July 15, 1930. S. M. LUCAS 1,770,705

RAILWAY TRAFFIC CONTROLLING APPARATUS

Filed Sept. 12, 1928

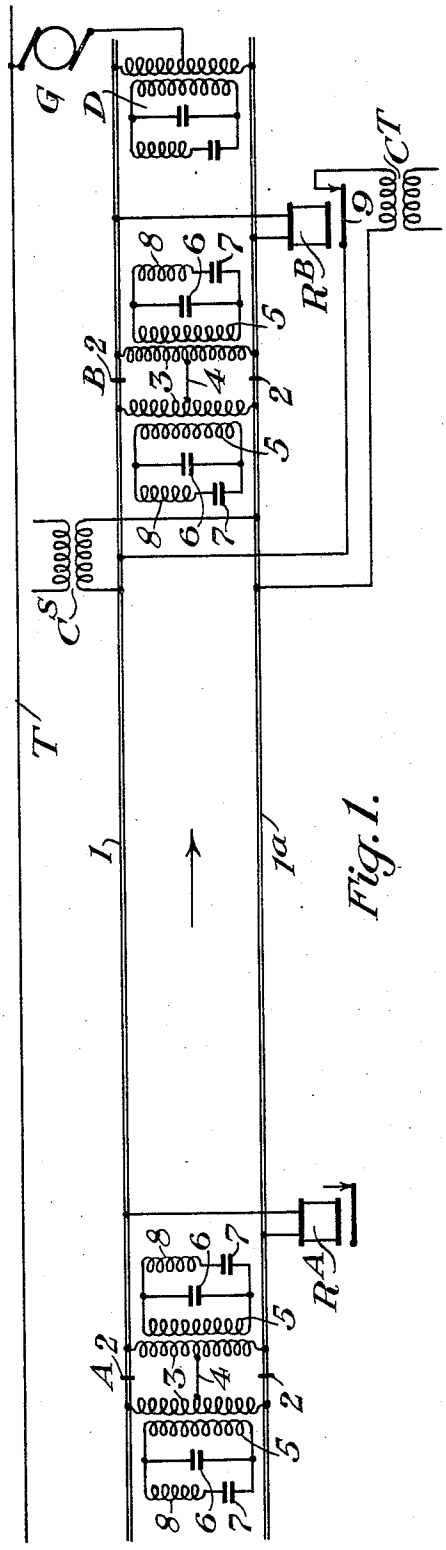



Fig. 1.

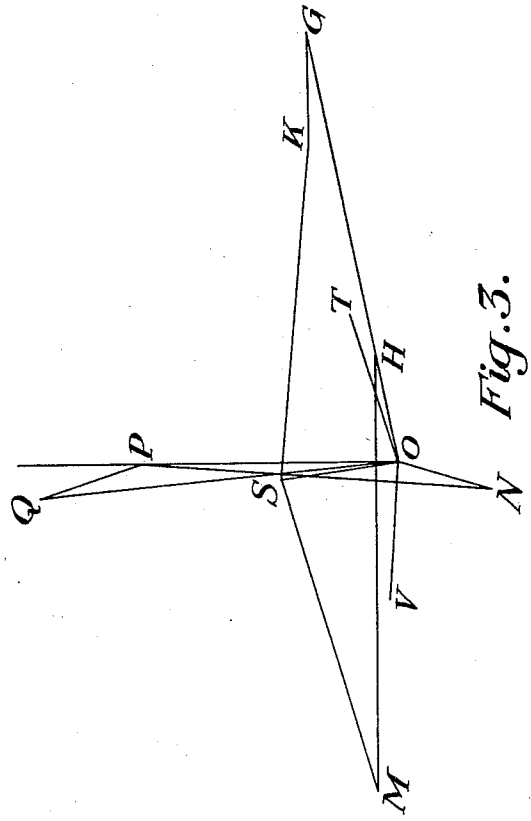



Fig. 3.

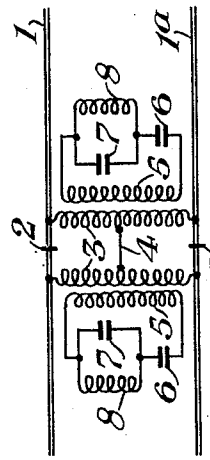



Fig. 2.

INVENTOR:
S. M. LUCAS,
by A. R. Vencill,
His Attorney

Patented July 15, 1930 1,770,705

# UNITED STATES PATENT OFFICE

SAMUEL M. LUCAS, OF PITTSBURGH, PENNSYLVANIA, ASSIGNOR TO THE UNION SWITCH & SIGNAL COMPANY, OF SWISSVALE, PENNSYLVANIA, A CORPORATION OF PENNSYLVANIA

## RAILWAY-TRAFFIC CONTROLLING APPARATUS

Application filed September 12, 1928. Serial No. 305,400.

My invention relates to railway traffic controlling apparatus, and particularly to signaling and train controlling apparatus on an electric railway. More specifically, the invention relates to an electric railway provided with a signaling system involving alternating current of one frequency in the track rails, and automatic train control system involving alternating current of a different frequency in the track rails.

One feature of my invention is the provision of bonds for freely conducting the propulsion current from section to section, but substantially preventing the flow of signaling current and train controlling current from rail to rail of each section.

Another feature of my invention is the provision, on an alternating current electric railway provided with a signaling system having alternating current track circuits, of a novel and improved bond for freely conducting the propulsion current from section to section but substantially preventing the flow of signaling current from rail to rail of each section.

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

In the accompanying drawing, Fig. 1 is a diagrammatic view showing one form of apparatus embodying my invention. Fig. 2 is a fragmentary view showing a modification of the inductive bonds shown in Fig. 1 and also embodying my invention. Fig. 3 is a vector diagram illustrating the operation of the bonds shown in Figs. 1 and 2.

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

Referring first to Fig. 1, the reference characters 1 and 1ª designate the track rails of an electric railway along which traffic normally moves in the direction indicated by the arrow. These rails are divided by insulated joints 2 to form a plurality of successive track sections, of which only one complete section A—B is illustrated in the drawing. The railway is of the electric propulsion type, and is therefore provided with a propulsion generator G, one terminal of which is connected with a trolley or third rail T, and the other terminal of which is connected with the track rails 1 and 1ª through a bond D which is similar to the other track bonds hereinafter described.

Located at the junction of each two adjacent track sections are inductive bonds for freely conducting the propulsion current around the insulating joints 2. Each of these bonds comprises two windings 3, one connected across the rails of each section, and a conductor 4 electrically connecting the middle points of the two adjacent windings 3. These bonds function in the usual and well known manner to conduct the propulsion current from the generator G around the joints 2, and detailed explanation of the manner in which this function is performed is not necessary for the purpose of the present specification.

The railway is provided with a signaling system which involves an alternating current track circuit for each section. The source of track circuit current for section A—B is a transformer $C^S$, the secondary of which is connected across the rails of the section, and the primary of which is connected with a source of alternating signaling current, which is not shown in the drawing. This signaling current actuates a track relay $R^A$.

The railway is also provided with an automatic train control system which involves the supply of alternating train controlling current to the track rails of each section. The source of train controlling current for section A—B is a transformer $C^T$, the secondary of which is connected across the rails of the section through a front contact 9 of track relay $R^B$ for the section next in advance, and the primary of which is connected with a source of alternating train controlling current which is not shown in the drawing.

The frequencies of the signaling current and the train controlling current are different; for example, the frequency of the signaling current may be 25 cycles per second, and the frequency of the train controlling current may be 100 cycles per second. Under these circumstances, if the inductive bonds 3 are tuned to multiple resonance at the frequency of the signaling current they

will act to conduct a considerable portion of the train controlling current from rail to rail; whereas, if these bonds are tuned to multiple resonance at the frequency of the train controlling current, they will act to conduct a considerable amount of the signaling current from rail to rail. To overcome this difficulty I tune each bond 3 to multiple resonance at both the frequency of the signaling current and the frequency of the train controlling current. To accomplish this, each bond is provided with a secondary winding 5 inductively related to the main winding 3. A first condenser 6 is connected across the terminals of the secondary winding 5, and a second condenser 7 and a reactor 8 are connected in series across the terminals of winding 5. The condensers 6 and 7 and the reactor 8 are so chosen that the bond 3 is tuned for multiple resonance at both 25 cycles per second and 100 cycles per second.

Referring now to Fig. 3, as well as to Fig. 1, the vector O—P represents the voltage applied to the terminals of the bond 3. The line O—G represents the magnetizing current taken by the bond at 25 cycles, this line being drawn to a scale corresponding to the impedance of the bond when viewed from the terminals of the secondary winding 5, and it lags behind the voltage O—P by approximately 0.2 power factor. The vector K—G represents the current through condenser 6 at 25 cycles, and it will be noted that this vector leads the voltage O—P by 90°. The magnitude of the vector K—G is so chosen that at 50 cycles the inductive reactance of the bond and the condensive reactance of the condenser 6 are equal. The 50 cycle value is the geometric means between the high frequency of 100 cycles and the low frequency of 25 cycles. Considering now the path comprising the auxiliary reactor 8 and the second condenser 7, the voltage impressed across this path is also represented by the vector O—P. The values chosen for reactor 8 and condenser 7 are such that at 50 cycles these two elements are in series resonance, that is, at 50 cycles the voltage drops across reactor 8 and condenser 7 are equal and approximately opposite. Then when 25 cycle current is applied to this path, the relative drop across the reactor and the condenser changes in the ratio of 1 to 4, this being due to the fact that at 25 cycles the reactance of the reactor is halved and the condensive reactance of the condenser is doubled. With the voltage O—P applied to this auxiliary path, the vectors P—N and N—O represent respectively the 25-cycle voltage across the condenser 7 and the reactor 8. The angle O—N—P is the angle obtained when the vector O—N is laid off at the power factor of the reactor ahead of the current through the path, and the vector N—P is laid off at 90° behind the current. The exact location of the triangle O—N—P is determined from the three known factors, namely, angle O—N—P, side O—P, and the ratio $\frac{O—N}{O—P}$. When the position of the vector O—N is located, the vector O—V is readily drawn representing the position of the current through the auxiliary path at 25 cycles. To the vectors O—G and K—G, a third vector S—K is drawn parallel to the vector O—V and terminating at the point S on or closely adjacent to the vector O—P. The vector O—S then represents the total current through the bond, and the bond is resonant at 25 cycles.

I will now consider the condition when 100-cycle energy is impressed on the bond. The capacity and inductance of all elements remain fixed, but the impedance of the bond proper, and also the impedance of the reactor 8, will vary directly in proportion to the change in frequency, while the impedances of the condensers 6 and 7 will vary inversely as the frequency. Assuming for present purposes that the 100-cycle voltage is the same in magnitude as the 25-cycle voltage previously considered, the vector O—P will also represent the 100-cycle potential impressed on the terminals of the bond. This assumption as to relative magnitudes of the currents of the two frequencies is made solely to simplify the explanation, and is in no way essential for the correct and intended operation of the bond. The current through the bond proper, which is inductive, shrinks to $\frac{25}{100}$ of its 25-cycle value O—G, and is now represented by the vector O—H. The current through the condenser 6 increases to $\frac{100}{25}$ of its 25-cycle value K—G, and is now represented by the vector M—H. In the auxiliary path, comprising condenser 7 and reactor 8, if a 100-cycle current of same magnitude as the 25-cycle current is assumed, the 100-cycle potential across the reactor is $\frac{100}{25}$ of the 25-cycle potential which was represented by the vector O—N, and the 100-cycle potential across the condenser 7 is $\frac{25}{100}$ of the 25-cycle potential which was represented by the vector N—P. By laying off and adding these 100-cycle potentials with proper magnitudes and with proper phase angles between them, and then swinging the resultant vector about until it falls on the vector O—P, we find the positions of the 100-cycle vectors to be O—Q and Q—P. The phase position of the current through the auxiliary path, is, of course, at 0.2 power factor behind the potential across the reactor O—Q, that is, the phase position of the current is O—T. From the point M, a vector is laid off representing the auxiliary path, which vector is parallel with O—T and

equal in magnitude to the vector K—S, and this new vector M—S terminates in point S, which means that the bond is resonant at 100 cycles per second.

Referring now to Fig. 2, the condenser 7 and reactor 8 are connected in multiple, and these two elements are interposed between condenser 6 and one terminal of the secondary winding 5. This circuit is the electrical equivalent of the secondary circuit for winding 5 in Fig. 1, and, consequently, the foregoing discussion concerning Fig. 1 applies equally well to the modified form of bond shown in Fig. 2.

In some instances, the propulsion energy may be an alternating current of one frequency, and the alternating signaling current may be of a different frequency, the train control current being omitted. In such instances, bonds embodying my invention are advantageous because they are susceptible to broad tuning to the signaling current frequency, that is, a small variation in the frequency of the signaling current causes very little change in the phase of the current taken by the bond.

Although I have herein shown and described only two forms of apparatus 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, an electric railway having its track rails divided into sections, a source of alternating signaling current connected with the rails of each section, means for supplying the rails of each section with alternating train controlling current differing from the signaling current in frequency, an inductive bond connected across the rails of each section, a connection between the middle points of the bonds for each two adjacent sections, a secondary winding inductively related to each bond, a first condenser connected across the terminals of each secondary winding, and a second condenser and a reactor connected in series across the terminals of each bond.

2. In combination, an electric railway having its track rails divided into sections, a source of alternating signaling current connected with the rails of each section, means for supplying the rails of each section with alternating train controlling current differing from the signaling current in frequency, an inductive bond connected across the rails of each section, a connection between the middle points of the bonds for each two adjacent sections, a secondary winding inductively related to each bond, a condenser connected with said secondary winding, and a second condenser and a reactor connected in multiple and interposed between said first condenser and one terminal of said secondary winding.

3. In combination, an electric railway having its track rails divided into sections, a source of alternating signaling current connected with the rails of each section, an inductive bond connected across the rails of each section, a connection between the middle points of the bonds for each two adjacent sections, a secondary winding inductively related to each bond, a first condenser connected across the terminals of each secondary winding, and a second condenser and a reactor connected in series across the terminals of each bond.

4. In combination, an electric railway having its track rails divided into sections, a source of alternating signaling current connected with the rails of each section, an inductive bond connected across the rails of each section, a connection between the middle points of the bonds for each two adjacent sections, a secondary winding inductively related to each bond, a condenser connected with said secondary winding, and a second condenser and a reactor connected in multiple and interposed between said first condenser and one terminal of said secondary winding.

In testimony whereof, I affix my signature.

SAMUEL M. LUCAS.