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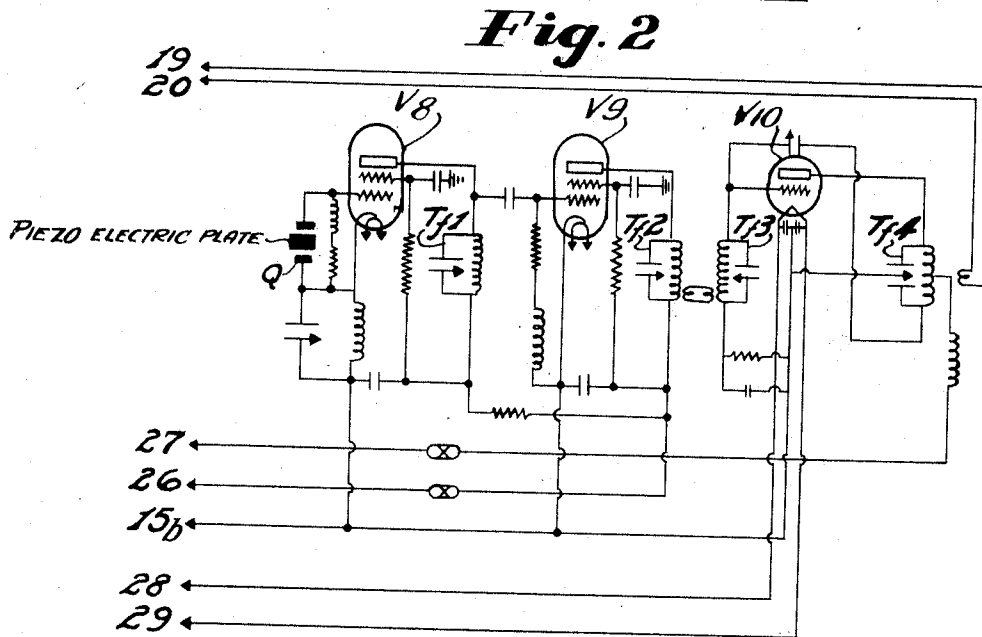
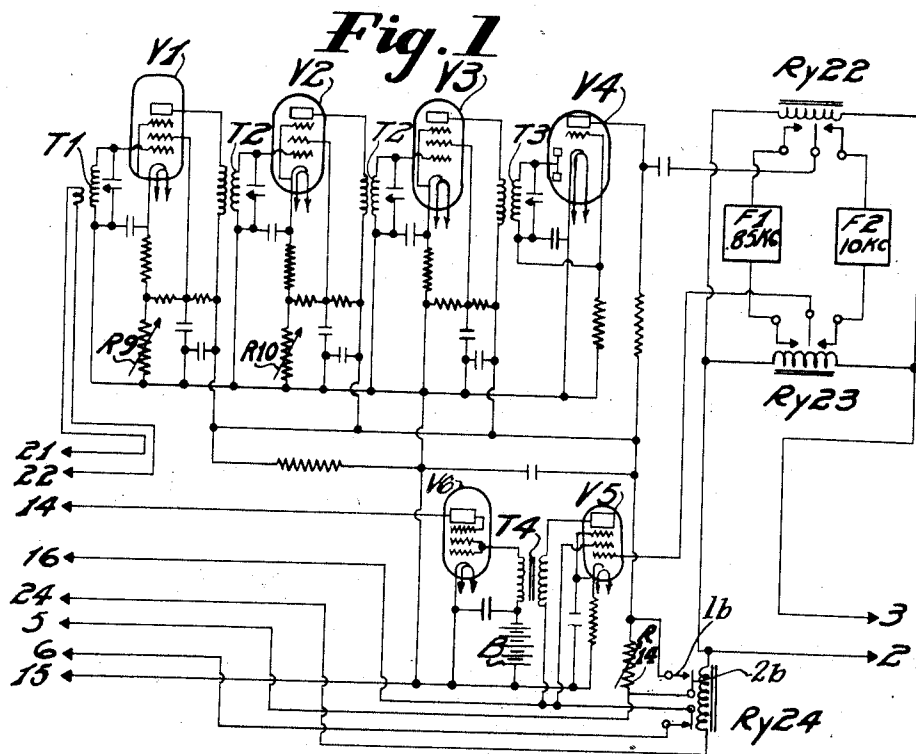
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2,252,525

RAILWAY TRAIN CONTROL SYSTEM

Filed Aug. 31, 1939

8 Sheets-Sheet 1



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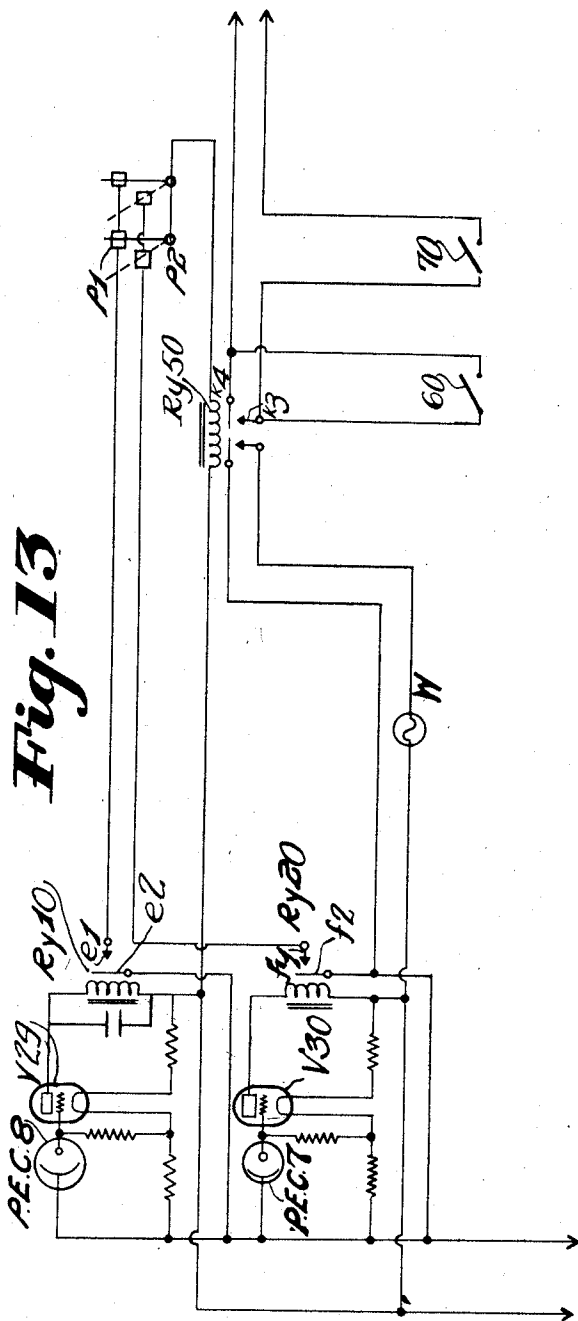
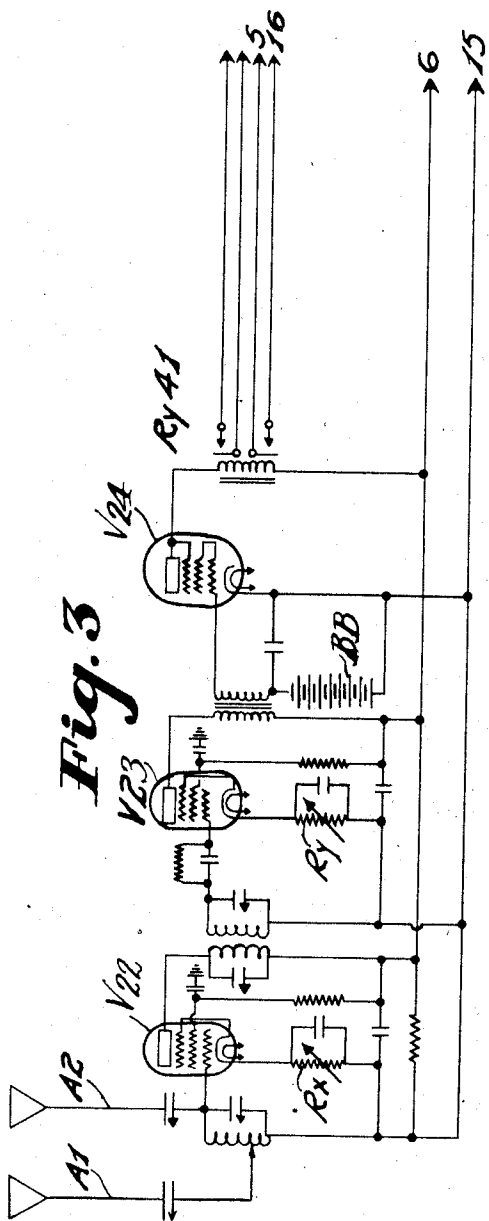
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RAILWAY TRAIN CONTROL SYSTEM

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8 Sheets-Sheet 2



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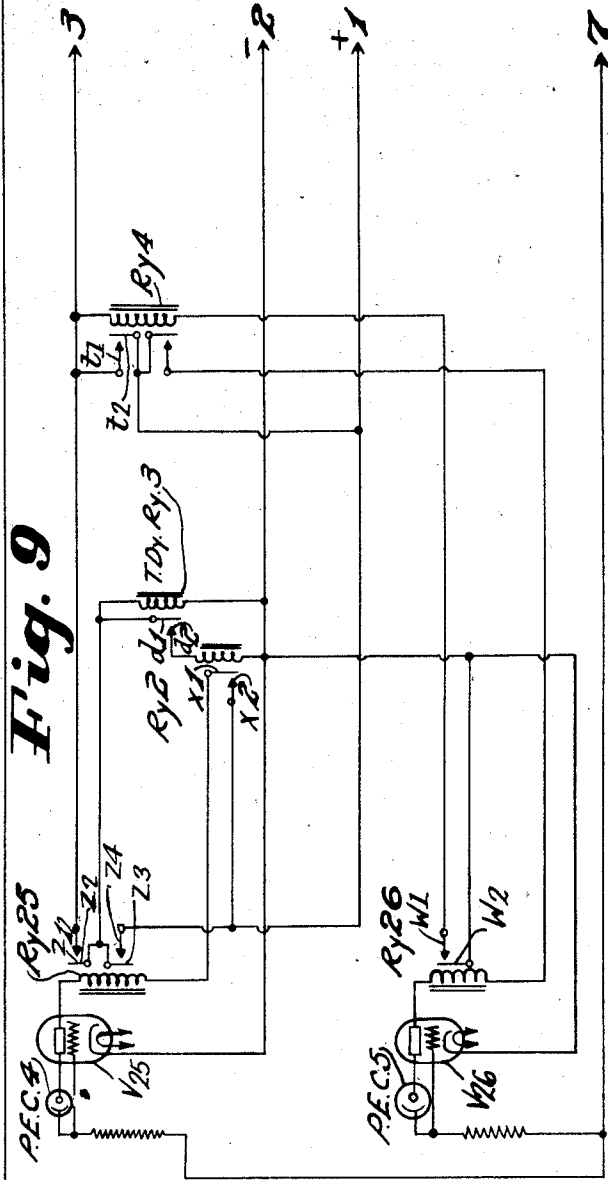
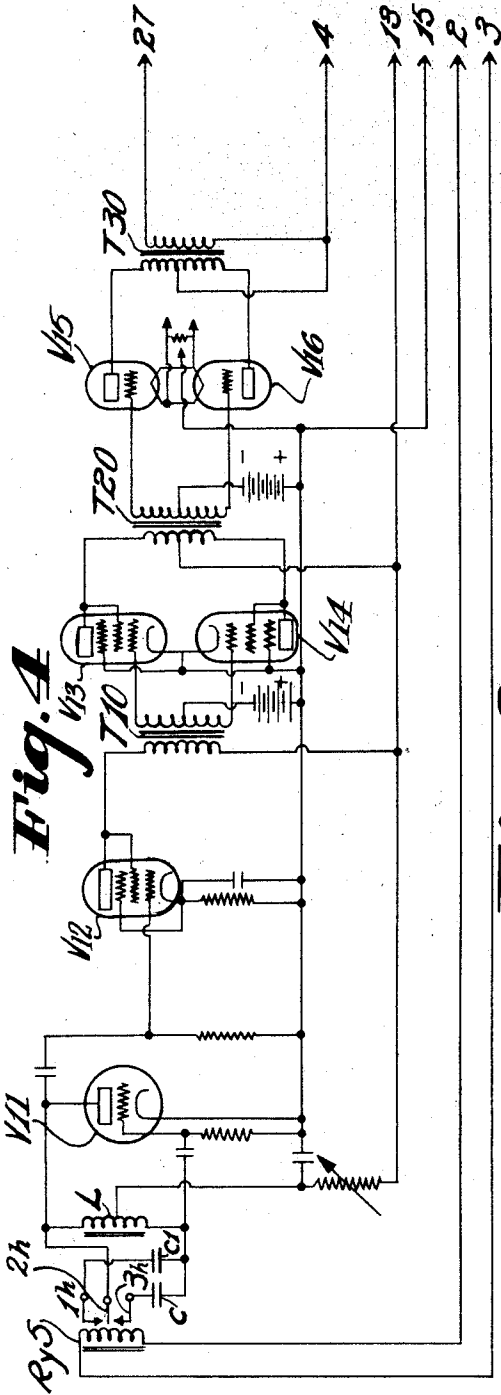
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RAILWAY TRAIN CONTROL SYSTEM

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8 Sheets-Sheet 3



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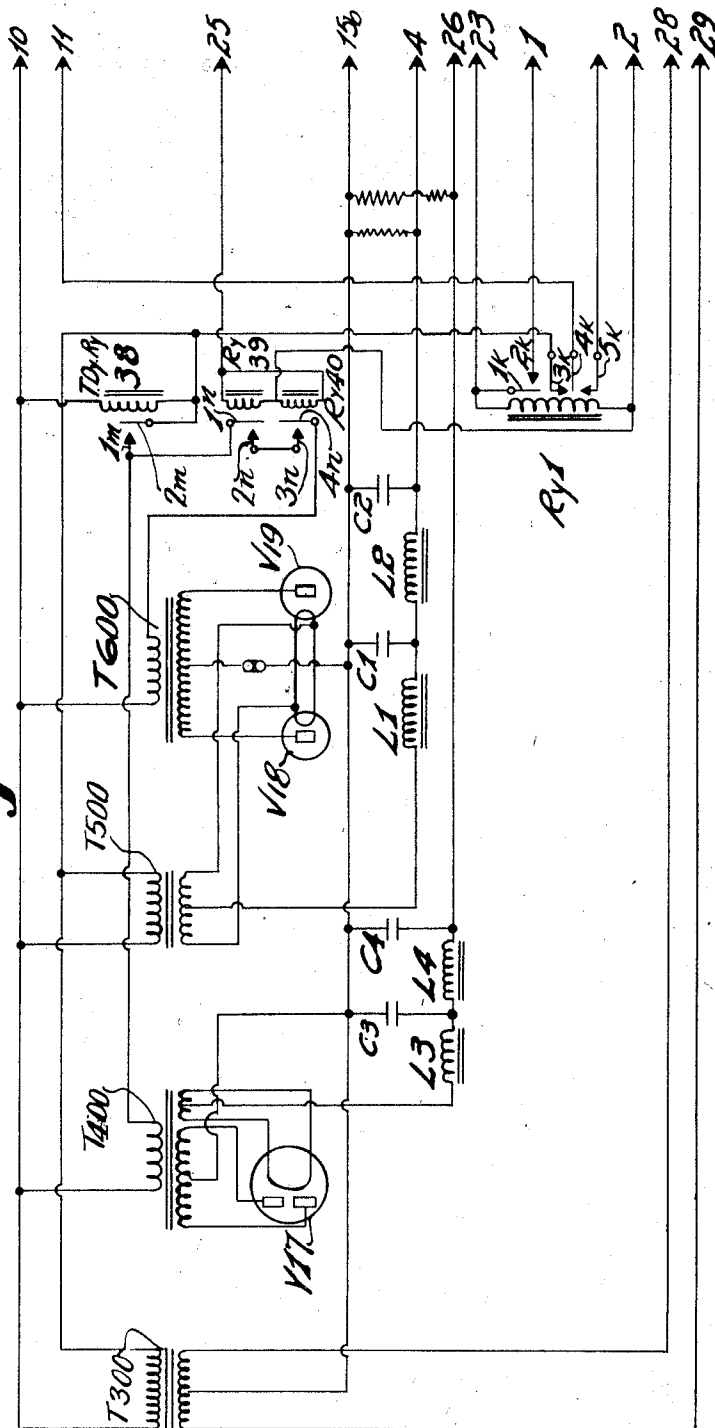
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Fig. 5



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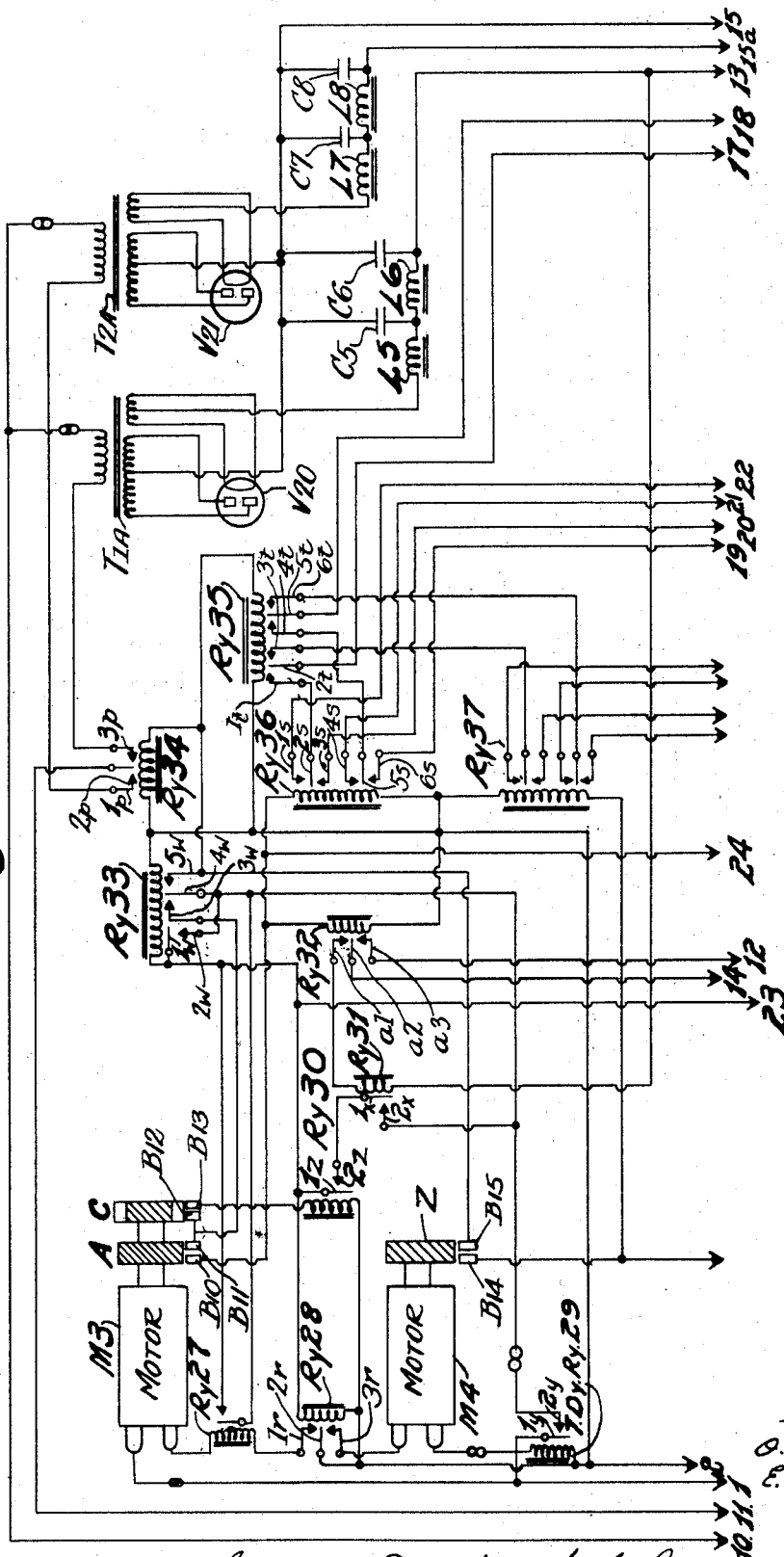
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RAILWAY TRAIN CONTROL SYSTEM

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Fig. 6



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Fig. 7

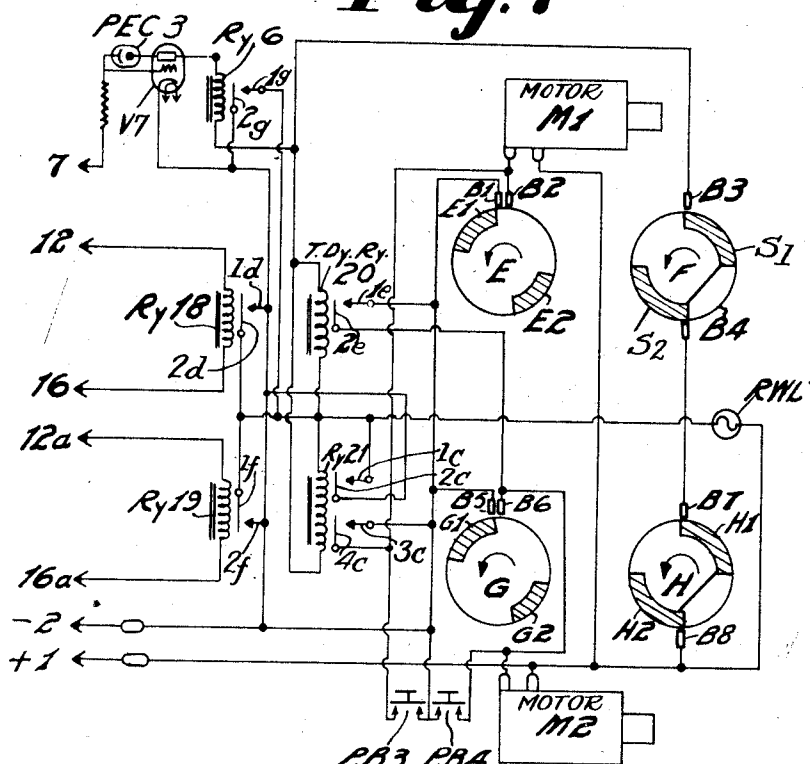
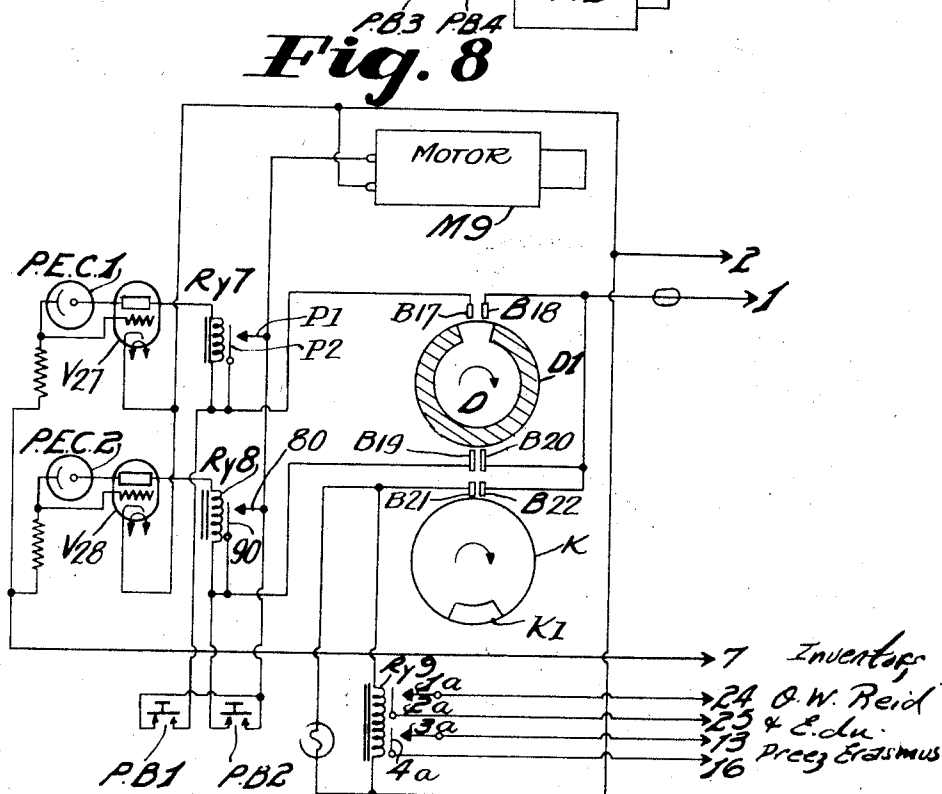


Fig. 8



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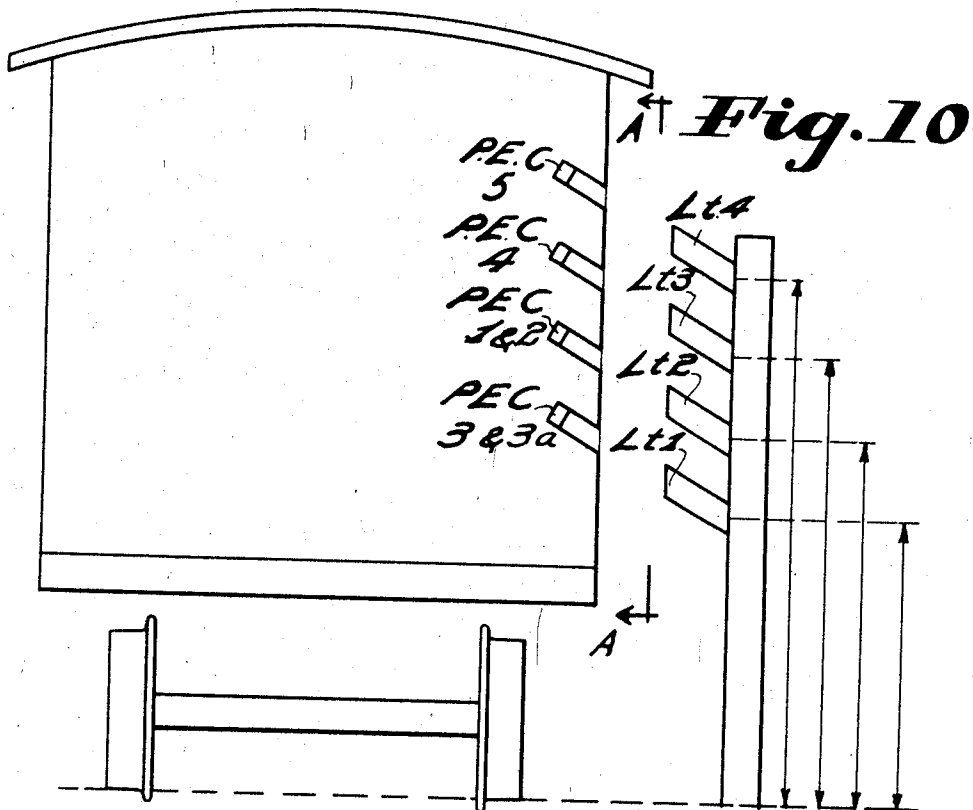
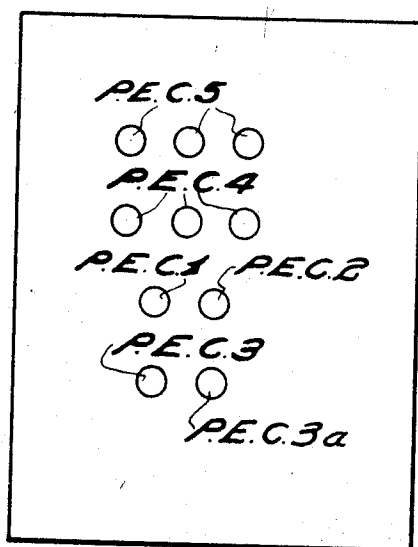


Fig. 10a



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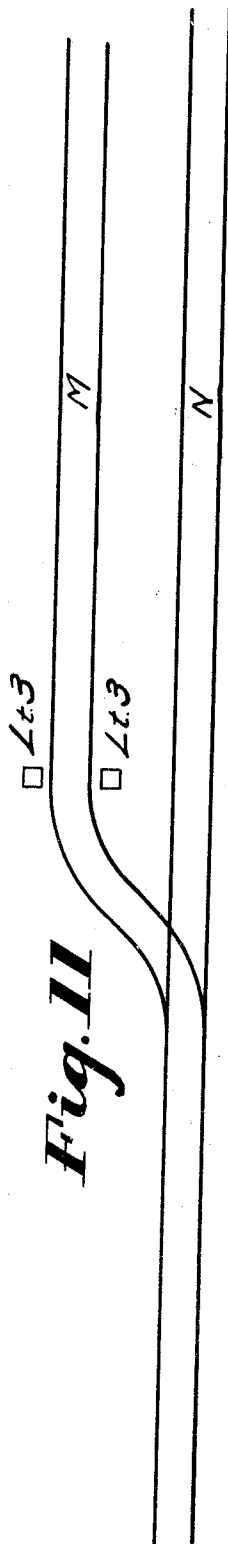
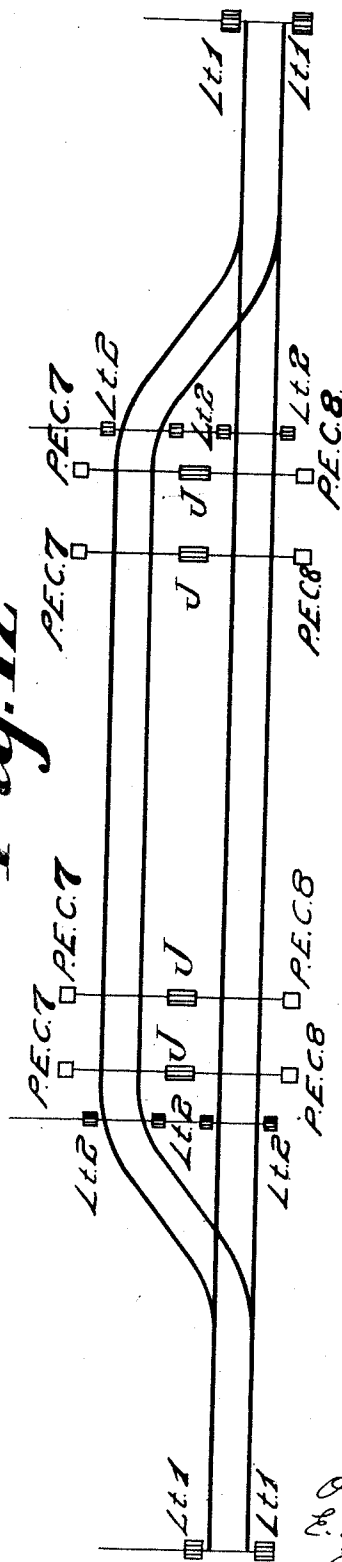


Fig. 12



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UNITED STATES PATENT OFFICE

2,252,525

RAILWAY TRAIN CONTROL SYSTEM

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Application August 31, 1939, Serial No. 292,946
In the Union of South Africa September 16, 1938

8 Claims. (Cl. 246—29)

This invention relates to railway control systems and is concerned with such systems for the control of trains independently of their drivers, for the purpose primarily of preventing collisions.

The railway train control system according to the present invention comprises for each train an electric wave signal transmitter and an electric wave signal receiver, means for rendering the transmitter and the receiver alternately operative and means controlled by the signal output of the receiver of a train due to signals received from the transmitter of another train, on reaching a predetermined strength due to relative approach of the trains, to apply the brakes of the train. Thus, when in the operation of trains, two trains come within a predetermined range of one another the brakes of both trains are automatically applied to stop the trains.

According to a further feature of the invention means is provided for rendering the receiver operative with decreased sensitivity during periods of transmission from the same train and means is employed operated by the output of the receiver as a result of signals received from the transmitter on the train to determine the efficiency of operation of the installation. Preferably, means is automatically operated when the output of the receiver during the transmission periods falls below a predetermined value to put stand-by apparatus into operation. Therefore, if for any reason the transmitter or the receiver fails to operate with a predetermined efficiency the stand-by apparatus is put into operation.

Another feature of the invention consists in the provision of auxiliary signal receiving apparatus and means controlled by this receiving apparatus for rendering the receiver inoperative for incoming signals of which the strength is greater than a predetermined value. This auxiliary receiving apparatus thus prevents the brakes from being operated as a result of a strong interfering signal being received on the main receiver.

According to yet another feature of the invention the transmitter comprises means for changing a frequency for example a modulation frequency, of the transmission, and the receiver comprises selective means for each frequency, and furthermore, means is provided adjacent the track for automatically effecting the change of the frequency of operation of both transmitter and receiver when the train passes from one track to another. Conveniently, the means for effecting a change of frequency comprises light responsive devices on the train controlled by

means of light sources on the track. Different signal frequencies may therefore be employed for trains working on different tracks so as to avoid mutual interference and by the provision of the automatic change-over as regards frequency a train operating on one track may be passed on to another track and automatically come under the control system for that track.

A further feature of the invention consists in the provision of light responsive means on the train for controlling the actuation of the brakes, which light responsive means is arranged for control by means of light sources on the track. A train may thus be stopped at predetermined locations, for example, in station sections of the track.

Furthermore, light responsive means may also be provided on the train for rendering the transmitter and receiver inoperative in predetermined track sections, for example in stations under the control of light sources on the track. Under these conditions, means is provided for detecting the presence of a train in a section in which its transmitter and receiver are inoperative, together with light sources on the track remote from said section and controlled by the detecting means in order to render the installation of an approaching train operative, to apply the brakes. In the case where the track comprises points for directing a train on to alternative tracks there are conveniently provided light sources on the track for stopping an oncoming train, which light sources are controlled by the position of the points, and by the presence of a train on the track, opened by the points for the oncoming train.

In one construction means to apply the brakes of the train comprises a brake operating motor, means for completing an energising circuit for the motor under the control of the output of the receiver, switch means automatically opening the motor circuit when the brakes have been operated and means for re-energising the motor to release the brakes. Preferably, there is a stand-by brake operating motor and means such as a relay controlled by the output of the receiver and operating with a time delay for completing an energising circuit for the stand-by motor to apply the brakes.

For the alternate operation of the transmitter and receiver it is convenient for the receiver to be normally operative and to provide a keying switch automatically operated periodically to change over antenna connections from the receiver to the transmitter and to connect a power

supply to the transmitter for its operation. Conveniently, the keying switch, when operated, effects a change-over of the output of the receiver from the brake-applying means to a monitoring relay which when energised serves to open contacts in a control circuit for stand-by transmitting and receiving apparatus. Conveniently, a test switch is operated in synchronism with the keying switch and is operative for periods less than the transmission periods to control contacts in the control circuit to complete this circuit for putting the stand-by apparatus into operation if the monitoring relay is not operated to open the control circuit.

In one arrangement for effecting a change of frequency there are provided light responsive devices allocated to each of two alternative frequencies and means controlled by each of these light responsive devices to operate a change-over switch for effecting a change from one frequency to the other.

The light-responsive devices for controlling the brakes for rendering the transmitter and receiver inoperative in a predetermined track section and for determining the signal frequency and for operating the brakes are preferably mounted at different heights on the train so as to be responsive only to light sources disposed at correspondingly different heights above the track.

One specific form of the train control system according to the invention is shown by way of example in the accompanying drawings, in which:

Figure 1 is a circuit diagram of the receiver;

Figure 2 is a circuit diagram of the transmitter;

Figure 3 is a circuit diagram of the auxiliary receiving means;

Figure 4 is a circuit diagram of a modulator for the transmitter;

Figure 5 is a circuit diagram of power supply apparatus for the transmitter;

Figure 6 is a circuit diagram of means for controlling alternate transmission and reception and the bringing into action of stand-by apparatus;

Figure 7 is a circuit diagram showing brake-applying apparatus;

Figure 8 is a circuit diagram of the means for disconnecting and reconnecting the transmitter and receiver under track control;

Figure 9 is a circuit diagram of photo-electric cell circuits for changing signal frequency;

Figure 10 is a diagram showing the disposition of photo-electric cells on the train and in relation to light sources on the track;

Fig. 10a is a diagram showing the arrangement of the photo-electric cells.

Figure 11 is a diagram showing a particular arrangement of light sources on the track;

Figure 12 is a diagram showing control devices for a looped track, and

Figure 13 is a circuit diagram of control means for the light sources for track control, as shown in Figure 12.

Referring to Figure 1 of the drawings, the main receiver of the train installation for receiving the modulated carrier wave signals has three valve amplifying stages V1, V2 and V3 operating at the carrier frequency. An input is applied to the valve V1 through a tuned input transformer T1 from terminals 21 and 22 which are bridged with terminals 21 and 22 shown in Fig. 6 and these terminals are connected to relays Ry35 and Ry36 for controlling the connection

of an antenna system to the receiver as hereinafter described. The valves V1, V2 and V3 are coupled by tuned transformers T2 and the valve V3 is in turn coupled by means of a tuned transformer T3 to a diode section of a valve V4 for detecting the modulation signal frequency which is amplified in a triode section of this valve V4. The output from the valve V4 is applied through modulation signal selective means to the input of the signal frequency amplifying valve V5 which is, in turn, transformer-coupled by means of a transformer T4 to a signal output valve V6.

For single track operation, in which only one signal frequency is used, the frequency selective means may simply consist of a filter for this frequency. Where different signal frequencies are used for multiple track operation the frequency selective means comprises filters for these frequencies and means for connecting them individually in circuit. In Figure 1 there are shown two filters F1 and F2 for two different signal frequencies arranged to be alternatively connected in circuit by means of relays Ry22 and Ry23. These relays are connected in parallel and to terminals 2 and 3 of the receiver through which they are energised, as hereinafter described, according to the signal frequency on which operation of the system is to be effected.

The normal sensitivity of the receiver may be adjusted to the required value by means of variable resistors R9 and R10 in the cathode circuits of the valves V1 and V2 respectively and the output valve V6 of the receiver is biased to cut-off by means of a battery B. Thus, when no signals are being received, no current will flow in the output circuit of the valve V6 but, on signals being received at the appropriate modulation signal frequency, the valve V6 will pass current.

The anode of the valve or tube V6 is connected to a terminal 14 which is bridged to a terminal 14 in Fig. 6. The terminal 14 in Fig. 6 is connected to a contact a2 of a relay Ry22. The contacts a2 and a3 of this relay are normally closed. The terminal 12 shown in Fig. 6 is connected to the contact a3. The terminal 12 of Fig. 6 is bridged to the terminal 12 in Fig. 7. The terminal 12 in Fig. 7 is connected to the winding of a relay Ry18 shown in Fig. 7. The other end of the winding of the relay Ry18 is connected to the terminal 16 which is connected to the terminal 16 in Fig. 8. The terminal 16 in Fig. 8 is connected to a contact 4a of a relay Ry9. The contacts 3a and 4a of the relay Ry9 are normally closed. The contact 3a is connected to a positive terminal 13 of a high voltage supply. The relay Ry18 is thus energized on signals of sufficient strength being received by the receiver.

The receiver is required to operate also in a comparatively insensitive condition and for this purpose the high tension current for the valves V1, V2, V3 and V4 is fed through a resistor R14 which, for normal operation is short-circuited by normally closed contacts 1b and 2b of a relay Ry24. The anode supply for these valves is applied through a terminal 5 which is bridged to a terminal 5 in Fig. 3. The terminal 5 in Fig. 3 is connected to a terminal 16 in Fig. 3 through normally closed contacts of a relay Ry41. The terminal 16 in Fig. 3 is connected to the terminal 16 in Fig. 8 and this terminal is connected to the positive terminal 13 in Fig. 8 by means of the normally closed contacts 3a and 4a

of the relay $Ry/8$. The anode of the valve $V5$ is connected to the terminal 16 in Fig. 1 which is bridged to the terminal 18 in Fig. 8. Thus the anode of the tube or valve $V5$ receives a positive potential from the positive terminal 18 in Fig. 8 through the normally closed contacts 3a and 4a. The cathodes of the receiver tubes are connected to a terminal 15 as shown in Fig. 1 and this terminal is connected to negative side of the high voltage supply.

Referring to Figure 7, a D. C. electric motor $M1$ is arranged to operate a valve (not shown) to apply the brakes of the train. This motor is also arranged to rotate two commutators E and F. The commutator F has diametrically opposite conducting segments $S1$ and $S2$ which are electrically bridged together and each extending over 25% of the total periphery of the commutator. A stand-by electric motor $M2$ is provided also for operating the valve to apply the brakes and this motor drives two commutators G and H of which the commutator H has diametrically opposite conducting segments $H1$ and $H2$ bridged together and similar to the segments $S1$ and $S2$ of the commutator F. The commutator E has diametrically opposite conducting segments $E1$ and $E2$ and the commutator G has similar conducting segments $G1$ and $G2$. Each of these segments $E1$, $E2$, $G1$ and $G2$ extends over 20% of the periphery of the commutator. In the position of the motors $M1$ and $M2$ corresponding to the brakes being off, brushes $B3$ and $B4$ engage respectively the leading ends of the segments $S1$ and $S2$ of the commutator F and brushes $B1$ and $B2$ similarly engage the leading ends of the segments $H1$ and $H2$ of the commutator H. Two brushes $B1$ and $B2$ are arranged side-by-side just past the trailing edge of the conducting segment $E1$ of the commutator E and similarly two brushes $B5$ and $B6$ engage the commutator G just behind the trailing edge of the segment $G1$.

On the relay $Ry/18$ being energized by a received signal its contacts 1d and 2d are closed and a circuit is completed from terminal 1 through the segments of commutators H and F, a relay $Ry/21$, contacts 1c and 2c of relay $Ry/18$ to a terminal 2, a D. C. supply being applied across terminals 1 and 2. The relay $Ry/21$, on being energized, closes its contacts 3c and 4c and completes a circuit from terminal 1 through the motor $M1$ and the contacts 3c and 4c of the relay $Ry/21$ back to the negative terminal 2. The relay $Ry/21$ being energized also closes holding contacts 1c and 2c to maintain the relay energized regardless of further operation of the relay $Ry/18$.

The motor $M1$ continues to rotate and drives the commutators E and F until the segments $S1$ and $S2$ of the latter pass beyond the brushes $B3$ and $B4$ respectively so as to open the circuit of the relay $Ry/21$ which, being thus de-energized, interrupts the motor circuit, by the opening of its contacts 3c and 4c. The drive from the motor $M1$ to the commutators E and F is in such relation to the drive of the brake-operating valve that, by rotation of the commutators E and F, the valve is moved to the fully-open position to apply the brakes. In this position of the commutators the segments $E1$ and $E2$ of the commutator E are so arranged that the leading part of segment $E2$ is now just short of a position bridging the brushes $B1$ and $B2$. These brushes $B1$ and $B2$, when electrically bridged, serve to connect the motor $M1$ directly across the supply terminals 1 and 2. A press-button switch $PB3$ is connected in parallel with the brushes $B1$ and $B2$

so that operation of this switch serves to energize the motor $M1$ again, the motor circuit being maintained, when the press-button $PB3$ is released, through the brushes $B1$ and $B2$ and the commutator segment $E2$. The motor continues to rotate until the segment $E2$ rides past the brushes $B1$ and $B2$, or to the position of the segment $E1$ in Figure 7, at the same time bringing the segment $S2$ of commutator F into the position of the segment $S1$ as shown in Figure 7. The drive from the motor is such that during this further rotation of the commutators the brake-operating valve is moved to the closed position and the apparatus is ready for a repetition of its operation. A relay $TDy/Ry/20$ is connected in parallel with the relay $Ry/21$, and on being energized, operates with a time delay of, for example, three to four seconds to close its contacts 1e and 2e in circuit with the stand-by brake-operating motor $M2$ which is also arranged to transmit a drive to the brake-operating valve for applying the brakes. Thus, should the main brake-operating motor $M1$ fail to operate, the application of the brakes is assured and by the operation of the stand-by brake-operating motor $M2$. Means may be provided for rendering the stand-by brake-operating motor $M2$ inoperative when the main brake-operating motor $M1$ has operated to apply the brakes. With the operation of the stand-by brake-operating motor $M2$, the commutators G and H driven thereby are rotated so that, when the brake-operating valve has been opened, the segments $H1$ and $H2$ are moved clear of the brushes $B1$ and $B2$ respectively and the segment $G2$ of the commutator G has moved to a position in which it nearly bridges brushes $B5$ and $B6$. A press-button switch $PB4$ connected in parallel with the brushes $B5$ and $B6$ serves to complete a circuit for the motor $M2$ which circuit is maintained, after the press-button is released, by the brushes $B5$ and $B6$ being bridged by the segment $G2$. As in the case of the main brake-operating motor $M1$, the further operation of stand-by motor $M2$ serves to return the valve to the normally closed position and, in doing so, turns the commutators G and H to the position in which the segment $H2$ occupies the position of segment $H1$ in Fig. 7 and the positions of segments $G1$ and $G2$ of commutator G are reversed. The commutators G and H are, therefore, re-positioned for a subsequent braking operation. It will be understood that the commutators E, F, G and H are rotated through 180° for each complete cycle operations of the brake-operating valve.

A relay $Ry/19$ when energized closes contacts 1f and 2f connected in parallel with the contacts 1d and 2d of relay $Ry/18$. This relay $Ry/19$ is connected by terminals 12a and 16a to the output of a stand-by receiver which is a receiver of the same form as that shown in Figure 1 and is brought into operation as hereinafter described. Thus, the brake-operating motors $M1$ and $M2$ may be put into operation either by relay $Ry/18$ or relay $Ry/19$ being energized. A warning lamp RWL is connected in circuit with the contacts of relays $Ry/18$ and $Ry/19$ so as to give an indication when either of these relays is energized.

For the purpose of stopping the train at a predetermined location there is provided a photo-electric cell $PEC3$ associated with an amplifying valve $V7$ arranged to energize a relay $Ry/6$ connected in the anode circuit of the valve. The anode circuit is completed through the commutators F and H to the positive supply terminal

1 and the cathode is connected directly with the negative terminal 2 of the supply. The relay Ry6, when energised, closes contacts 1g and 2g serving to complete the circuits of the relays Ry21 and TDyRy20. The photo-electric cell PEC3 is connected between the anode and a control grid of the valve V7, the control grid being further connected by a terminal 7 to a source of control potential such as to bias the valve V7 to the cut-off. Thus, when the photo-electric cell PEC3 is energised, the valve V7 is made conductive to pass anode current through the relay Ry6 to effect this operation and, in consequence, the operation of the brakes of the train in the manner hereinbefore described.

Referring to Figure 2 of the drawings, the transmitter of the train installation comprises a master oscillator V8 controlled by a quartz crystal Q which conveniently operates at one-half of the required carrier frequency. The carrier frequency is selected by a tuned circuit T/1 in the anode circuit of the valve V8 and is applied through a resistance capacity coupling to an amplifying valve V9. The output of the valve V9 is applied through coupled tuned circuits T/2 and T/3 to an output valve V10 having a tuned output circuit T/4 which is coupled to a feed coil connected to terminals 19 and 20 as shown in Fig. 2 and these terminals are bridged to terminals 19 and 20 in Fig. 6 which are connected, under the control of relays Ry35 and Ry36, to an antenna system connected to terminals 17 and 18 (Figure 6). The anodes of the valves V8 and V9 are connected through terminal 26 (Figures 2 and 5) to the positive pole of a high tension supply. The valve V10 is shown as having a directly heated cathode of which the electrical centre is connected to the cathodes of the valves V8 and V9 and through terminal 15b (Figures 2 and 5) to the negative pole of a high tension supply for the transmitter.

The transmitter is modulated by modulation signals applied to the electrical centre of tuned circuit T/4 via the terminal 27. This terminal 27 (Figures 2 and 4) is connected from the secondary winding of a modulating transformer T30, terminal 4 (Figures 4 and 5) to the positive pole of a high tension supply for the output valve V10 of the transmitter.

In Figure 4 there is shown modulating means for two frequencies corresponding to the frequencies of the filters F1 and F2 of the main receiver. The modulator comprises a valve oscillator V11 having an oscillating circuit comprising an inductance L and either a condenser C or a condenser C1 in parallel therewith. The selection of the condensers C and C1 is effected by a relay Ry5 of which contacts 1h and 2h are normally closed connecting the condenser C1 in circuit for the production of a modulation frequency of, say 10 kilocycles. When the relay Ry5 is energised relay contacts 1h and 2h are opened and relay contacts 2h and 3h are closed connecting the condenser C in circuit for producing another modulation frequency of, say, 85 kilocycles. The valve V11 is coupled by means of a resistance coupling to a valve V12, this, in turn, being coupled by means of a transformer T10 to a further amplifying stage comprising valves V13 and V14 connected in push-pull. The output of this stage is applied through a transformed coupling T20 to a push-pull output stage comprising valves V15 and V16 feeding the pri-

mary winding of the transformer T30. The valves V11, V12 and V13 of the modulator have their anodes connected through terminal 13 (Figures 4 and 6) to the positive pole of a high tension supply, the cathodes of the valves being connected through terminal 15 (Figures 4 and 6) to the negative pole of the high tension supply. The relay Ry5, which controls the modulation frequency is connected through terminals 2 and 3 (Figure 4) to means for effecting a change of modulation signal frequency, as hereinafter described.

The power supply for the transmitter and modulator is derived from the power supply means illustrated in Figure 5. In Figure 5 an alternating current supply applied to terminals 10 and 11 feeds the transformers T300, T400, T500 and T600 through normally closed contacts 3k and 4k of a relay Ry1. The output for the transformer T300 is applied through terminals 28 and 29 (Figures 5 and 2) to the directly heated cathode of the transmitting valve V10. The transformer T400 feeds a rectifier V17 applying, through a smoothing circuit L3C3, L4C4, a high tension supply through terminal 26 (Figures 5 and 2) to the valves V8 and V9 of the transmitter. The transformers T500 and T600 feed a rectifier comprising valves V18 and V19 for providing a high tension supply applied through a smoothing circuit L1C1, L2C2 through the terminal 4 (Figures 5 and 4) to the anode of the transmitting valve V10 by way of the transformer T30 of the modulator. A relay TDyRy38, operating with a time delay, serves to close its contacts 1m and 2m, which are in circuit with the primary windings of the transformers T400 and T600, so that current is only supplied to these transformers after the valves of the transmitter have reached the required operating temperature. The circuit through the primary of the transformer T600 is also controlled by contacts 1n and 2n and 3n and 4n of relays Ry39 and Ry40 connected in a circuit from the positive terminal 2 of the D. C. supply, through the relays Ry39 and Ry40 to terminal 26 (Figures 5 and 8) through normally closed contacts 1a and 2a of relay Ry8, through terminal 24 (Figures 8 and 6) and through means hereinafter described for controlling the alternate operation of the transmitter and receiver.

The supply to the transformers T300, T400, T500 and T600 is effected through normally closed contacts 3k and 4k of the relay Ry1 and this relay, when energised opens this pair of contacts and closes another pair of contacts 4k and 5k to apply the A. C. supply to a stand-by high tension supply apparatus like that shown in Figure 5. The relay Ry1 is energised through the terminal 2 for the positive pole of the D. C. supply terminal 23 (Figures 5 and 6) and control means, hereinafter described with reference to Figure 6, and on being energised also closes contacts 1k and 2k connecting the relay Ry1 directly across the terminals 1 and 2 of the D. C. supply.

A high tension supply for the receiver and modulator is obtained through a transformer T1A (Figure 6) of which the primary winding is connected through normally closed contacts 2p and 3p of a relay Ry34 to terminals 10 and 11 for the A. C. supply. The secondary winding of the transformer T1A feeds a rectifier V20 from which the D. C. output is applied through a smoothing circuit L5C3 and L5C5 to terminal 13 to the receiver and modulator as hereinbefore described, the negative pole of the high tension supply be-

ing connected through terminal 15 to the cathodes of the valves of the receiver and modulator. When energised, as hereafter described, Ry34 opens its contacts 2p and 3p and closes contacts 1p and 2p to connect the primary of another transformer T2A to the supply. The secondary of this transformer feeds another valve rectifier V21 of which the D. C. output is applied through a smoothing circuit L7C1 and L8C8 to a terminal 15a for connection to the stand-by receiver and modulator (not shown).

Each train is provided with the transmitting and receiving apparatus hereinbefore described and, for single track operation, a single modulation frequency is employed. As one train approaches another the field strength of a transmitter in one of the trains increases at the receiver of the other train and, when it reaches a value predetermined by the sensitivity of the receiver, Ry18 or Ry19 of the braking apparatus becomes operative to apply the brakes and stop the train. The distance apart of the trains when the brakes become operative is dependent upon the requirements of the railway system and may, for example, be 1,200 yards. Thus, in this case, having regard to the power of the transmitter, the sensitivity of the main receiver would be such as to effect an operation of the brakes by reception of the transmission when the trains are this distance apart.

In order that the transmitter shall not interfere with the operation of the receiver of the same installation, the transmitter is energised periodically for instance, for periods of 4 seconds separated by non-operative intervals of 4 seconds and the receiver is operated with reduced sensitivity, as hereinbefore referred to during the periods of operation of the transmitter. The operation of the transmitter and receiver are controlled by means of a keying motor M3 (Figure 6) which rotates two commutators A and C at a speed of one revolution per 8 seconds. The motor is connected to D. C. supply terminals 1 and 2 through a relay Ry27 and normally closed contacts 1r and 2r of a relay Ry28. These commutators each have a single conducting segment, the segment of commutator A extending through 50% of the circumference and that of commutator C through a lesser angle, for instance 40% of the circumference. The commutator A co-operates with brushes B10 and B11 and the commutator C with brushes B12 and B13 and the arrangement is such that the conducting segment of commutator A electrically connects the brushes B10 and B11 for an interval before the brushes B12 and B13 are connected by the segment of commutator C and for an interval after the brushes B12 and B13 leave the conducting segment of the commutator C. The commutator A renders the transmitter operative and reduces the sensitivity of the receiver during the one-half of each revolution in which its conducting segment bridges the brushes B10 and B11. The commutator C serves to bring the stand-by apparatus into operation should a fault occur. During the period in which the brushes are not bridged by the conducting segment of the commutator A the receiver is operative with its normal sensitivity. It is connected by terminals 21 and 22 (Figures 1 and 6) through normally closed contacts 4s and 5s and 1s and 2s of relay Ry36 and normally closed contacts 4t and 5t and 1t and 2t of relay Ry35 to the antenna terminals 17 and 18. The high tension supply is also provided and the output of the receiver includes the brake-operating relay Ry18.

The brushes B11 and B12 are electrically connected together and are also connected through normally closed contacts 3w and 4w of a relay Ry33 and normally closed contacts 1y and 2y of a relay TDyRy29 to the terminal 1 for the positive pole of the D. C. supply. The relay TDyRy29 is connected across the D. C. supply and operates with a time delay after the installation has been switched on to close its contacts 1y and 2y. When the brushes B10 and B11 are electrically bridged, a circuit is completed through terminal 24 of Fig. 6 to the relay Ry24 of Fig. 1 to terminal 2 for the negative pole of the D. C. supply. Another circuit is completed through terminal 24 of Fig. 6 and normally closed contacts 1a and 2a of Ry9 in Fig. 8 terminal 25, relays Ry39 and Ry40 in Fig. 5 back to terminal 2 of the D. C. supply. A further circuit is completed from the brushes B10 and B11 through relays Ry32 and Ry36 direct to terminal 2 (Figure 6).

By Ry39 and Ry40 in Fig. 5 being energised, their contacts are closed to complete the circuit of the transformers T400 and T600 through contacts 1n to 4n and the contacts 1m and 2m of the relay TDyRy38 normally closed during operation of the system. The high tension supply from terminals 4 and 26 thus becomes available and is applied, as hereinbefore described, to the transmitter to enable it to operate. The modulating means, being in operation, the modulated carrier wave signal is propagated by the transmitter. Relay Ry36 being energised closes its contacts 2s and 3s, and 5s and 6s to connect antenna terminals 17 and 18 through normally closed contacts 1t and 2t and 3t and 4t respectively of a relay Ry35 to terminals 19 and 20 of the transmitter.

On Ry32 being energised its contacts a2 and a3 are opened to interrupt the output circuit of the receiver through the brake-operating relay Ry18 and, by closing of its contacts a1 and a2, completes another output circuit of the receiver from terminal 14 (Figures 1 and 6) through a relay Ry31 to the terminal 13 the high tension supply. By relay Ry24 being energised, its contacts 1b and 2b are open to decrease the sensitivity of the receiver as a result of the resistance of R14 being introduced into the circuit and this reduced sensitivity is such that the receiver output is sufficient to operate Ry31 by the output derived from the transmitter of the same installation only if the installation is otherwise operating with proper efficiency.

As rotation of the commutators A and C proceeds, the brushes B12 and B13 are bridged by the conducting segment of commutator C and a circuit is completed through a relay Ry30 causing its contacts 1z and 2z to close, thus connecting the brush B12 with contact 1x of Ry31. Should there be any defect in the transmitter or the receiver, rendering either of them inefficient or inoperative, the output of the receiver will not be sufficient to energise the relay Ry31 so that its contacts 1x and 2x will remain closed and thus connect relays Ry33, Ry28 and Ry1 (Figure 5) in circuit with the terminals 1 and 2 of the D. C. supply, Ry1 being connected to these terminals through terminal 23 (Figures 5 and 6). Ry33 will remain energised by the closing of holding contacts 1w and 2w and Ry1 (Figure 5) will also remain energised by the closing of its holding contacts 1k and 2k. Moreover, Ry28 is maintained energised being in circuit with the holding contacts of relay Ry1.

Ry28 being energised, opens its contacts 1r and

2r and closes its contacts 2r and 3r thus connecting a standby keying motor M4 to the D. C. supply and disconnecting the motor M3 from the supply. Ry33 being energised, its contacts 3w and 4w are opened to interrupt the circuits of Ry24, Ry32, Ry36, Ry39 and Ry40 restoring the condition for normal reception. Contacts 4w and 5w of relay Ry33 are closed to complete circuits through relays Ry34 and Ry35. Ry34 thus being energised opens its contacts 2p and 3p and closes its contacts 1p and 2p so that the transformer T2A of the stand-by receiver high tension supply unit is energised to put the stand-by receiver into operation. Relay Ry1 on being energised closes its contacts 4k and 5k to connect the A. C. supply to a stand-by power supply apparatus for feeding the stand-by transmitter and modulator so as to bring these into operation. Ry35 on being energised, opens contacts 1t and 2t and 4t and 5t and closes contacts 2t and 3t and 5t and 6t to transfer the connection of the antenna feeders 17 and 18 from the control relay Ry36 to a stand-by antenna control relay Ry37. This relay Ry37 performs the same functions as the relay Ry37 for the stand-by apparatus, serving to change the antenna connections from transmitter to receiver.

The motor M4 drives a commutator Z, serving to bridge brushes B14 and B15. This commutator serves to render the stand-by transmitter alternately operative and inoperative in the same way as the commutator A for the primary apparatus. The brush B15 is connected through contacts 4w and 5w, now closed, of relay Ry33 and contacts 1y and 2y of relay TDyRy29 to the terminal 1 of the D. C. supply, the circuit being completed, when the brushes are electrically bridged, from B14 through relay means not shown for effecting the change over in stand-by transmission and reception. The circuit of the relay Ry37 controlling the antenna connections for stand-by operation is also energised under the control of the commutator Z and brushes B14 and B15. The relay Ry27 is energised by current taken by the main keying motor M3 so that should any defect develop causing fuses in the circuit with the motor to fail, the relay is deenergised to bring the stand-by apparatus into operation.

Thus, summarising the operation of the apparatus, as so far described, the transmitter of the installation operates for alternate periods of, say 4 seconds under the control of the commutator A. If the receiver is energised by an incoming signal from the transmitter of another installation within a given distance, the brakes are operated to stop the train. During the period of operation of the transmitter the receiver operates with less sensitivity such that the pick-up transmitter provides an output which is of the same order as the output which would be obtained from the receiver on receipt of signals from another installation at such a distance away as to operate the brakes. However, during the transmission period, the output of the receiver is not applied to operate the brakes but is directly connected to a monitoring relay Ry31 which serves to maintain the normal operation of the system. Should either the transmitter or the receiver fail to perform adequately, this relay, being energised, brings the stand-by apparatus into operation. It would be very improbable that any two installations would operate with their periods of transmission coinciding in time but any such possibility may be overcome by effecting a change-over of operation by the commutator A at dif-

ferent intervals for different installations. When it is required that the train shall be stopped at a specific location a light source may be provided at the side of the track to operate the photo-electric cell PEC3 of the train installation so as to operate the brakes in the manner described with reference to Figure 6 and independently of the receiver.

It is possible that a strong signal, even though not coming from another train installation on the same track, may be sufficient to cause the application of the brakes and such a signal may, for example, be caused by a lightning discharge or be produced by a train passing on an adjacent track. For instance, if the installation of one train is working on .85 kc. and the other on 10 kc., the filters provided in the receiver may, due to the very large field strength provided when the trains are passing, produce sufficient output to actuate the brakes. In order to avoid this possibility there is provided an auxiliary receiver, as shown in Figure 3. This receiver comprises a radio frequency amplifying valve V22 to which alternative antennae A1 and A2 may be connected, a valve detector V23 and a modulation signal output valve V24, in the output circuit of which there is included the winding of a relay Ry41. The valve V24 may be biased by a battery BB to the cut-off. When, on a signal being received, Ry1 is energised and contacts 3k and 4k are open to interrupt the high tension supply circuit to the valves V1 to V4 of the main receiver. The relay R1 is also provided with other contacts 1k and 2k which provide a similar control for the stand-by receiver hereinbefore referred to.

The auxiliary receiver is controlled, as regards sensitivity, for example, by means of resistances Rx and Ry so that no current flows in the output circuit of the valve V24 as a result of signals received from the installation on another train on the same track at a distance of, say, greater than 900 yards. With trains approaching on the same track, when this separation is reached, the brakes will have already been applied but, with trains passing on adjacent tracks, should the signal strength at the main receiver increase as the trains pass within this distance to a value which would operate the main receiver and thus apply the brakes, this auxiliary receiver comes into operation to deenergise and thus safeguard the main receiver and, moreover, prevent the brakes being applied under such circumstances.

In the case of a railway system having more than one track, in which a train is required to pass from one track to another, means is provided automatically to change the signal frequency on which the apparatus works from that allocated to one track to the frequency allocated to the other track. This change of modulation signal frequency is controlled by photo-electric devices operated by means of light sources arranged at the side of the track.

In Figure 1, the relays Ry22 and Ry23 are de-energised and so connect the filter F2 operating at say 10 kc. in circuit. Similarly, in the modulator shown in Figure 4, Ry5 is de-energised and relay contacts 1h and 2h are closed completing the tuned circuit Lc1 also for a frequency of 10 kc.

For a change-over of the filters of the receiver and the frequency of the modulator to the other signal frequency of say .85 kc., the train installation comprises (as shown in Figure 9), a photo-electric cell PEC4 connected across the anode

and grid of a thermionic valve V25, the cathode of the valve being connected through the terminal 2 to the negative pole of the D. C. supply. The positive pole, which is connected to terminal 1, applies a positive potential through normally closed contacts z1 and z2 of a relay Ry2 and through a relay Ry25 to the anode of the valve V25. The valve is arranged normally to be non-conducting. When energised, the photo-electric cell PEC4 applies a positive potential to the grid of the valve V25 and current flows through the winding of Ry25 thereby closing the contacts z1, z2 and z3, z4 of this relay. Current is therefore applied from the terminal 1, contacts z4 and z1 of Ry25 to energise a relay Ry4 through normally closed contacts w1 and w2 of a relay Ry26. A circuit is also completed through the contacts of Ry25 and terminal 3 energising Ry5 shown in Fig. 4. The latter relay, being energised, the contacts 1h and 2h are open and contacts 2h and 3h are closed to complete the tuned circuit LC for the modulation frequency of .85 kc.

Referring again to Fig. 9, the relay Ry4 is provided with holding contacts t1 and t2 completing the circuit of Ry4 through the normally closed contacts of Ry26 so that, although Ry25 may become de-energised Ry4 is maintained energised while the required signal frequency is .85 kc. For effecting a change back to the first modulation signal frequency another photo-electric cell PEC5 is provided associated with a valve V26 in the same way as the photo-electric cell PEC4 is associated with valve V25. The anode of the valve V26 is connected through Ry26 and contacts t1 and t4 of Ry4, through terminal 1 to the positive pole of the D. C. supply, the cathode being connected through terminal 2 to the negative pole. The photo-electric cell PEC5 is energised by means of a light source suitably disposed at the side of the track and, when so energised, causes current to flow in the anode circuit of the valve V26 thus energising Ry26 and opening its contacts. The opening of contacts w1 and w2 of Ry26 opens the circuit of Ry4, thereby opening the anode circuit of the valve V26 and opening the circuit of Ry5 for changing the tuned signal circuit back to 10 kc. The valves V25 and V26 may be of the gas-filled type which, having been set in operation, require their anode circuits to be interrupted in order to restore the original operating conditions. The provision of such valves ensures that Ry4 has operated its holding contacts and interruption of the anode circuits is effected by a relay TDyRy3 coming into operation after, say, 4 seconds and closing contacts d1 and d2 in circuit with Ry2 and thereby interrupting the supply to the valve V25 through Ry25. The circuit of the valve V26 will be interrupted by Ry4 being energised, as aforesaid.

The train installation comprises three devices, as shown in Figure 9, one for controlling the change-over frequency for the modulation of the transmitter, as hereinbefore described, another for controlling the change-over of the filters F1 and F2 of the receiver and yet another for effecting the change-over in the modulator and the receiver filters of the stand-by apparatus. In this way a high factor of safety is achieved.

A further arrangement of photo-electric cells 70 is provided in the train installation for rendering the transmitter and receiver inoperative in stations. For this purpose there are provided, as shown in Figure 8, an electric motor M8 driving two commutators D and K. The commutator D 75

has a conducting segment D1 extending through 90% of its periphery and the commutator K has a conducting segment K1 extending through 15% of its periphery. Cooperating with the commutator D there are two pairs of brushes B17, B18 and B19, B20, the two pairs being diametrically opposite one another. Co-operating with the commutator K there is a single pair of brushes B21 and B22. The arrangement is such that, when the brushes B21 and B22 are on the conducting segment K1 of the commutator K, the brushes B19 and B20 are disposed between the ends of the conducting segment D1 of the commutator D. A photo-electric device PEC1 controls the operation of the valve V27 and another photo-electric device PEC2 controls the operation of another valve V28 in the same manner as in Figure 9. The photo-electric cell PEC2, on being energised by a light source situated at the side of the track, causes current to flow in the anode circuit of a valve V28 from terminal 1 connected to the positive pole of the D. C. electric supply, through brushes B19 and B20 short-circuited by the commutator segment D1 and Ry8 to the anode of the valve, the cathode of the valve being connected through terminal 2 to the negative pole of the D. C. supply. On being energised, Ry8 closes its contacts 80 and 90 to complete a circuit energising the motor M9, also through the brushes B19, B20. The motor thus rotates the commutators D and K until the insulating part of the commutator D, between the ends of the segment D1, comes into register with the brushes B19 and B20 thus interrupting the motor circuit. A circuit is, however, now completed from terminal 1 through brushes B21 and B22 short-circuited by the segment K1 of the commutator K and through Ry9 back to the terminal 1. This relay Ry9, on being energised, opens its contacts 1a and 2a which are connected through terminals 24 and 25 of Fig. 5 to open the circuit of the primaries of transformers T400 and T600 for the high tension supply to the transmitter. The opening of contacts 3a and 4a of Ry9, connected through terminal 13 Fig. 6 and through terminal 16 Fig. 1 interrupts the high tension supply to the receiver.

On leaving the station, a light source is arranged to energise the photo-electric cell PEC1 causing current to flow in the anode circuit of valve V27 from the terminal 1 connected to the positive pole of the D. C. supply, through Ry7 to the anode of valve V27, the cathode being connected through terminal 2 to the negative pole of the D. C. supply. Ry7, by being energised, closes its contacts p1 and p2 and completes a circuit through brushes B17 and B18, which at this time will engage with the conducting segment D1 of the commutator D, and through contacts of Ry7 to again energise the motor M9. The motor thus rotates the commutators D and K through another revolution and then the motor circuit is broken by the insulating part of the commutator D arriving beneath the brushes B17 and B18. Also the conducting segment K1 will have moved away from the brushes B21 and B22 to its original position, thus deenergising Ry9 and closing its contacts, thus restoring the transmitter and receiver to the operating condition. Press-button switches PB1 and PB2 may be provided in parallel with the contacts of Ry7 and Ry8 respectively for manual operation in case of an emergency. Thus, the photo-electric cells PEC1 and PEC2 control the operation of the transmitter and receiver to put them out of operation on the train

entering a station and to reinstate them in operation on the train leaving the station. The grid electrodes of the valves associated with the photo-electric cells are connected through a terminal 7 to a source of biasing potential such as to render the valves normally non-conducting.

As shown in Figure 10, the photo-electric cells may conveniently be housed in recesses in the cars of a train directed downwardly for control by light sources indicated at Lt1, Lt2, Lt3 and Lt4 at the side of the track. Thus, the photo-electric cell PEC3 and stand-by cell 3A may be arranged for operation by a light source Lt1, the photo-electric cells PEC1 and PEC2 for disconnection and connection of the transmitter and receiver may be arranged for operation by the light source Lt2 at a different height, the photo-electric cells PEC4 at one level for operation by the light source Lt3 at another height and the photo-electric cells PEC5 for introducing the other modulation signal frequency are in line for operation by the light source Lt4 at yet another height. It will be understood that the light source Lt1 to Lt4 will be arranged at standard heights throughout the train systems.

Arrangements of the light sources on the track are shown in Figures 11 and 12. In Figure 11 there is shown a portion of a railway system in which a track M runs into another track N. In this case, alongside the track M, at a suitable distance from the points, light sources Lt3 are arranged at the height necessary for operating the photo-electric cells PEC4 for changing the modulation signal frequency from that allocated to track M to that allocated to track N.

In Figure 12 there is shown a track section comprising a loop at a railway station. In this case, at a distance of, say, 500 yards from the points at each end of the loop, light sources Lt1 are provided for energising the photo-electric cell PEC3 or stand-by PEC3A of the train installation to apply the brakes should there be a train already in the station on the required track. At each end of the station area of both the loop and through tracks, there is provided light sources Lt2 for energising the photo-electric cells PEC1 and PEC2 for dis-connecting the transmitter and receiver as the train enters the station section and re-connecting them for operation as the train leaves the station section.

The light sources Lt1, (Figure 12) may be controlled by photo-electric cell detectors on the track within the station area. These detectors may consist of a pair of light sources J at each end of the station section spaced apart along the tracks, the spacing being less than the length of any truck or carriage which is employed and co-operating with photo-electric cells PEC7 and PEC8 arranged at the opposite sides of the two tracks. The photo-electric cells are employed to control light sources Lt1 in order to extinguish these light sources when there is no train in the station section so that, under these conditions, the brakes of the train are not automatically applied.

In Figure 13 there is shown an apparatus for controlling the light sources Lt1 by means of the photo-electric cells PEC7 and PEC8 according to the position of the points. For each end of the station section each photo-electric cell PEC7 and photo-electric cell PEC8 is connected in circuit respectively with valves V30 and V29 having in their anode circuits relays Ry20 and Ry10, such that light falling on the photo-electric cells produces an increase in valve current. The relay

Ry10 when energised closes its contacts e1 and e2 to complete a circuit with a relay Ry30 and a switch P1 closed by the points when they are set to open the straight track through the station section. The relay Ry20 when energised closes its contacts f1 and f2 to complete a circuit with the relay Ry50 and a switch P2 closed by the points when they are set to open the loop through the station section. The relay Ry50 when energised closes contacts k3 and k4 for completing a circuit to energise the light sources Lt1 beyond the station section. Thus, if a train occupies the straight or loop tracks of the station section the light from the source J on to photo-electric cells PEC7 or PEC8 as the case may be is interrupted and the corresponding relay Ry10 or Ry20 is energised. If, at the same time, the points are set to open the same track on which the train stands, the relay Ry50 is energised to operate the light source Lt1 which serves to apply the brakes of an approaching train, as hereinbefore described. The relay Ry50 may be provided with additional contacts k1 and k2 in circuit with a warning lamp W and switches 60 and 70 may be provided in circuit with the contacts k3 and k4 for emergency control of the light source on the track.

What we claim is:

1. A railway train control system comprising for each train an electric wave signal transmitter and an electric wave signal receiver, brakes for each train, means for rendering the transmitter and the receiver alternately operative, and means controlled by the signal output of the receiver of a train due to signals received from the transmitter of another train, on reaching a predetermined strength due to relative approach of the trains, to apply the brakes of the train.

2. A railway train control system as claimed in claim 1, including means for rendering the receiver operative with decreased sensitivity during periods of transmission from the same train, and means operated by the output of the receiver as a result of signals received from the transmitter on the train to determine the efficiency of operation of the control system.

3. A railway train control system comprising, an electric wave signal transmitter and an electric wave signal receiver carried by each train, brakes for each train, means rendering the receiver and transmitter of each train alternately operative, means responsive to signals of a predetermined strength present in the receiver of one train from the transmitter of another train resulting from the relative approach of the trains for applying the brakes of the trains, and stand-by means for applying the brakes of the trains upon failure of the last mentioned means.

4. A railway train control system comprising, an electric wave signal transmitter and an electric wave signal receiver carried by each train, brakes for each train, means rendering the receiver and transmitter of each train alternately operative, means responsive to signals of a predetermined strength present in the receiver of one train from the transmitter of another train resulting from the relative approach of the trains for applying the brakes of the trains, an auxiliary signal receiver carried by each train, and means controlled by the output of the auxiliary receiver for rendering the first receiver inoperative to incoming signals of a strength greater than a predetermined value.

5. A railway train control system comprising an electric wave signal transmitter and an elec-

tric wave signal receiver carried by each train, brakes for each train, means rendering the receiver and transmitter of each train alternately operative, means responsive to signals of a predetermined strength present in the receiver of one train from the transmitter of another train resulting from the relative approach of the trains for applying the brakes of the trains, means for altering the frequency of signals emitted by the transmitters of the trains when the same pass from one track to a second track, and means rendering the receivers carried by trains passing onto the second track responsive to said altered frequency.

6. A railway train control system comprising, an electric wave signal transmitter and an electric wave signal receiver carried by each train, brakes for each train, means rendering the receiver and transmitter of each train alternately operative, means responsive to signals of a predetermined strength present in the receiver of one train from the transmitter of another train resulting from the relative approach of the trains for applying the brakes of the trains, light responsive means carried by each train for rendering the transmitters and receivers inoperative, and a light source adjacent the track for controlling said light responsive means.

7. A railway train control system comprising, an electric wave signal transmitter and an electric wave signal receiver carried by each train, brakes for each train, means rendering the receiver and transmitter of each train alternately

operative, means responsive to signals of a predetermined strength present in the receiver of one train from the transmitter of another train resulting from the relative approach of the trains for applying the brakes of the trains, light responsive means carried by each train for rendering the transmitters and receivers inoperative, a light source adjacent the track for controlling said light responsive means, means for detecting the presence of a train in a track section on which the transmitters and receivers are inoperative, and a light source adjacent the track remote from said section controlled by said detecting means for rendering the second mentioned means carried by an approaching train operative to apply the brakes.

8. A railway train control system comprising, an electric wave signal transmitter and an electric wave signal receiver carried by each train, brakes for each train, means rendering the receiver and transmitter of each train alternately operative, means responsive to signals of a predetermined strength present in the receiver of one train from the transmitter of another train resulting from the relative approach of the trains for applying the brakes of the trains, stand-by means for applying the brakes, and time delay means for rendering said stand-by means operative at a predetermined interval after failure of said second mentioned means.

ERROL DU PREEZ ERASMUS.
OLIVER WALTER REID.