding for said amplifier, means in the wayside associated with said section and governed by traffic conditions for controlling the current received by said input winding from said rails, and a circuit for said output winding including a source of alternating current and a signal.

27. In combination, a section of railway track, a source of unidirectional current connected with the rails of said section, a magnetic amplifier having an input winding connected with the rails of said section, an output winding for said amplifier, means in the wayside associated with said section and governed by traffic conditions for controlling the current received by said input winding from said rails, and a circuit for said output winding including a source of alternating current and a signal.

28. In combination, a section of railway track, a source of current connected with the rails of said section, a magnetic amplifier having an input winding connected with the rails of said section, an output winding for said amplifier, means in the wayside associated with said section and governed by traffic conditions for controlling the current received by said input winding from said rails, a circuit for said output winding including a source of alternating current, and signaling means controlled by said output circuit.

29. In combination, a section of railway track, a source of current connected with the rails of said section, a regenerative magnetic amplifier having its input winding connected with the rails of said section, an output winding for said amplifier, means in the wayside associated with said section and governed by traffic conditions for controlling the current received by said input winding from said rails, a circuit for said output winding including a source of alternating current, and signaling means controlled by said output circuit.

30. In combination, a section of railway track, a source of current connected with the rails of said section, an amplifying transformer having its input winding connected with said rails and having its primary winding connected with a source of alternating current, means in the wayside associated with said section and governed by traffic conditions for controlling the current received by said input winding from said rails, and signaling means controlled by the secondary winding of said transformer.

31. In combination, a section of railway track, means for supplying coded current to the rails of said section, a translating device having a magnetizable core provided with a control winding thereon, means for supplying unidirectional current impulses from the rails of said section to said winding for changing the flux condition in said core in step with said impulses, a local source of current, a signal, and means including said local source and responsive to changes in said flux condition for controlling said signal.

32. In combination, a section of railway track, means for supplying coded current to the rails of said section, a translating device having a magnetizable core provided with an input and an output winding, means for supplying unidirectional current impulses from the rails of said section to said input winding for varying the flux condition in said core in step with said impulses to thereby vary the output of said output winding, a local source of current, a signal, and means including said local source and said output winding for controlling said signal.

33. In combination, a section of railway track, means for supplying coded current to the rails of said section, a translating device having a magnetizable core provided with an input and an output winding, means for supplying unidirectional current impulses from the rails to said input winding for producing a pulsating unidirectional flux in said core, the pulsations of said flux corresponding to the code variations of said rail current, signaling apparatus, and a control circuit for said apparatus governed by said output winding in accordance with the presence or absence of said pulsating flux in said core.

34. In combination, a stretch of railway track divided into sections, a source of current connected with the rails of each section, a master amplifying transformer for each section having its input winding connected with the rails of the section, a double input amplifying transformer for each section, means for supplying the primary winding of each of said transformers with alternating current, a secondary circuit for each master transformer including the first input winding of the double input transformer for the associated section and the second input winding of the double input transformer for the section next in the rear, and signaling means controlled by the secondary winding of each of said double input transformers.

35. In combination, a rear and a forward section of railway track, an amplifying transformer, a source of current connected with the rails of the rear section through the input winding of said amplifying transformer, an output winding for said transformer, and signaling means for the forward section controlled by said output winding.

36. In combination, a section of railway track, means for supplying the rails of said section with unidirectional current of normal or reverse polarity, two magnetic amplifiers each having an input circuit which receives energy from the rails of said section, a rectifier for each input circuit for permitting current of normal polarity to affect the first amplifier and current of reverse polarity to affect the second amplifier but preventing current of reverse polarity from affecting the first amplifier and current of normal polarity from affecting the second amplifier, and an output circuit for each amplifier including a source of periodic current and a load.

37. In combination, a section of railway track, two rectifiers one supplying current of normal polarity and the other supplying current of reverse polarity to the rails of said section, an input circuit for each rectifier including a source of periodic current and the output circuit of a magnetic amplifier, means for energizing the input circuit of both amplifiers when the section next in advance is unoccupied but not when it is occupied, and means for tuning the output circuit of one amplifier but not the other to resonance at the frequency of said periodic source when its input circuit is deenergized but not when it is energized.

38. In combination, a section of railway track, means for supplying the rails of said section with unidirectional current of normal or reverse polarity, two magnetic amplifiers each having an input circuit receiving energy from the rails of said section, an output circuit for each amplifier including a source of periodic current, the parts being so connected that one amplifier responds to current of normal polarity but not to current of reverse polarity and that the other amplifier responds to current of reverse polarity but not to current of normal polarity, and signaling means controlled by said output circuits.

39. In combination, a section of railway track, means for supplying the rails of said section with unidirectional current of normal polarity, a magnetic amplifier having an input circuit receiving energy from the rails of said section, means for rendering said amplifier responsive to current of said normal polarity in the rails but not to rail current of reverse polarity, an output circuit for said amplifier including a source of periodic current, and signaling means controlled by said output circuit.

40. In combination, a stretch of railway track divided into sections, means for supplying current to the rails of each section, an amplifying transformer for each section having a control circuit receiving energy from the rails of the section and having an input circuit connected with a source of periodic current, an output circuit for each transformer, a line circuit for each section connecting the amplifying transformer of one section with the amplifying transformer of the adjoining section, and signaling means for each section controlled in part by the output circuit of the transformer for the associated section and in part by the associated line circuit.

41. In combination, a rear and a forward section of railway track, an amplifier transformer, means including the input circuit of said amplifying transformer for supplying current to the rails of the rear section, an output circuit for said transformer, and signaling means for the forward section controlled by said output circuit.

42. In combination, a rear and a forward section of railway track, a magnetic amplifier associated with said rear section, means effective when said rear section becomes occupied by a train for energizing the input circuit of said amplifier to thereby cause an output to be delivered from said amplifier, and traffic controlling apparatus for said forward section governed by the output of said amplifier.

43. In combination, a rear and a forward section of railway track, a normally inactive magnetic amplifier associated with said rear section, means effective when said rear section becomes occupied by a train for rendering said amplifier active so as to cause an output to be delivered

therefrom, and traffic controlling apparatus for said forward section governed by the output of said amplifier.

44. In combination, a rear and a forward section of railway track, a translating device for said rear section having an input and an output circuit and having all of its component parts stationary, means effective when said rear section becomes occupied by a train for energizing said input circuit to thereby cause an output to be delivered from said output circuit, and traffic controlling apparatus for said forward section governed by said output circuit.

45. In combination, a rear and a forward section of railway track, a translating device for said rear section having an input and an output circuit and having all of its component parts stationary, means including the rails of said rear section for energizing said input circuit, and traffic controlling apparatus for said forward section governed by said output circuit.

46. In combination, a rear and a forward section of railway track, a translating device for said rear section having an input circuit connected with the rails of said section and having an output circuit, all of the component parts of said translating device being stationary, means effective when said rear section becomes occupied by a train for causing an output to be delivered from said output circuit, and traffic controlling apparatus for said forward section governed by said output circuit.

47. In combination, a rear and a forward section of railway track, a source of current connected with the rails of each section, a magnetic amplifier for said forward section, an approach control magnetic amplifier for said rear section having an input circuit connected with the rails of the rear section, an output circuit for said approach control magnetic amplifier, means governed by said output circuit effective when said rear section becomes occupied by a train for controlling the output of the magnetic amplifier for said forward section, and traffic controlling apparatus governed by the magnetic amplifier for said forward section.

48. In combination, a first and a second section of railway track, means for supplying current to the rails of said first section, a translating device all of the component parts of which are stationary, an input circuit for said translating device receiving energy from the rails of said first section, an output circuit for said translating device, and means including a source of current and said output circuit for supplying current to the rails of said second section.

49. In combination, a first and a second section of railway track, means for supplying current to the rails of said first section, a static translating device having an input circuit receiving energy from the rails of said first section and having an output circuit, a source of energy for said translating device for energizing said output circuit under the control of said input circuit, and means controlled by said output circuit for supplying current to the rails of said second section.

50. In combination, a first and a second section of railway track, means for supplying current to the rails of said first section, a static translating device, means for supplying energy from the rails of said first section to the input circuit of said translating device, a source of energy for said translating device for causing an output to be delivered from the output circuit of said translating device under the control of said input circuit, and means including said output circuit for sup-

plying current to the rails of said second section.

51. In combination, a first and a second section of railway track, a source of current for the rails of said first section, a magnetic amplifier comprising a magnetizable core having an input and an output winding thereon, means for establishing a magnetization in said core for causing an output to be delivered from said output winding, means for supplying current from the rails of said first section to control the energization of said input winding and thereby to control the magnetization of said core so as to govern the energy delivered from said output winding, and means controlled by said output winding for supplying current to the rails of said second section.

52. In combination, a first and a second section of railway track, means for supplying current to the rails of said first section, a back contact magnetic amplifier having an input circuit receiving energy from the rails of said first section, an output circuit for said amplifier and means including said output circuit and a source of current for supplying current to the rails of said second section.

53. In combination, a section of railway track, a static translating device having an input and an output circuit, said device being of the type wherein a decrease in the amount of energy supplied to said input circuit causes an increase in the amount of energy delivered from said output circuit, means governed by traffic conditions in advance of said section for supplying energy to said input circuit, and means controlled by said output circuit for supplying current to the rails of said section.

54. In combination, a section of railway track, a static translating device having an input and an output circuit, said device being of the type wherein a decrease in the amount of energy supplied to said input circuit causes an increase in the amount of energy delivered from said output circuit, means in the wayside associated with said section and governed by traffic conditions in advance of the section for supplying current to said input circuit, and traffic controlling apparatus for said section governed by said output circuit.

55. In combination, a first and a second section of railway track, a back contact magnetic amplifier having an input circuit receiving energy from the rails of said first section when the section is unoccupied but not when it is occupied, an output circuit for said amplifier and means controlled by said output circuit and including a source of current for supplying current to the rails of said second section.

56. In combination, a first and a second section of railway track, a static translating device having an input and an output circuit, said device being of the type wherein a decrease in the amount of energy supplied to said input circuit causes an increase in the amount of energy delivered from said output circuit, means for supplying current to the rails of said first section, means for connecting said input circuit with the rails of said first section, and means including a source of current for connecting said output circuit with the rails of said second section.

57. In combination, a first and a second section of railway track, means for supplying current to the rails of said first section, a translating device all of the component parts of which are stationary and having an input and an output circuit, means for connecting the input circuit of said translating device with the rails of said first section, and means including a source of current

for connecting the output circuit of said translating device with the rails of said second section, whereby current will be supplied to the rails of said second section by said translating device depending on the condition of occupancy of said first section.

58. In combination, a first and a second section of railway track, means for supplying current to the rails of said first section, two static translating devices each having an input and output circuit, one being of the type wherein a decrease in the amount of energy supplied to its input circuit causes an increase in the amount of energy delivered from its output circuit and the other being of the type wherein an increase in the input energy causes an increase in the output energy, means for supplying energy from the rails of said first section to the input circuits of both said translating devices, and means for supplying current to the rails of said second section controlled by the output circuit of said one or said other translating device according as said first section is occupied or unoccupied respectively.

59. In combination, a first and a second section of railway track, means for supplying current to the rails of said first section, two static translating devices each having an input and an output circuit, one being of the type wherein a decrease in the amount of energy supplied to its input circuit causes an increase in the amount of energy delivered from its output circuit and the other being of the type wherein an increase in the input energy causes an increase in the output energy, means for supplying energy from the rails of said first section to the input circuits of both said translating devices, means controlled by the output circuit of said one or said other translating device for supplying current of a first or a second character to the rails of said second section respectively according as said first section is occupied or unoccupied, and traffic governing apparatus for said second section selectively controlled according as the current supplied to the second section is of said first or said second character.

60. In combination, a section of railway track, means for supplying the rails of said section with unidirectional current, a magnetic amplifier having an input winding connected with the rails of said section, an output winding for said magnetic amplifier, a circuit for said output winding including a source of alternating current and a signal, and means for periodically interrupting the current supplied to said rails at a rate such that a distinctive indication will normally be provided by said signal when the interrupted unidirectional current is effective in said input winding, whereby a dangerous short-circuit in said output winding will be detected by said signal.

61. In combination, a section of railway track, a source of current connected with the rails of said section, a magnetic amplifier having an input winding connected with the rails of said section, an output winding for said magnetic amplifier, a circuit for said output winding including a source of alternating current and a signal, and means for periodically interrupting the current flowing from said source to the rails at a rate such that a distinctive indication will normally be provided by said signal when the interrupted current is effective in said input winding, whereby a dangerous short-circuit in said output winding will be detected by said signal.

62. In combination, a section of railway track, means for supplying current to the rails of said section, a translating device having a magnetizable core provided with an input winding receiving energy from the rails of said section, an output winding for said translating device, a circuit for said output winding including a source of alternating current, signaling means controlled by said output circuit, and means for periodically interrupting said rail current at a rate such that a distinctive indication will normally be provided by said signaling means when said periodically interrupted current is effective, whereby a dangerous short-circuit in said output winding will be detected by said signaling means.

63. In combination, a section of railway track, means for supplying the rails of said section with coded current, a translating device having a magnetizable core provided with an input winding receiving coded energy from the rails of said section, an output winding for said translating device having an impedance which varies in accordance with the code variations of the energy received by said input winding, and signaling apparatus controlled in accordance with the code variations in impedance of said output winding, said code variations occurring at a rate such that a distinctive indication will normally be provided by said signaling apparatus when said coded current is effective, whereby a short-circuit in said output winding will be detected by said signaling apparatus.

64. In combination, a section of railway track, means for supplying current to the rails of said section, a static translating device having an input circuit receiving energy from the rails of said section and having an output circuit, a source of energy for said translating device for energizing said output circuit under the control of said input circuit, a back contact amplifier having an input circuit controlled by the output circuit of said translating device, and traffic governing apparatus controlled by the output circuit of said back contact amplifier.

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