Oct. 15, 1940. F. H. NICHOLSON ET AL 2,218,120

RAILWAY TRAFFIC CONTROLLING APPARATUS

Original Filed May 28, 1938 3 Sheets-Sheet 1

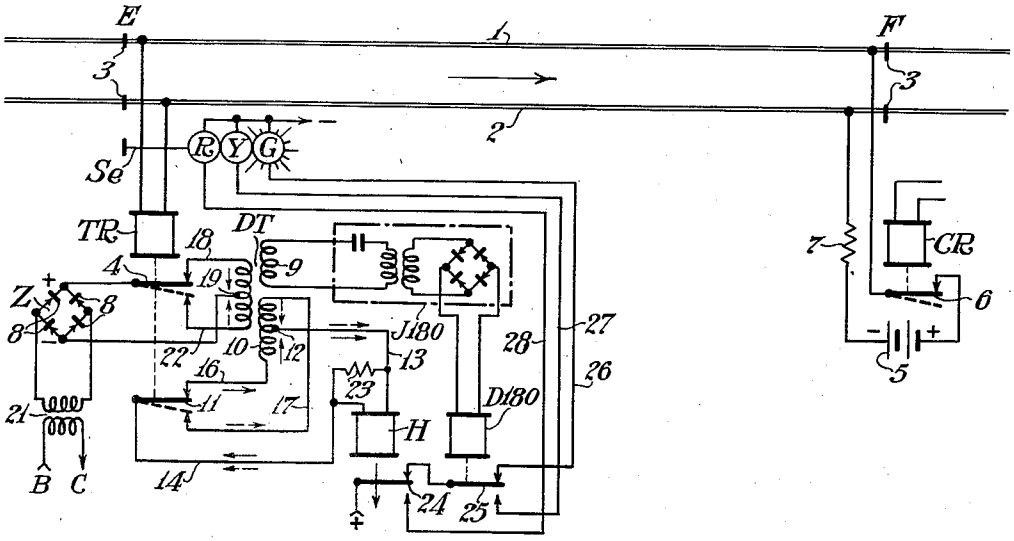


Fig. 1.

INVENTORS
Frank H. Nicholson and
BY Leslie R. Allison.
Lockwood
THEIR ATTORNEY

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Original Filed May 28, 1938 3 Sheets-Sheet 2

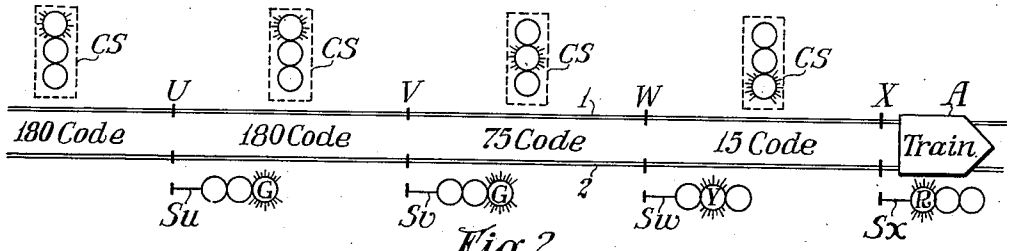


Fig. 2

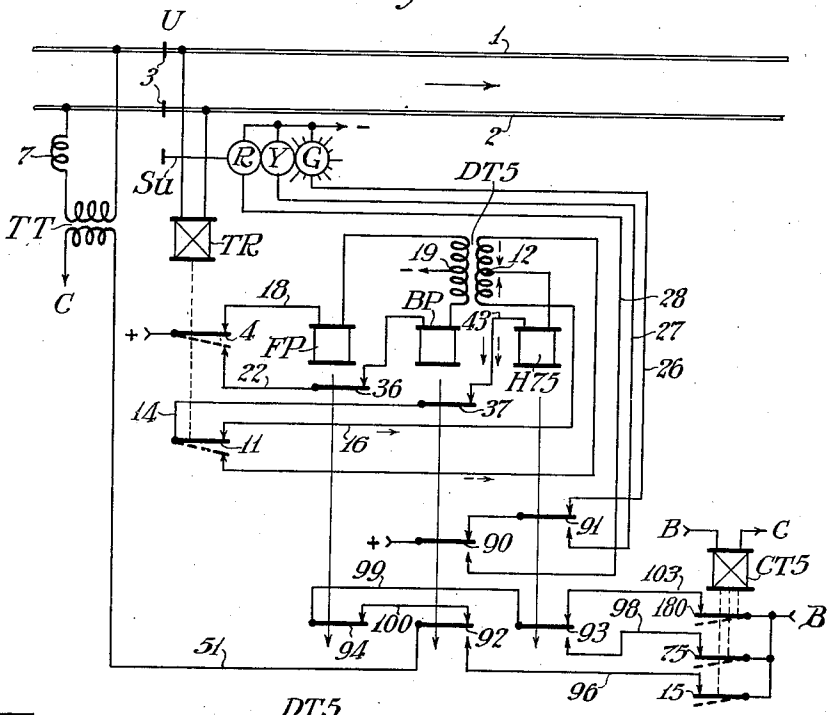


Fig. 3

Fig. 4

INVENTORS
Frank H. Nicholson and
BY Leslie R. Allison.
THEIR ATTORNEY

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Original Filed May 28, 1938 3 Sheets-Sheet 3

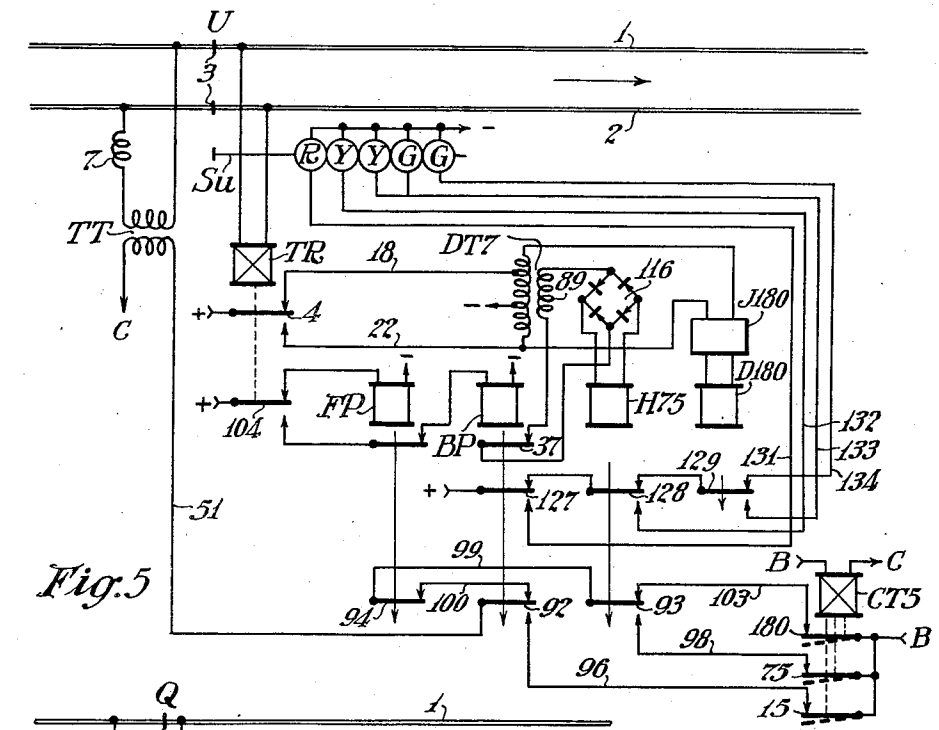


Fig. 5

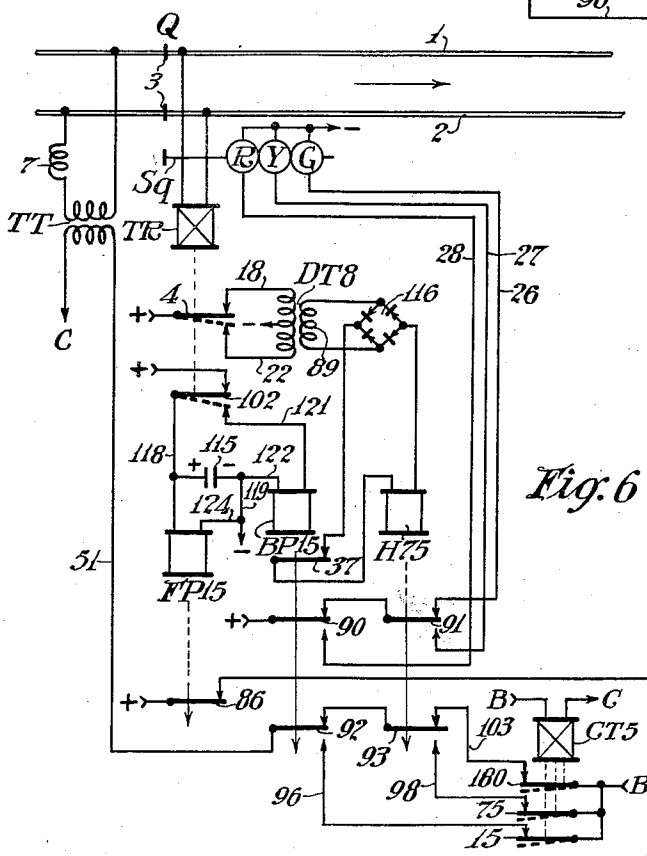


Fig. 6

INVENTORS
Frank H. Nicholson and
Leslie R. Allison.
BY
THEIR ATTORNEY

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UNITED STATES PATENT OFFICE

2,218,120

RAILWAY TRAFFIC CONTROLLING APPARATUS

Frank H. Nicholson, Wilkinsburg, and Leslie R. Allison, Forest Hills, Pa., assignors to The Union Switch & Signal Company, Swissvale, Pa., a corporation of Pennsylvania

Original application May 28, 1938, Serial No. 210,744. Divided and this application July 22, 1939, Serial No. 286,030

8 Claims. (Cl. 246—34)

Our invention relates to railway traffic controlling apparatus and it has special reference to the organization of such apparatus into signalling systems of the class wherein a code-following relay at each wayside location and/or on a train receives coded operating energy from the trackway and in accordance with the character of that energy effects various control functions through the medium of associated decoding equipment.

This application is a division of our earlier application bearing Serial No. 210,744 which was filed May 28, 1938, for "Railway traffic controlling apparatus" and assigned to The Union Switch & Signal Company.

As in that earlier case, the broad object of the present invention is to lower the cost, simplify the construction and improve the operating characteristics of decoding equipment of the referred to type.

A more specific object is to assure that this equipment will not falsely respond when rectifier or other foreign ripples are present in the decoding transformer supply circuit.

Another object is to safeguard the decoding equipment against false response in the event that the front and back contact points of the associated code following relay become accidentally interconnected.

An additional object is to permit the code following relay safely to be adjusted for closer spacings between the movable member and the front and back points of each of its contact sets.

A further object is to assure that the wayside decoding equipment will respond to each initial shunting of the associated track circuit with a quickness which is adequate for all possible train running conditions.

A still further object is to detect codes and distinguish between different pulse rates thereof without employing the usual resonant or frequency tuned circuits.

An additional object is to provide the above features of operation through the use of a restricted number of contacts on the code following relay.

A still additional object is to accomplish the above without dispensing with any of the desirable features of continuously coded track circuit control.

In practicing our invention we attain the above and other objects and advantages by associating the various decoding equipment parts with the code following relay in new and improved manners. Involved in these associations are a number of cooperating features of which introductory mention will here be made of but two: (1) Rectifying the secondary voltage of the decoding transformer over a contact of the code following relay and using this rectified output to energize a code detecting relay, and (2) Serially including in the primary supply circuit of the decoding transformer the windings of relays which repeat the front and back contact closures of the code following relay.

We shall describe several forms of railway traffic controlling apparatus embodying our invention and shall then point out the novel features thereof in claims. These illustrative embodiments are disclosed in the accompanying drawings, in which:

Fig. 1 is a diagrammatic representation of traffic governing apparatus embodying the feature of our invention first named above;

Figs. 2, 3 and 4 are diagrammatic showings of one application of the principles of our invention to a combined wayside and cab signalling system of the three indication type;

Fig. 5 is a similar representation of an application wherein the number of wayside signal indications is extended to four; and

Fig. 6 is a diagrammatic view of a still further application of the improvements of our invention to a railway signalling system.

In the several views of the drawings, like reference characters designate corresponding parts. Referring first to Fig. 1, character TR designates a track relay of the code following type, DT a decoding transformer which receives primary current under the control of a pole changing contact 4 of the track relay, H a code detecting relay of the direct current delayed release type which is energized from a secondary winding 10 of the decoding transformer and D180 a code distinguishing relay which is energized from a second secondary winding 9 of the transformer through a resonant or frequency selective circuit J180.

Device TR typifies relays which are used in any of the various different code following applications encountered in railway signalling. In addition, therefore, to being a track relay as shown, it may, for example, also be a train carried master relay adapted to control a cab signal, or a code following relay which receives operating energy over line wires. In the illustrative application represented in Fig. 1, this relay TR is directly connected to the rails 1 and 2 of a section of railway track E—F which is separted from adjoining sections by the customary insu-

lated joints 3 and along which it will be assumed that traffic moves in the single direction indicated by the arrow.

Installed at the opposite or exit end of the section is a source of trackway energy, shown in the form of a direct current battery 5, which is connected to the rails 1 and 2 over a contact 6 of a relay CR and by way of a circuit which includes the usual current limiting impedance 7. Each time that contact 6 is in its uppermost position, the rail supply circuit is completed and the voltage of battery 5 then is impressed between the rails and by them transmitted to the winding of relay TR at the opposite or entrance end of the section. Each time, however, that contact 6 occupies its open position, the rail supply circuit is interrupted and the winding of the track relay TR then is deenergized.

Device CR typifies apparatus for coding the trackway energy at one or another of a plurality of distinctive rates in accordance with preselected conditions. In the system of Fig. 1, it will be assumed that under certain conditions of advance traffic this device periodically actuates its contact 6 at one rate to provide what will be termed a "low speed" code and that under other conditions it increases the rate of periodic opening and closing of the rail supply circuit to provide what will be referred to as a "high speed" code. In receiving this coded energy, relay TR picks up its contacts upon the occasion and for the duration of each pulse thereof and releases its contacts each time that the relay winding is deenergized, thereby repeating the operation of the coding relay CR.

Aside from having two separate secondary windings, the decoding transformer which is shown at DT in Fig. 1 is of the conventional type and under the control of contact 4 of the code following relay TR its single primary winding receives energizing current from any suitable direct current source, designated by the terminals "plus" and "minus." In territory in which the energy for operating the signalling system is supplied from an alternating current transmission line (not shown) which runs along the right-of-way in the customary manner, these terminals are usually identified with the output circuit of a rectifier of the full wave type shown at Z. Typically, such a rectifier consists of four branch paths or units 8 interconnected in the manner shown, and ordinarily its input terminals receive 100 cycle or other signal frequency energy from the mentioned power supply line through a circuit which includes a transformer 21 and power source terminals B and C.

Each time that the pole changing contact 4 of relay TR is picked up, direct current flows downwardly through one portion of the transformer primary and by way of a circuit shown as extending from the positive terminal of rectifier Z, through front contact 4, conductor 18, the upper half of the transformer winding, and mid tap 19 back to the negative terminal of the supply rectifier. Likewise, each time that contact 4 is released, current flows in the opposite direction or upwardly through another portion of the winding and by way of a circuit shown as extending from the positive supply terminal through back contact 4 of device TR, conductor 22, the lower half of the transformer winding, and mid tap 19 back to the negative terminal of rectifier Z.

In thus pole changing the direct current primary circuit for the decoding transformer DT, contact 4 causes the transformer to induce in each of its two secondary windings 9 and 10 an alternating voltage the frequency of which is the same in cycles per minute as the code pulse rate of the trackway energy to which relay TR is responding. If this frequency is of the "high speed" rate, code distinguishing relay D180 responds as a result of its winding receiving actuating energy from the secondary winding 9 of transformer DT through the tuned circuit J180 which is arranged to be resonant to the high speed frequency only. If, however, the referred to frequency is of the "low speed" rate, this tuned circuit fails to transmit sufficient current to operate relay D180 and the contacts of that relay then are released.

As a result of incorporating the improvements of our invention, the energizing circuit for the code detecting relay H functions to supply unidirectional operating current to that relay whenever the track relay TR is following either the "high speed" or the "low speed" code. In either event, the alternating voltage which is generated in the secondary winding 10 of the decoding transformer DT is rectified over a second contact 11 of the code following relay TR and in this rectified condition it is impressed upon the direct current winding of the relay H.

The particular circuit shown, therefore, causes unidirectional current to be supplied to relay H. To this end the transformer winding 10 is provided with a mid tap connection 12 which is joined, through a conductor 13, with one side of the H relay winding and the other side of the relay winding is connected to the heel of contact 11 by means of a conductor 14. Finally, the end terminals of the secondary winding 10 are joined to the front and back points, respectively, of contact 11 by means of conductors 16 and 17.

In operation, each time that contact 11 is in its picked up position, the winding of relay H is connected with the lower half of the secondary winding 10 of the decoding transformer DT through a circuit which extends from the mid tap 12 of that winding, through conductor 13, the winding of relay H, conductor 14, front contact 11, and conductor 16 back to the lower terminal of winding 10. In consequence, what will be referred to as the "positive" half cycles of the induced transformer voltage become effective for circulating current through the winding of relay H.

Likewise, each time that the track relay contact 11 is in its released position, the winding of relay H is connected with the upper half of the transformer secondary 10 through a circuit which may be traced from the mid tap 12, through conductor 13, the winding of relay H, conductor 14, back contact 11, and conductor 17 back to the upper terminal of winding 10. In consequence, what will be termed as the "negative" half cycles of induced transformer voltage also become effective to provide current flow through the winding of the relay.

To clarify the foregoing explanation, the direction of current flow during the positive half cycles of induced transformer voltage is designated in Fig. 1 by the small full line arrows while the direction of current flow during the negative half cycles of this voltage is similarly designated by the small broken line arrows. From that explanation it will be apparent that the winding of code detecting relay H receives recurring pulses of unidirectional energizing current during the continuance of each code following operation which is effected by relay TR.

The constants of the H relay energizing circuit are so chosen that these pulses are effective to pick up the relay contacts. In order that this picked up condition may be retained continuously as long as relay TR continues to follow a trackway code, relay H is further designed to have sufficient release retardation to span the open circuit interval during which the contacts of relay TR move from one position to the other in response to the current pulses of the coded operating energy. For this purpose, any one of a number of familiar expedients may, of course, be used. As shown in Fig. 1, the release delay is provided by means of a snubbing resistor 23 which is bridged across the terminals of the winding of relay H in a well-known manner.

In operation of the just-described decoding equipment of Fig. 1, when the contacts of the code following relay TR occupy one position continuously (as, for example, when the relay fails to receive coded energy from the track section E—F), decoding transformer DT passes no energy and the contacts of both of the relays H and D180 then occupy the deenergized or released position. Each time, however, that relay TR receives and responds to a trackway code, contacts 4 and 7 thereof simultaneously pole change the primary and secondary circuits of the decoding transformer and in consequence the contacts of relay H are then picked up, as are also those of relay D180 when the responded to code is of the "high speed" frequency. In other words, as long as relay TR fails to receive coded energy, the contacts of both of the relays H and D180 occupy their released positions; when relay TR responds to the "slow speed" code, the contacts of code detecting relay H only are picked up; and when relay TR responds to trackway energy of the "high speed" code, the contacts of the code distinguishing relay D180 are also picked up.

Any desired use of the just-described response characteristics of relays H and D180 may, of course, be made. As shown in Fig. 1, the represented contacts 24 and 25 of these devices are arranged to control the energizing circuits for the lamps of a wayside signal Se. This signal is of a well-known color light type and comprises three lamps G, Y and R which, when lighted, respectively project into the range of vision of the engineman of an approaching train beams of light having the colors of green, yellow and red.

Assuming that the apparatus of Fig. 1 is combined into a system of automatic block signalling in the manner partially represented, the operation will be as follows: As long as the rails 1 and 2 transmit energy of the "high speed" code to the track relay TR, lamp G of signal Se will be lighted to display the "clear" indication as a result of relays H and D180 both being energized and completing for the lamp an energizing circuit which may be traced from the positive terminal of a suitable supply source through front contact 24 of relay H, front contact 25 of relay D180, conductor 26 and the lamp G back to the negative terminal of the supply source.

When the track relay TR receives energy of the "slow speed" code, the contacts of relay H only will be picked up and the signal will then display the "approach" indication as a result of lamp Y receiving lighting current over a circuit which extends from the positive supply terminal through front contact 24 of relay H, back contact 25 of relay D180, conductor 27 and the lamp Y back to the negative supply terminal.

Finally, in the event that the relay TR fails to receive coded energy, as when the track section E—F is occupied, the contacts of both relays H and D180 will be released and the signal will then display the "stop" indication as a result of lamp R receiving lighting current over a circuit which extends from the positive supply terminal through back contact 24 of relay H, conductor 28 and the lamp R back to the negative supply terminal.

Among the advantages afforded by our improved arrangement of Fig. 1, mention may be made of the simplification of code detecting apparatus and also of the superior operating characteristics. Regarding the former, the single relay H performs all of the code detecting functions for which a pair of repeater relays (for the front and back contacts of the code following device) formerly have been required and thus this expedient reduces both the cost and complexity of decoding equipment of the character under consideration.

Regarding the improvement in operating characteristics, the novel feature described above effectively guards against the display of a false "approach" wayside indication should rectifier ripples be introduced into the decoding transformer supply circuit or should the front and back contact points of the code following relay TR accidentally become interconnected, as by fusing due to lighting. In the latter event, if the interconnection involves the points of contact 11, the resulting short circuiting of the transformer secondary 10 will permanently deenergize relay H and thereby effect completion of the circuit for the "stop" lamp R of the associated signal S. Likewise, if the faulty condition referred to takes place at pole changing contact 4, transformer DT will transfer no energy at all and relay H will again be deenergized continuously.

Concerning the introduction of rectifier or other foreign ripples into the decoding transformer supply circuit, this may happen as a result, for example, of failure of one of the branch units 8 of the supply rectifier Z. If the energy were supplied to relay H by means of the conventional static circuits (comparable to J180 but untuned) these ripples might, due to alternation of the primary current of transformer DT, effect actuation of that relay under conditions of contact stalling by relay TR.

With the circuits of Fig. 1, however, such false response by the decoding equipment is effectively guarded against, for with contact 11 stalled in either position, the winding of relay H is continuously connected to the decoding transformer secondary 10. Being of the direct current design, this relay H is incapable of picking up on any resulting alternating current which it may receive and in this manner false response to foreign current ripples in the transformer supply circuit is effectively prevented.

An attendant advantage of the arrangement of Fig. 1 is that the core following relay TR may now safely be adjusted for closer spacings between the movable member and the front and back points of each of its sets of contacts. In previous decoding arrangements, safety requirements made it imperative that relatively wide contact spacings be used in order to avoid any possibility of false operation. However, by means of our improved apparatus, the contact spacings may safely be reduced to a value which is limited only by the normal operating characteristics of the code following device. By thus lowering the

range of movable member travel, such a reduction has the effect of raising the efficiency of the relay TR and hence is most desirable from an operating point of view.

Referring now to Figs. 2 and 3, these show another application of the improvements of our invention to an automatic block signalling system of the three indication type. Fig. 2 represents: a stretch of protected track which includes four section dividing locations U, V, W and X; the distribution of the coded train control energy which is present in the four track sections immediately behind a train A; and the aspects of the associated wayside signals S.

From Fig. 2 it will be seen that three codes designated as **15**, **75** and **180** are employed. These are respectively produced by correspondingly designated contacts of a code transmitter CT5 forming a part of the apparatus of Fig. 3 which is installed at each of the section dividing locations. In the particular system represented, the trackway energy is derived from an alternating current source, designated by the terminals B and C, and is transmitted to the trackway through the medium of the usual track transformer TT. Use also is made of alternating current track relays TR of the code following type and of three aspect color light wayside signals S of the character shown in Fig. 1.

The apparatus of Fig. 3 further employs front and back contact repeater relays FP and BP which cooperate in a novel manner with the code following track relay TR and the decoding transformer DT5. The windings of these repeater relays are included in the conductors **18** and **22** of the decoding transformer supply circuit in a manner which causes the relays alternately to be energized over contact **4** of the track relay.

Each time that this contact is picked up, the resulting current which flows through the upper half of the transformer primary (again from a source designated by the terminals "plus" and "minus") passes through the winding of relay FP; likewise, each time that the contact **4** is in its released position the resulting flow of current through the lower half of the decoding transformer primary similarly energizes the second repeater relay BP over a path which includes a front contact **36** of device FP. Through an employment of means not represented, each of these relays is provided with a retardation sufficient to maintain the contacts thereof continuously picked up when the track relay responds to a code frequency of 15 cycles per minute or higher.

The code detecting relay shown at H75 in Fig. 3 receives energizing current from the secondary winding of the decoding transformer DT5 over circuits which include contact **11** of the code following relay TR. That contact controls the relay current in the same manner as has been explained in connection with Fig. 1. This H75 relay, however, does not pick up on the lowest or **15** code and responds only when the code frequency is of the medium or **75** pulse per minute order or higher.

This selective characteristic is preferably obtained by designing the decoding transformer DT5 to have special saturating characteristics as a result of which the amount of energy transferred at the low or **15** code frequency is insufficient to pick up the relay contacts. Conveniently, such characteristics may be provided by making the magnetic circuit of the transformer of comparatively small cross section and so coordinating the primary and secondary windings therewith that the speed of operation of contact **4** of relay TR must at least approach the **75** code rate before the induced secondary voltage will be adequate to circulate current of pick-up strength through the winding of relay H75. When thus arranged, relay H75 maintains its contacts in the released position as long as the relay TR responds to a code as low as 15 cycles per minute. However, on a code frequency of 75 cycles per minute or higher, the relay picks up its contacts and holds them continuously at full stroke.

For the purpose of controlling the lamps of the wayside signal S*u*, relays BP and H75 are provided with contacts **90** and **91** which control the lamp lighting circuits in the usual manner. Likewise, for the purpose of selecting which of the three contacts **15**, **75** and **180** of the device CT5 is included in the primary winding circuit for the track transformer TT connected to the rails of the rear track section, these two relays BP and H75 are further provided with contacts **92** and **93**. Further included in the rear section rail supply circuit is a contact **94** of the repeater relay FP, which contact functions to quicken changes in signal aspect in a manner later to be described.

In operation of these signal control and code selecting circuits, when the track relay TR fails to receive coded energy, as in the event that a train occupies the associated track section (as shown ahead of location X in Fig. 2), the resulting de-energization of all three of the relays FP, BP and H75 causes their contacts to be released. In consequence, the wayside signal S*u* shows "stop" by virtue of lamp R thereof being lighted over a circuit which extends from the positive supply terminal through back contact **90** of relay BP, conductor **28**, and the lamp R back to the negative supply terminal. At the same time, the rails of the track section to the rear receive energy of the **15** code over a circuit which extends from the supply terminal B through coding contact **15** of device CT5, conductor **96**, back contact **92** of relay BP, conductor **51** and the primary winding of transformer TT back to the supply terminal C.

At the entrance of the first vacant block behind the train, or at location W in Fig. 2, the response by the track relay TR to this **15** code causes the contacts of relays FP and BP only to be picked up. Under this condition, the controlled wayside signal S*w* shows the indication of "approach" by virtue of lamp Y thereof receiving lighting current over a circuit which extends from the positive supply terminal through front contact **90** of relay BP, back contact **91** of relay H75, conductor **27** and the lamp Y back to the negative supply terminal. At the same time, the rails of the track section to the rear of the location receive energy of the **75** code over a circuit which extends from the supply terminal B through coding contact **75** of device CT5, conductor **98**, back contact **93** of relay H75, conductor **99**, front contact **94** of relay FP, conductor **100**, front contact **92** of relay BP, conductor **51** and the primary of track transformer TT back to supply terminal C.

At the entrance of the second vacant section behind the train, or at location V in Fig. 2, the response by the track relay TR to this **75** code causes the contacts of all three of the relays FP, BP and H75 to be picked up. Under this condition, the wayside signal S*v* displays the indication of "clear" by virtue of lamp G thereof receiving lighting current over a circuit which extends from the positive supply terminal through front contact **90** of relay BP, front contact **91** of relay H75, conductor **26** and the lamp G back to the

negative supply terminal. At the same time, the rails of the rear track section receive energy of the 180 code over a circuit which may be traced from the supply terminal B through coding contact 180 of device CT5, conductor 103, front contact 93 of relay H75, conductor 99, front contact 94 of relay FP, conductor 100, front contact 92 of relay BP, conductor 51 and the primary of transformer TT back to the supply terminal C.

At the entrance of the third vacant block behind the train, or at location U in Fig. 2, the response by the track relay TR to the 180 code again causes all three of the relays FP, BP and H75 to be picked up and produce the "clear" indication on the part of the controlled signal Su and an inclusion of the coding contact 180 in the rail supply circuit for the rear section. These conditions, moreover, are also duplicated at each of the locations further to the rear which are associated with unoccupied track sections.

Regarding the action of the contact 94 of relay FP in the rail supply circuit, it has been indicated that this contact functions to quicken the change of signal aspect. This quickening occurs as a result of the fact that upon a stalling of the track relay TR in response to an entry of a train into the associated track section, relay FP must release its contacts before the winding of relay BP can be deenergized by a breaking of its supply circuit at contact 36. Accordingly relay BP does not release its contacts until after its full period of drop out delay has expired following the opening of the contacts of relay FP, and the contact 92 thereof thus does not transfer the coding device connection from the 75 contact to the 15 contact until some time following the release of relay FP.

It will thus be seen that by including contact 94 of the latter relay in the rail supply circuit in the manner shown, the supply of all energy to the rails of the rear track section is temporarily cut off by the release of the contacts of relay FP and resumed at the lowest or 15 code upon the subsequent release of the contacts of relay BP. In a system of the character shown in Fig. 3, this action is a desirable one in that it substantially accelerates response of the cooperating apparatus at the entrance end of the rear section.

The selection of codes just described in connection with Figs. 2 and 3 affords special advantages when the trains which pass through the protected stretch of track are equipped with cab signalling apparatus of the conventional type which does not respond to code frequencies as low as the 15 pulse per minute value. As has been seen, energy of that low frequency code is supplied to the rails of the track section immediately behind the one occupied by an advance train. One very practical benefit is that a one block overlap for the control of a "stop" cab signal is obtained without enforcing a corresponding stop indication at the wayside signal.

Typically, the referred to train carried cab signalling apparatus may be of the construction shown and described in United States Patent No. 1,773,472 granted to Paul N. Bossart on August 19, 1930, for Railway traffic controlling apparatus. Such apparatus makes use of devices for inductively receiving energy from the track rails, an amplifier which strengthens the received energy, a code following master relay which is energized from the amplifier output, a decoding transformer which is supplied under the control of the master relay with code following pulses of primary current, decoding relays which are connected with the decoding transformer through frequency selective circuits, and a cab signal having a plurality of indicating units which are selectively energized under the control of the decoding relays.

In the event that a train provided with equipment of the character just described passes over the protected stretch of the track which is represented in Figs. 2 and 3, a three unit cab signal thereof of the type shown at CS in Fig. 2 will respond in the manner there represented as the train progresses through the successive sections behind the advance train A. Of this signal, the top unit is assumed to designate "full authorized" speed, the center lamp "approach" speed, and the lower lamp the most restrictive or "stop" indication.

When the signal carrying train is receiving the 180 code, the top lamp of the signal CS is lighted; when the 75 code is received the middle lamp is lighted; and when energy of a code as low as the 15 pulse per minute variety is received, the equipment fails to respond and the lower lamp of the signal then lights to display the indication of "stop." This failure of response under conditions stated is due to the fact that the energy pulses of the 15 code are too widely separated to effect the picking up of the contacts of any of the frequency selective decoding relays which are carried on the train.

Referring now to Fig. 4, certain of the improvements of our invention which are shown in Fig. 3 are there represented as being applied to a cab signalling system which is arranged to cooperate with the trackway apparatus of Figs. 2 and 3 in a manner which causes a cab signal CS6 to repeat on board the train the indications which the wayside signals S of Figs. 2 and 3 display along the wayside. In this modification, it will be understood that the cab signalling apparatus is so designed that it responds to 15 code as well as to 75 code.

This signal CS6 takes the form of three lamps which are selectively supplied with energizing current over circuits which are controlled by the contacts 90 and 91 of relays BP and H75. These relays together with a companion device FP are duplicates of those shown and described in connection with the apparatus of Fig. 3. They, together with a decoding transformer DT5, are controlled by a train carried master or code following relay MR which corresponds to the track relay TR of the cooperating wayside apparatus of Fig. 3.

This master relay is of the direct current polarized type and is provided with a pair of contacts 106 and 107 which are respectively included in the circuits of the repeater relays FP and BP and of the code distinguishing relay H75. The relay MR receives operating current from an amplifier of any suitable well-known character, which, in turn, is controlled by the output voltage of a pair of windings 108 of the usual receiver 108—109 which is mounted ahead of the advance truck of the equipment carrying vehicle just above and spanning the two rails 1 and 2. When alternating current of the character supplied from source B—C flows in the rails, voltages are induced in and additively combined by these windings.

Like relay TR in the system of Fig. 3, the train carried master relay MR shown in Fig. 4 follows the coding of the energy transmitted thereto from the track rails 1 and 2 through the receiver windings 108, the amplifier, and the relay transformer

RT. Both of its contacts **106** and **107** shift from one position to the other when the polarity of the relay energization changes and when the relay is de-energized these contacts stay in the position to which they were biased by the last energization of the relay. Thus, at the beginning of each pulse of trackway energy (when buildup of current in the primary of transformer RT induces in the transformer secondary a surge of given polarity voltage), the contacts are moved to the right-hand position (shown heavy) and at the end of each energy pulse (when decrease of current in the primary of transformer RT induces in the transformer secondary a surge of opposite polarity voltage) they are returned to the left-hand position (shown dotted) where they remain until another pulse of energy appears in the trackway.

The operation of the cab signalling apparatus of Fig. 4 is similar to that of the wayside signalling equipment previously explained in connection with Fig. 3. When the receiver **108** picks up no energy at all or uncoded steady energy, the contacts of master relay MR are at rest and relays BP and H**75** then are both deenergized. Under this condition the cab signal CS**6** displays the indication of "stop" by virtue of the bottom unit thereof receiving lighting current over a circuit which extends from the positive supply terminal through back contact **90** of relay BP, conductor **111**, and the unit itself back to the negative supply terminal.

When the received energy is of the 15 pulse per minute code, the resulting response thereto by the master relay MR causes the contacts of repeater relays FP and BP to be picked up and still allows those of H**75** to remain released. Under this condition, the cab signal CS**6** displays the "approach" indication by virtue of the middle unit thereof receiving lighting current over a circuit which extends from the positive supply terminal through front contact **90** of relay BP, back contact **91** of relay H**75**, conductor **112**, and the unit itself back to the negative supply terminal.

Finally, when the received energy has a code rate of 75 pulses per minute or higher, the contacts of all three of the relays FP, BP and H**75** are picked up and the cab signal CS then displays the "clear" indication by virtue of the top unit thereof receiving energizing current over a circuit which extends from the positive supply terminal through front contact **90** of relay BP, front contact **91** of relay H**75**, conductor **113**, and the unit itself back to the negative supply terminal. It will be seen, moreover, that energy of the 180 code has the same effect as does that of the 75 code just described in acting to produce the "clear" indication of cab signal CS**6**.

With the exception of the fact that the contacts **106** and **107** of the master relay MR are substituted for contacts **4** and **11**, respectively, of the track relay TR, the relay and the decoding transformer circuits shown in Fig. 4 are duplicates of those previously explained in connection with Fig. 3. Hence, the train carried relay MR controls these circuits in precisely the same manner as does the wayside track relay TR. The arrangement of Fig. 4 thus provides a three indication cab signal system without the use of the usual resonant or frequency tuned decoding circuits. In it, as has been seen, the approach indication is obtained with 15 code (instead of 75 code as at present) and the 180 code has no different effect on the apparatus than does the 75 code which produces the "clear" indication.

Likewise, the wayside apparatus of Fig. 3 also offers the same advantage of detecting codes and distinguishing between different pulse rates thereof without employing frequency tuned circuits. As these involve comparatively bulky and expensive apparatus the stated advantage is a practical one. Moreover, through the represented inclusion of contact **94** of relay FP in the rail supply circuit for the rear track section, the equipment of Fig. 3 provides a shunting response having a quickness which is adequate for all train running conditions.

Referring to Fig. 5, we have there shown a further application of the improvements of our invention to a system of automatic block signalling wherein the number of wayside indications is extended to four. In this application, there is installed at the entrance end of each block section the equipment which is shown at the single location U of the drawing figure.

This equipment includes a code following track relay TR of the alternating current type already described, a decoding transformer DT**7** controlled by contact **4** of that relay in the same manner as in the system of Fig. 1, a pair of relays FP and BP arranged to repeat the front and back positions of a second contact **104** of relay TR, a first code distinguishing relay H**75** which is energized from secondary **89** of transformer DT**7** and a second code distinguishing relay D**180** which is energized through frequency selective circuits J**180** that are connected directly across the end terminals of the decoding transformer primary.

The facilities for coding the trackway energy are the same as those described in connection with the system of Fig. 3. They include a code transmitter CT**5** having three contacts **15**, **75** and **180** which, under the control of contacts **92** and **93** of relays BP and H**75**, are selectively connected in the rail supply circuit to interrupt the supply of primary current to transformer TT at the rate of 15, 75 or 180 times per minute. To quicken the shunting response of this apparatus use also is made of a contact **94** of relay FP, again arranged as in Fig. 3.

Regarding the wayside signal S*u*, it consists of five lamps controlled by contacts **127**, **128** and **129** of relays BP, H**75** and D**180** to give the four different indications which will be described presently.

In operation of the delays of Fig. 5, devices FP and BP respond in the same manner as in the system of Fig. 3. That is, both respond to the presence of coded energy in the associated track section. Consequently, trackway energy of any one of the three 15, 75 and 180 codes is effective to pick up both of devices FP and BP. The relay control circuits shown differ from those of the earlier figures only in that a separate contact **104** of the track relay TR is used to control the repeater devices.

The first code distinguishing relay H**75** picks up only in response to codes of the 75 pulse per minute rate or higher. It is of the same direct current type as that used in the system of Fig. 3 and rectification of its energizing current is effected by a full wave rectifier **116**. As in the case of the decoding transformer of the system of Fig. 3, transformer DT**7** is so designed that at code frequencies substantially below the 75 rate it fails to transmit sufficient energy through its secondary winding **89** to pick up the contacts of relay H**75**.

To safeguard that relay against false response when rectifier or other foreign ripples are present

in the decoding transformer supply circuit, a contact 37 of relay BP is interposed between winding 89 of the decoding transformer and the winding of relay H75 supplied therefrom. If, now, relay TR is not following code, this contact opens the circuit under consideration and thus provides the protection just stated. Obviously, the same result may be obtained by interposing the contact 37 between relay H75 and rectifier 116 (as in Fig. 6) instead of between the rectifier and transformer winding 89 as shown.

The second code distinguishing relay D180 picks up only in response to codes of the 180 pulse per minute rate or higher. It, therefore, is the full equivalent of relay D180 of Fig. 1.

In operation of the complete signal location equipment of Fig. 5, whenever the track relay TR fails to receive coded energy, as in the event that the track section ahead of location U is occupied, the contacts of all three of the relays BP, H75 and D180 are released. Under this condition, the rails of the rear track section receive energy coded by contact 15 of device CT5 and the wayside signal Su displays the indication of "stop" as a result of lamp R thereof receiving lighting current over a circuit which extends from the positive supply terminal through back contact 127 of relay BP, conductor 131 and the lamp R back to the negative supply terminal.

When energy of the 15 code is received by relay TR, the contacts of relays FP and BP only are picked up. Under this condition the rails of the rear track section receive energy coded by contact 75 of device CT5 and the signal Su displays the indication of "approach" as a result of its lower lamp Y receiving lighting current over a circuit which extends from the positive supply terminal through front contact 127 of relay BP, back contact 128 of relay H75, conductor 132, and the lamp Y back to the negative supply terminal.

When energy of the 75 code is responded to by relay TR, the contacts of relay H75 also are picked up. Under this condition the rear track section is supplied with energy coded by contact 180 of device CT5 and the wayside signal Su shows the "approach medium" indication as a result of its upper lamp Y and its lower lamp G being simultaneously energized over a circuit which extends from the positive supply terminal through front contact 127 of relay BP, front contact 128 of relay H75, back contact 129 of relay D180, conductor 133 and both of the named lamps back to the negative supply terminal.

Finally, when energy of the 180 code is responded to by relay TR, the contacts of all four of the relays FP, BP, H75 and D180 are picked up. Under this condition the track section to the rear of location U is again supplied with energy coded by contact 180 of device CT5 and the wayside signal Su displays the "clear" indication as a result of its upper lamp G receiving lighting current over a circuit which extends from the positive supply terminal through front contacts 127, 128 and 129 in series, conductor 134 and the lamp G back to the negative supply terminal.

Regarding the advantages of the arrangement of Fig. 5, the represented inclusion of contact 37 of relay BP in the energizing circuit for relay H75 assures that the latter relay will not falsely respond when rectifier or other foreign ripples are present in the supply circuit of the decoding transformer DT7. Moreover, the use of contact 94 of relay FP in the rail supply circuit assures the same quick shunting response as was discussed in connection with Fig. 3.

Referring to Fig. 6, we have there represented a modified form of circuits for obtaining the same wayside and cab signal operation as the circuits of Figs. 2 and 3. In this modified arrangement, however, the function of relays FP and BP of Fig. 3 is performed by a single relay BP15 which is energized through a capacitor 115 in a manner more completely described in a co-pending application, Serial No. 198,935, filed by Frank H. Nicholson on March 30, 1938, for Railway traffic controlling apparatus. Also, the energizing circuit for the code distinguishing relay H75 is modified to use, as does the apparatus of Fig. 5, a full wave rectifier 116 of the copper oxide or other equivalent type, which is connected with the single section secondary winding 89 of the decoding transformer DT8.

The primary winding of this transformer is controlled by contact 4 of relay TR in the same manner as that explained in connection with the representation of Fig. 1. As in the case of device DT5 of Fig. 3, the decoding transformer DT8 of Fig. 6 is designed to transmit to relay H75 sufficient energy to cause it to pick up its contacts only when the frequency of the coded energy to which the track relay TR responds has a value of 75 cycles per minute or higher.

Repeater relay BP15, however, is arranged to pick up its contacts upon code frequencies of 15 cycles per minute or higher. Moreover, it is provided with a contact 37 which is included in the supply circuit of relay H75 and arranged, as in the system of Fig. 5, to eliminate the possibility of falsely energizing that relay when ripples of rectifier or other foreign origin are present in the decoding transformer supply circuit.

Considering first the energizing facilities for the relay BP15, these are controlled by a contact 102 of the code following track relay TR, which in its front or picked up position completes for the capacitor 115 a charging circuit and which in its back or released position disconnects the capacitor from its charging source and connects it across the terminals of the relay winding. The mentioned charging circuit may be traced from the positive terminal of a suitable supply source through front contact 102, conductor 118, the capacitor 115, and conductor 119, back to the negative terminal of the supply source. The referred to discharging or relay energizing circuit may be traced from the left or positive terminal of the capacitor 115 through conductor 118, back contact 102 of relay TR, conductor 121, the winding of relay BP15, and conductor 122 back to the negative terminal of the capacitor 115.

In operation of the circuits just described, as long as the contacts of relay TR are at rest the winding of relay BP15 remains deenergized and the contacts of the relay then, of course, are released. In the event, however, of code following response on the part of the relay TR, the capacitor 115 becomes charged each time that the relay contacts are picked up and then is discharged through the winding of BP15 each time that the code following contacts are released. By providing relay BP15 with a release retardation sufficient to bridge the intervals between pulses of the lowest or 15 code, relay BP15 is in this manner enabled to hold its contacts continuously picked up as long as a trackway code is being received.

Accordingly, the device operates in the same

manner as the corresponding relay BP of Fig. 3 and in cooperation with relay H75 it controls, in the manner already explained, the lamps of the wayside signal S at location Q and aids in selecting the coding of the energy which is supplied to the rails of the track section to the rear of that location.

In situations where it is desired to control highway crossing signals (not shown), a second repeater relay FP15 may be added to the apparatus of Fig. 6 by bridging the winding thereof across the terminals of the capacitor 115 in the manner represented. Should, now, the track relay TR at location Q receive steady energy and continuously hold its contacts picked up, the winding of relay FP15 will receive operating current over a circuit which may be traced from the positive supply terminal, through front contact 102 of relay TR, conductor 118, the winding of relay FP15, and conductors 124 and 119 back to the negative supply terminal. Under this condition, contact 86 of the relay becomes effective to complete the energizing circuit for a conventional crossing signal control relay XR (not shown) and thereby discontinue operation on the part of the referred to highway crossing signals (not shown).

Regarding the advantages of the arrangement of Fig. 6, detection of code is effected through the use of but a single relay BP15; the function of distinguishing between different code frequencies is performed by a second relay H75 and conventional circuits; and immunity to false response to rectifier ripples in the supply circuit for decoding transformer DT8 is obtained by including contact 37 in the energizing circuit of relay H75.

From the foregoing description of Figs. 1 to 6, inclusive, it will be seen that all of the herein disclosed embodiments of our invention are effective to lower the cost, simplify the construction and improve the operating characteristics of decoding equipment which is suitable for control by a code following relay in railway signalling systems of the continuously coded track circuit class. In applying our inventive improvements, moreover, none of the desirable features of this advantageous form of signalling system control is dispensed with and in all of the represented applications only two sets of contacts are required on the code following relay to effect the desired code detecting and code distinguishing functions.

Although we have herein shown and described only a few forms of railway traffic controlling apparatus embodying our 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 our invention.

Having thus described our invention, what we claim is:

1. In a railway signalling system, the combination of a code following relay, a decoding transformer energized over a direct current circuit which is pole changed by a contact of said relay, a decoding relay, a circuit connecting the secondary of said transformer in energy supplying relation with the winding of said decoding relay, means included in said circuit for rectifying the transformer output current which is transmitted to said decoding relay winding, a code detecting relay responsive to code following operation on the part of said code following relay, and means controlled by said code detecting relay for interrupting said decoding relay supply circuit whenever said code following operation is discontinued.

2. In a railway signalling system, the combination of a code following relay, a decoding transformer energized over a circuit which is controlled by said relay, a first repeater relay energized over a circuit which includes a front contact of said code following relay, a second repeater relay energized over a circuit which includes a back contact of the code following relay and a front contact of said first repeater relay, a decoding relay energized by a rectified portion of the output of said decoding transformer, and a front contact of said second repeater relay included in the energizing circuit of said decoding relay to interrupt same whenever said code following relay fails to operate.

3. In combination, a code following relay, a decoding transformer energized over a direct current circuit which is pole changed by a contact of said relay, a decoding relay, a circuit connecting the winding of said decoding relay to the secondary of said transformer, a rectifier included in said circuit, and a code detecting relay responsive to code following operation on the part of said code following relay and having a front contact also included in said supply circuit of the decoding relay for the purpose of interrupting same whenever said code following operation is discontinued.

4. In a railway signalling system, the combination of a forward and a rear section of track, a code following relay operated by energy received from the rails of said forward section, a first repeater relay energized over a circuit which includes a front contact of said code following relay, a second repeater relay having slow release characteristics and energized over a circuit which includes a back contact of the code following relay and a front contact of said first repeater relay, means for supplying the rails of said rear track section with coded energy, a contact carried by said second repeater relay for selecting the rate of coding for said energy, and a contact of said first repeater relay included in said rail supply circuit and effective upon a release of said first repeater relay for interrupting the supply to the rear section of energy of the coding rate which the picked-up condition of said rate selecting contact determines.

5. In combination, a code following relay operated by energy received from the trackway, a first repeater relay energized over a front contact of said code following relay, a second repeater relay energized over a back contact of the code following relay and a front contact of said first repeater relay, a decoding transformer having portions of an input winding which are respectively included in the energizing circuits of said repeater relays, a code distinguishing relay energized from said transformer over an untuned circuit which includes other contacts of said code following relay and which transmits energy of sufficient intensity to pick up the relay only when the code frequency of said trackway energy exceeds a given rate, and traffic governing means jointly controlled by said code distinguishing relay and said second repeater relay.

6. In a railway signalling system, the combination with a forward and a rear section of track of a code following relay operated by coded energy received from said forward section, a first repeater relay energized over a front contact of said code following relay, a second repeater relay energized over a back contact of the code following relay and a front contact of said first repeater relay, a decoding transformer also controlled by said code following relay, a code distinguishing

relay energized from said transformer and arranged to pick up only when the code frequency of said forward section trackway energy exceeds a given rate, means for supplying said rear section of track with energy of one or another of a plurality of different codes, circuit means including contacts of said second repeater relay and of said code distinguishing relay for selecting the code for said rear section, and a contact of said first repeater relay included in said circuit means to quicken the shunting response of the apparatus above defined.

7. In combination with a forward and a rear section of railway track, means for supplying said forward track section with coded energy pulses that recur at one or another of three different rates, a code following relay operated by energy received from said forward section, a pair of repeater relays and a decoding transformer controlled by said code following relay, a first code distinguishing relay energized from said decoding transformer and arranged to respond only to code speeds which exceed the lowest of said three different rates, a second code distinguishing relay also energized from said transformer but arranged to respond only to the highest of said three different code rates, a traffic governing signal controlled by said two code distinguishing relays and a second of said repeater relays, means for supplying said rear section of track with energy of one or another of a plurality of different codes, and circuit means including contacts of said two repeater relays and of said first code distinguishing relay for selecting the code supplied to said rear section.

8. In a railway signalling system, the combination of a code following relay, a decoding transformer controlled thereby, a code distinguishing relay energized from said transformer and arranged to respond to code rates which are in excess of a predetermined value, a code detecting relay, a capacitor which receives charging current each time that said code following relay picks up, a circuit for discharging said capacitor through the winding of said code detecting relay each time that the code following relay releases, and traffic governing means jointly controlled by said code detecting and code distinguishing relays.

FRANK H. NICHOLSON.
LESLIE R. ALLISON.