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J. RABOURDIN

CONTROL SYSTEM AND METHOD ESPECIALLY FOR RAILWAY CAR CLASSIFICATION YARDS

Filed Feb. 26, 1940

Serial No. 320,937

4 Sheets-Sheet 1

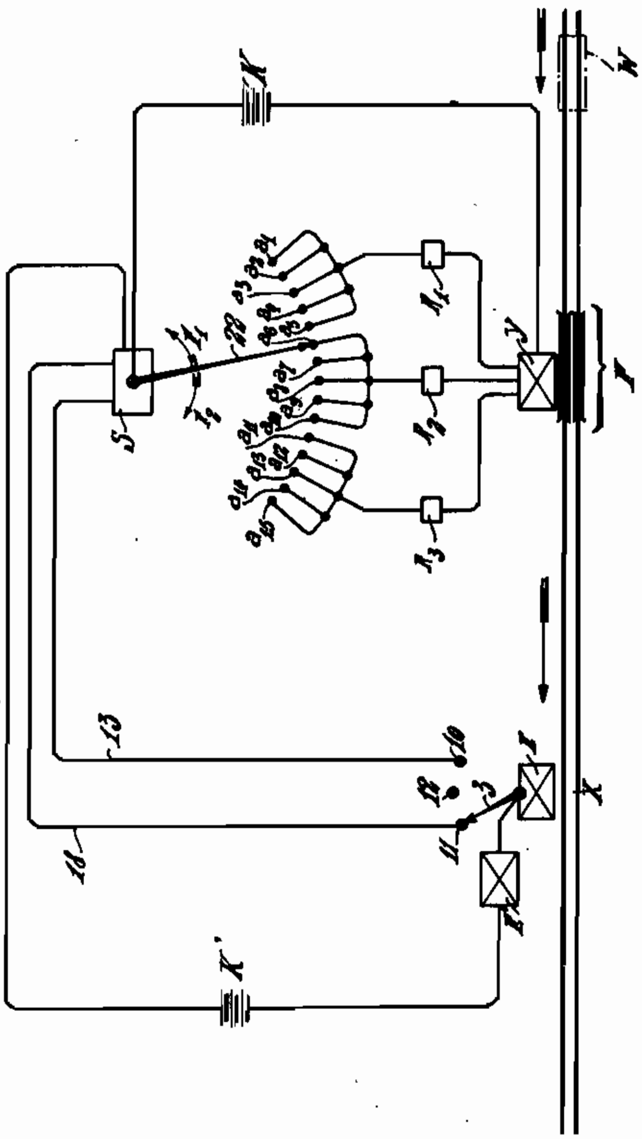

Fig. 1

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Fig. 2.

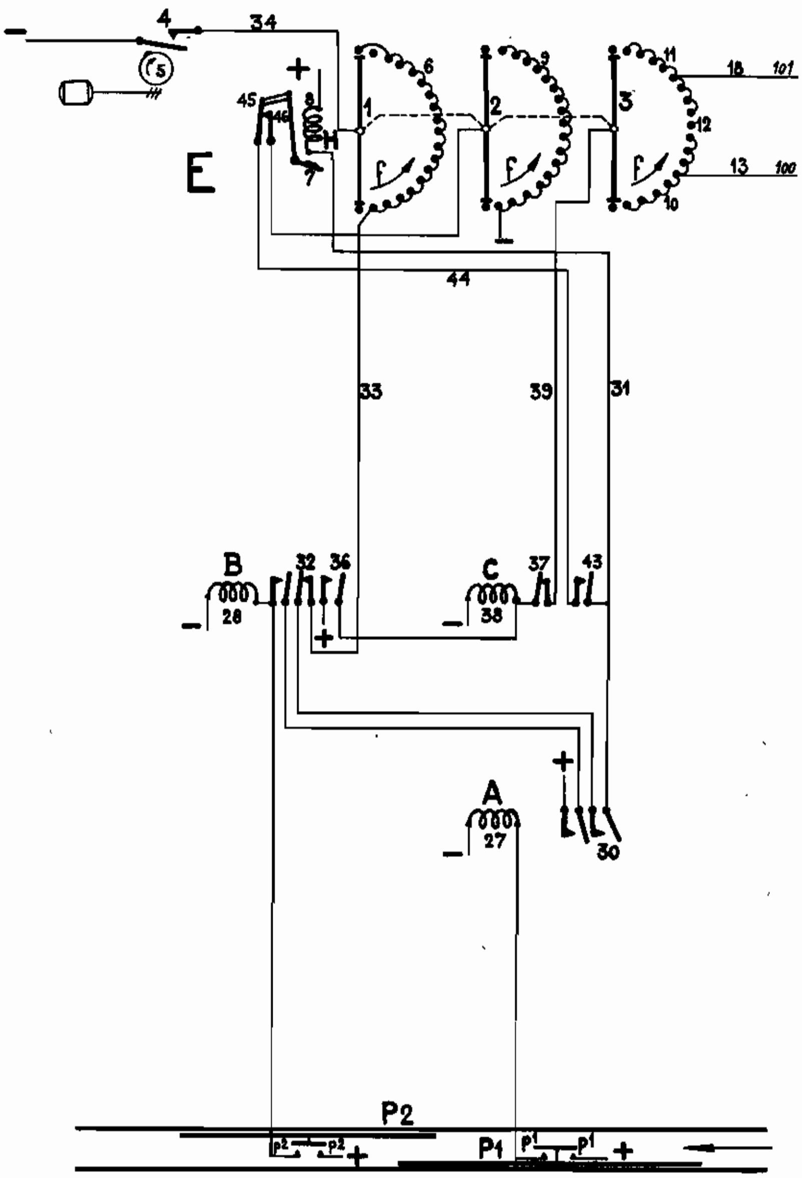

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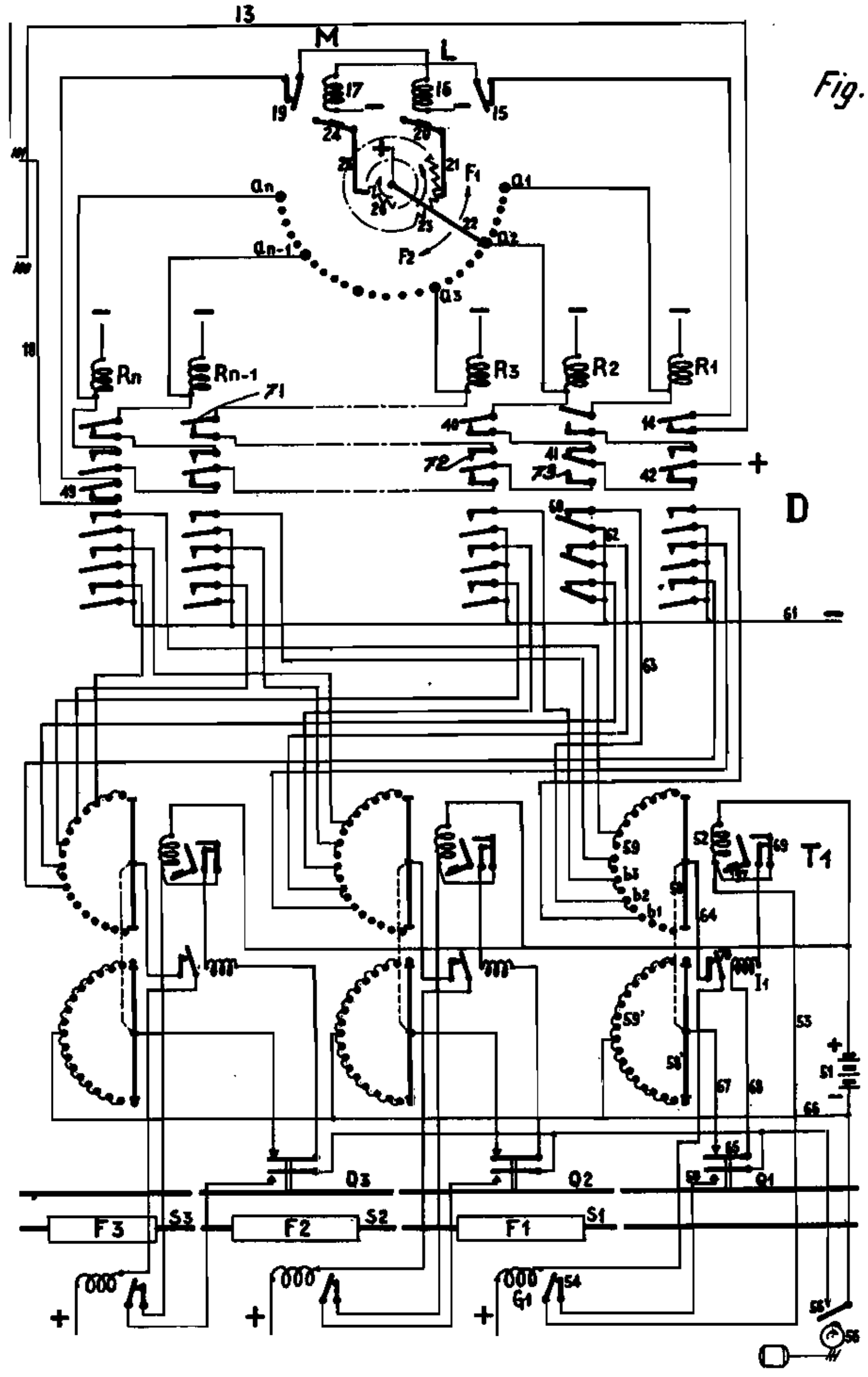
Fig. 3



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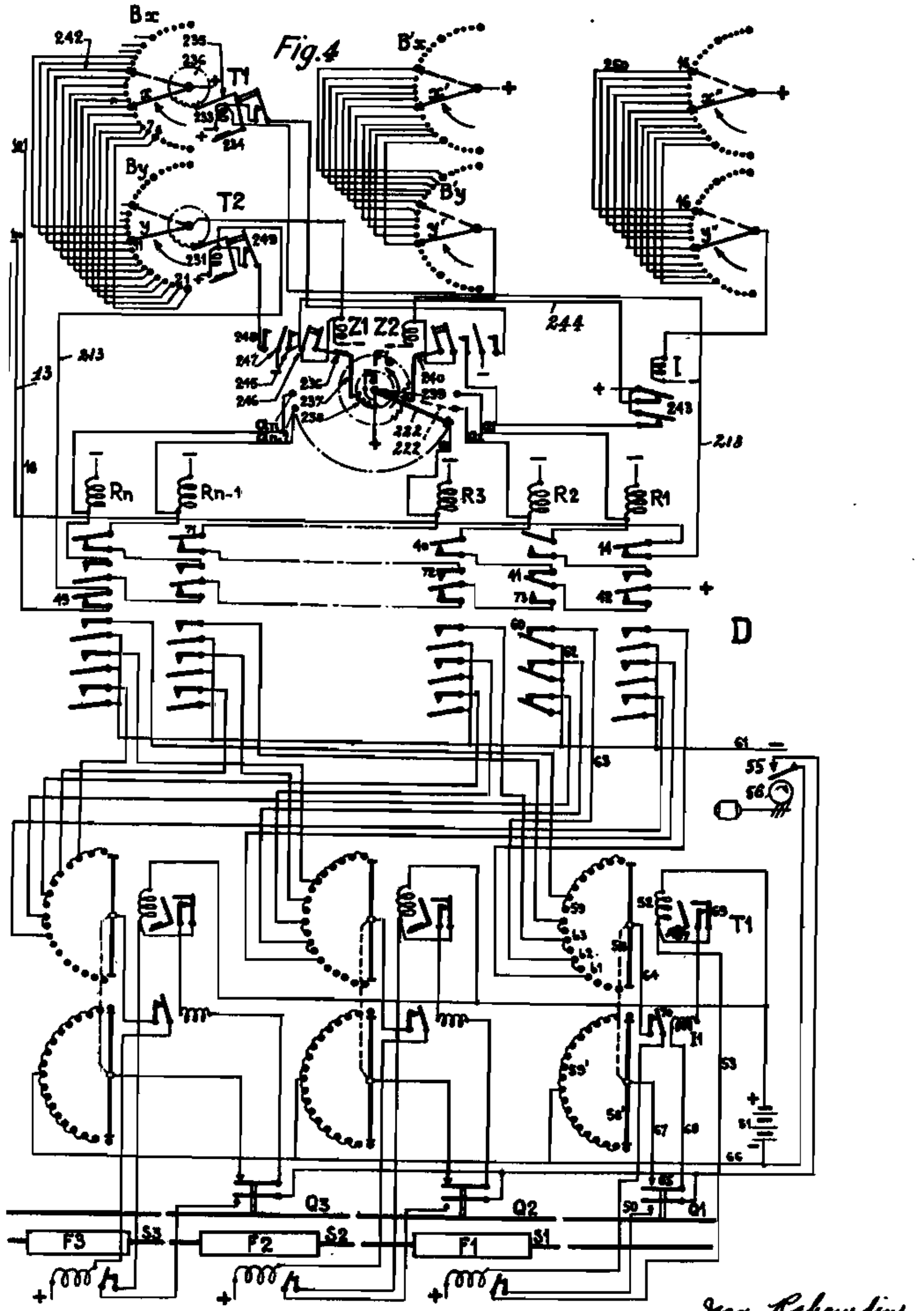

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ALIEN PROPERTY CUSTODIAN

CONTROL SYSTEM AND METHOD ESPECIALLY FOR RAILWAY CAR CLASSIFICATION YARDS

Jean Rabourdin, Paris, France; vested in the Alien Property Custodian

Application filed February 26, 1940

The present invention relates to devices for the giving movable bodies a controlled displacement and, in particular, automatically controlling the movement of railway cars in classification yards, so as to cause said cars to move under predetermined speed and spacing conditions.

The chief object of the present invention is to solve the following problem: These movable bodies (railway cars) move along a given path and they can be acted upon only at certain points of said path and it is desired to obtain, among other things, a predetermined average, maximum or minimum speed at a further point of said path. It should be well understood that as the conditions of displacement of the successive movable bodies or cars are not the same, only average, maximum or minimum speeds can be considered.

At the points where the movable bodies (cars) can be acted upon, said bodies are subjected to accelerating or braking actions which are determined, for instance, by prior running or speed conditions. But the action to be applied at these points depends upon other factors, which cannot practically be determined in advance. According to an essential feature of the invention, this preliminary determination of these conditions is replaced by an "a posteriori" control responsive to indications taken at points where it is possible to ascertain whether the speed of the cars, or other movable bodies complies with the desired conditions.

According to the invention, these indications will be registered and they will be caused to influence the adjustment of the accelerating or braking means so as to correct the error which will thus eventually have been found to exist.

In other words, according to the invention, the adjustment of the accelerating or braking means is modified by successive approximations indicated by the errors found precedingly to exist. This can be considered as an automatic, or mechanical, application of the methods used in artillery for finding the exact range of an objective, and which consist in modifying the firing elements in view of the error precedingly found by observation.

In the particular case of the speed control of railway cars in a classification yard two chief problems are to be considered:

a—As, in the switch zone, there are braking devices which can be used for obtaining a given speed of the railway cars when they reach the point from which start the various classification tracks, a speed measuring device placed at this point is used for automatically controlling the action of the braking devices in question.

b—As other braking devices can be placed at the entrance of each classification track for obtaining a given speed of the railway cars as they come into contact with other cars already stopped on these classification tracks, means for measuring the speed of said moving cars as they come into contact with these stationary cars are used for automatically controlling said braking devices.

Other features of the present invention will result from the following description of some specific embodiments thereof.

Fig. 1 is a diagrammatic view of an embodiment of the invention as applied to the braking control of railway cars;

Figs. 2 and 3 are parts of a detailed diagram of such an embodiment, these two Figs. completing each other;

Fig. 4 shows a modification of the apparatus of Figs. 2 and 3.

Fig. 1 shows a railway track element on which cars (one of which is diagrammatically shown at W) are running from right to left under the effect of an impulse imparted, in any suitable manner, on the right hand side of the drawing. At F, I have diagrammatically shown a car braking device of any suitable type. This device F is actuated by an electric motor Y, controlled by any one of the three relays R_1, R_2 and R_3, in such manner that the intensity of the braking action exerted by apparatus F has a high value when the motor is controlled through relay R_3, a mean value when the motor is controlled through relay R_2, and a low value when the motor is controlled through relay R_1.

The energizing of these relays R_1, R_2 and R_3 is made from a battery K one terminal of which is directly connected to motor Y, while the other terminal is connected to the pivot of a brush **22**. The end of this brush **22** passes successively on contacts a_1, a_2, a_3, a_4, a_5, a_6, a_7, a_8, a_9, a_{10}, a_{11}, a_{12}, a_{13}, a_{14}, a_{15} arranged along a circular arc.

Contacts a_1 to a_5 inclusive are electrically connected to one another and to relay R_1. Contacts a_6 to a_{10} inclusive are electrically connected to one another and to relay R_2. Contacts a_{11} to a_{15} inclusive are electrically connected to one another and to relay R_3.

Thus, when brush **22** is on one of the first five contacts a_1 to a_5 motor Y is controlled through relay R_1 and produces a relatively low braking of the cars, such as W, by apparatus F. The presence of brush **22** on any one of the five next contacts a_6 to a_{10} corresponds to a medium braking being exerted by apparatus F. Finally, the presence of brush **22** on any of the last five contacts a_{11} to a_{15} corresponds to a high braking action.

Brush **22** is driven by a device S, called "selector" of any suitable type actuated by electric impulses and such that, under the effect of each impulse that is received, apparatus S causes brush **22** to turn, through an angle equal to the angular interval between two consecutive contacts, in the direction of arrow F_2 when the electric impulse that is received is produced by current flowing in one direction through S and in a direction opposed to arrow F_2 when the direction of this current is reversed.

The electrical impulses are transmitted from a battery K' to device S through two lines **13** and **18** leading to contacts **10** and **11**.

Then contacts cooperate with a rotating brush **3** electrically connected to one terminal of battery K' the other terminal of which is directly connected to one of the terminals of device S.

Furthermore, brush **3** can pass on an electrically insulated intermediate contact stud **12**.

This brush **3** is controlled by an apparatus E, located at the point X of the track where it is desired to have all the cars passing at speed V. This apparatus E is adapted to control at any time the position of brush **3**, as a function of the speed of the car which has just passed at X in such manner that:

a—brush **3** is on insulated contact stud **12** when the speed of the car that has just been passing is equal to the desired speed V;

b—brush **3** is on contact **11** when the speed of the car that has just been passing is lower than V;

c—brush **3** is on contact **13** when the speed of the car that has just been passing is higher than V.

A device E' is interposed in the circuit of battery K' so that, whenever brush **3** comes on one of the contacts **10** and **11**, a short electric impulse flows through the circuit thus closed.

Lines **13** and **18** are connected to terminals of device S arranged in such manner that, when the current impulse supplied by battery K' passes through line **13** (case of brush **3** being located on contact **10** and, therefore, of a speed of the last car that has passed at X being higher than V), the direction of the current flowing through device S corresponds to the displacement of the brush **22** thereof in the direction of arrow F_2.

On the contrary, when the circuit of battery K' is closed across line **18** (case of brush **3** being located on contact **11** and therefore of the speed of the last car that has passed at X being lower than V), the direction of the current flowing through device S is reversed and corresponds to the displacement of the brush **22** thereof in the direction opposed to arrow F_1.

This device works as follows:

It will be supposed that, initially, brush **22** is located on contact a_6 (first contact of the middle group). The braking applied by apparatus F is a medium braking adapted to give the cars passing at X a speed equal to V.

As long as these conditions are complied with, brush **3** remains on contact **12**.

If a car passes at B with a speed higher than V, brush **3** comes on contact **10**. An electrical impulse is then transmitted from K' to device S through line **13** and, as above explained, this causes brush **22** to pass from contact a_6 to contact a_7.

If, immediately after this, a car passes at X with a speed lower than V, brush **3** comes onto contact **11** and an impulse is transmitted, through line **18**, to device S, which brings back brush **22** from contact a_7 to contact a_6.

Thus, it will be seen that, excepting the cars which pass at X with a speed equal to V, and which do not modify the position of brush **22**, the successive passage at X of five cars running at a speed higher than V will cause brush **22** to pass from group $a_6 \ldots a_{10}$ to group $a_{11} \ldots a_{15}$, which brings relay R_3 into play and increases the braking action of apparatus F. If a single car passing at X with a speed lower than V is intercalated in this series of five cars running at speeds higher than V, brush **22** is caused to move backward a distance equal to one interval and the brush remains on group $a_6 \ldots a_{10}$ corresponding to relay R_2.

Of course, the passage of the brush to group $a_1 \ldots a_5$ corresponding to a reduction of the braking action of apparatus F is produced by inverse conditions.

Now, it will be understood that, if accidental or temporary circumstances may cause the speed of one or two cars to vary, that is to say to be higher or lower than the desired speed V, the fact that five successive cars (or six out of seven successive cars, and so on) pass at a speed higher than V surely indicates a variation of the working conditions (atmospheric conditions for instance) which is sufficiently permanent to necessitate a modification of the adjustment of braking apparatus F capable of increasing the braking action thereof. Likewise, the consecutive passage of five cars at a speed lower than V corresponds to the necessity of reducing the braking action of apparatus F.

Thus, the apparatus above diagrammatically described ensures the adjustment of the braking device (and more generally, of the means for acting on the speed of cars and other movable bodies) as a function of the actual speed of the movable bodies as they pass at a given point of their path of travel, but in such manner as to eliminate the influence of accidental or temporary circumstances, whereby the adjustment of the braking or equivalent means is modified only if the circumstances under which the movable bodies travel along the track undergo a substantial and sufficiently permanent modification.

In other words, it is the variation of speed of the movable bodies at a given point, with reference to a given value, which conditions any modification of the adjustment of the means which act on said speed. But, in order to be sure that only variations of a sufficiently stable character will be taken into account, the adjustment of the means above mentioned takes place only if a series containing a given majority of variations of speed in one direction of the cars passing at the above mentioned given point.

In the above example, it has been supposed that there were five contacts corresponding to each relay R_1, R_2, R_3, but of course this number has been chosen merely by way of example. Likewise, instead of the three relays above mentioned, I might have any number of relays, corresponding each to a different action of the braking or equivalent means F.

Of course, relays R_1, R_2, R_3 do not necessarily act braking or analogous apparatus so as automatically to modify the adjustment or operation thereof. The apparatus shown at F might be a signalling apparatus indicating to an operator which modifications are to be brought, either manually or otherwise, to the action of braking or analogous apparatus.

As for the various apparatus, such as S, E, etc. above mentioned, they can be made in many different ways, provided that they comply with the conditions above mentioned. I will now describe two embodiments of such apparatus.

Referring more particularly to Figs. 2 and 3, the place X of the track where the speeds of the cars are measured includes two points, corresponding to contacts p_1 and p_2 controlled by treadles or pedals P_1 and P_2 successively operated by the passage of each car.

In this embodiment, apparatus E comprises a rotary switch including three movable contacts 1, 2 and 3 keyed on a common rotary shaft as diagrammatically shown by dotted lines. Contact 1 is connected to the negative terminal of a source of electrical energy through a contact 4 closed at regular time intervals by a cam 5 revolving at constant speed under the action of a motor. Contact 1 is adapted to engage stationary contacts 6 which are all connected together (except for the first and the last but one, which are isolated) and it is adapted to move forward a distance equal to the interval between two successive stationary contacts whenever a movable armature 7 is attracted (or repelled as an alternative arrangement) by the coil 8 of a relay H, said coil 8 being connected to the positive terminal of said source of electric energy. Similarly, movable contact 2 is adapted to engage stationary contacts 9, all of which, except for the extreme ones, are connected to one another and to the negative terminal of the source. To movable contact 3 correspond stationary contacts distributed into three groups, to wit, group 10 comprising contacts initially engaged by movable contact 3 when it rotates in the direction of arrow *f*, group 11 comprising contacts ultimately engaged by the same movable contact 3, and an intermediate group, located between groups 10 and 11, and which, in the example shown consists of a stationary contact 12. Stationary contacts 10 are connected together as well as stationary contacts 11; the two extreme stationary contacts are insulated.

Group 10 is connected to the negative terminal of the source of electric energy through conductor 13 (broken at 100 between Figs. 1 and 2), the normally closed contact 14 of relay R_1, the normally closed contact 15 of relay L and the coil 17 of relay M. Group 11 is similarly connected to the negative terminal of the source of electric energy through conductor 18 (broken at 101 between Figs. 1 and 2), the normally closed contact 49 of relay R_n, the normally closed contact 16 of relay M and the coil 19 of relay L. The armature 20 of relay L is adapted to rotate through lever 21, the movable contact 22 of selecting device S in the direction of arrow F_1 by engaging ratchet wheel 23. The armature 24 of relay M is similarly adapted to move contact 22 through lever 25, but in the opposite direction (arrow F_2) by acting on ratchet wheel 26. Movable contact 22 is connected to the positive terminal of the source of electric energy and the coils of relays R_1 to R_n are connected to the negative terminal thereof.

The operation of the above described system will now be explained:

It will be supposed that movable contact 22 originally engages stationary contact a2. When a car moving from right to left (as shown by the arrow on Fig. 1) engages treadle P_1, it closes contact p_1, thereby energizing relay A. The coil 27 of relay A shifts its movable armature or fingers from right to left, thereby closing contact 30; then, whenever contact 4 is closed by cam 5, the coil 8 of relay H receives an impulse through the following circuit: positive terminal of the source, coil 8, conductor 31, contact 30, the normally closed contact 32 of relay B, conductor 33, fixed contacts 6, movable contaet 1, conductor 34, contact 4, and the negative terminal of the source. Movable contacts 1, 2 and 3 are simultaneously moved step by step.

When the car engages treadle P_2, thus closing contact p_2, the coil 28 of relay B is energized and the above circuit is broken at 32, while relay C has its coil 38 energized through the following circuit: positive terminal of the source, the contact 36 of relay B since the contact armatures or fingers of B have been attracted from right to left, the coil 38 of relay C and the negative terminal of the source. As relay C is a slightly delayed action relay, i. e. its normally closed contact 37 is not immediately broken, movable arm 3 is momentarily connected to the positive terminal of the source through the contact 36 of relay B, the contact 37 of relay C and conductor 39. Therefore the position assumed by movable contacts 1, 2, 3 when they have stopped, indicates the speed of the car when running from treadle P_1 to treadle P_2.

Assuming that movable arm 3 has stopped (due to the energizing circuit of coil 8 being broken at 32) upon a stationary contact of group 10, then the hereinafter mentioned circuit has been momentarily closed from the time when contact 36 was closed until the time when contact 37 has opened; said circuit is the following: positive terminal of the source, the contact 36 of relay B, the contact 37 of relay C, conductor 39, movable arm 3, stationary contact group 10, conductor 13 (broken at 100 between Figs. 1 and 2), contact 14, the contact 15 of relay L, the coil 17 of relay M, and the negative terminal of the source. Since the coil 17 of relay M is thus energized, its armature 24 is attracted and simultaneously contact 19 is broken; when armature 24 is picked up, ratchet wheel 26 driven by lever 25 turns movable contact 22 a distance equal to the interval between two stationary contacts in the direction of arrow F2. Although the normal energizing circuit of relay R2, which is as follows; positive terminal of the source, movable contact 22, the coil of R2 and negative terminal of the source, is now broken, relay R2 is still energized through a stick circuit which is as follows: negative terminal of the source, relay R2, the contact 40 of relay R3, the contact 41 of relay R2, the contact 42 of relay R1 and positive terminal of the source.

Assuming that the movable contact arm 3 has stopped upon stationary contact 12, then no energization of relays in selecting device S can take place, and relay R2 remains energized through movable contact 22 as above described.

Assuming now that movable contact 3 has stopped upon a stationary contact in group 11, then the following circuit is closed: positive terminal of the source, contact 36 of relay B, contact 37 of relay C, conductor 39, movable arm 3, the contacts of group 11, conductor 18 (broken at 101 between Figs. 1 and 2), contact 49 (Fig. 2), contact 19, coil 16 of relay L, and negative terminal of the source; in the same manner as above described, contact 22 is moved but now in the direction of arrow F1 a distance equal to the interval between two stationary contacts.

As above explained, relays R1 to R*n*, control, through armatures or movable fingers 41, 42 . . . 49, signal devices, motive devices or the like, an example of which is to be hereinafter described.

I will now explain how the speed detecting means or rotary switch E is restored to its original position. When relay B is energized and therefore contact 36 is closed, the coil 38 of relay C closes contact 43, with a certain lag, thus closing the following circuit: positive terminal of the source, coil 8 of the relay H, conductor 31, contact 43, conductor 44, movable contact finger 35, stationary contact finger 46, movable contact 2 (engaging one of the stationary contacts 9), stationary contacts 9, and the negative terminal of the source. Coil 8 is thus energized and picks up its armature 7, whereby movable contacts 1, 2 and 3 are rotated a distance equal to the interval between two successive stationary contacts, in the direction of arrow *f*, but, immediately, movable finger 45 attached to armature 7 opens the above energizing circuit of relay H, whereby armature 7 is dropped to its original position, carrying therewith movable finger 45; then the circuit is closed again and the same operation takes place until movable contact 2 reaches the extreme stationary contacts in the corresponding row i. e. until the switch resumes its original position.

I will now describe the case in which the apparatus according to the invention is employed in a car classification yard and automatically controls, as a function of the speed of cars at point X, a braking apparatus.

In this instance, relays R_1, R_2, . . . R_n are intended to govern the amount of braking imposed on the cars while they pass through the braking apparatus. According to the showing on Fig. 2, stationary contacts a_1, a_2, . . . a_n connected to respective relays R_1, R_2 . . . R_n, have between them four stationary contacts bearing no connection (the number four is optional and has been selected solely for illustrative purposes).

If a car has cleared the braking apparatus and passes at point X with a speed such that apparatus E brings its movable contact 3 on stationary contact 12, no electrical impulse is transmitted to the selecting means S and consequently, contact 22 remains on contact a_2.

If now, a car passes from the treadle P_1 to treadle P_2 at a higher speed, the movable contact 3 has not time enough to reach stationary contact 12 and is stopped upon one of the stationary contacts in group 10; consequently, as above explained, relay M causes movable contact 22 to rotate one step in the direction of arrow F_2. Should five successive cars have similarly a speed higher than speed V, then movable contact 22 will reach stationary contact a_3 in the selecting means S; accordingly, relay R_3 is energized and substituted, in so far as its effect is concerned, for relay R_2 because relay R_3 is energized by the following circuit: positive terminal of the source, movable contact 22, stationary contact a_3, coil of relay R_3, negative terminal of the source, and relay R_2 which was no longer directly energized, has now its stick circuit broken at the contact 40 of relay R_3 (the armatures of which are picked up). A stick circuit for relay R_3 is simultaneously closed as follows: negative terminal of the source, coil of R_3, contact 71 of relay R_{n-1}, contact 72 of relay R_3, contact 73 of deenergized relay R_2, contact 42 of deenergized relay R_1, positive terminal of the source.

Assuming that relay R_3 is arranged and constructed so as to cause the braking apparatus to exert a higher braking action than relay R_2, it will be understood that its substitution for relay R_2 tends to bring down the speed of the cars closer to the optimum value; should its action be insufficient, then the step by step movement of movable contact 22 continues in the same direction, whereby another relay R_4 is substituted for relay R_3 and so on.

As a specific example, it will be assumed that the braking apparatus is made as follows (Fig. 3). After treadles P_1 and P_2, the track comprises a plurality of braking sections, say three S_1, S_2, S_3. Each section is provided with a braking device F_1, F_2 or F_3 which includes a braking shoe (not shown) normally maintained in readiness for operation but adapted to be sidetracked and thus rendered inoperative by a motor. To each braking section is associated a treadle Q_1, Q_2 or Q_3.

When a car engages treadle Q_1, contact 50 is made and the following circuit: positive terminal of battery 51, coil 52 of relay T_1, conductor 53, contact 54, contact 50, contact 55, and negative terminal of battery 51, is closed whenever contact 55 is closed by cam 56 rotated at constant speed. Thus coil 52 receives a number of successive impulses whereby, as above described with reference to rotary switch E, armature 57 is successively picked up and dropped, simultaneously causing a step by step motion of contacts 58, 58', which are keyed on a common shaft, as conventionally indicated by dotted lines. The operation of this impulse device is well known and is substantially the same as described with respect to the speed detecting means E, so that no further explanation is needed.

It will be assumed that relay R_2 is directly energized through movable contact 22 being in engagement with stationary contact a_2. Contact 60 is then closed and the negative terminal of the main source is connected with the stationary contact b_2 of the rotary switch or impulse device T_1 through conductors 61 and 62, contact 60 and conductor 63. Assuming that the car has remained in engagement with treadle Q_1 for such a time that movable contact 58 has reached stationary contact b_2, the engagement of said contacts results in the closing of the following circuit: negative terminal of the main source, conductor 61, conductor 62, contact 60 of relay R_2, conductor 63, stationary contact b_2, movable contact 58, conductor 64, contact 70 of relay I_1, coil of relay G_1 arranged in braking sub-section S_1 and positive terminal. Relay G_1, thus energized, sets in section, in a well known manner, the braking shoe control motor (not shown) in section S_1 so as to side-track said shoe and accordingly the car is not braked in section S_1. Simultaneously, the energizing of relay G_1 causes contact 54 to be broken, thereby deenergizing the coil 52 of relay T_1 so that movable contacts 58, 58' are stopped. When the car leaves treadle Q_1, contact 65 is closed, thus completing the following circuit: negative terminal of battery 51, conductor 66, group of stationary contacts 59', movable contact 58', conductor 67, contact 65, coil I_1, contact 89 of relay T_1, coil 52 of relay T_1, and positive terminal of battery 51. Then, in known manner, coil **52** picks up its armature **57**, which breaks the energizing circuit of coil **52**, by engaging movable contact finger **69**, so that armature **57** is dropped, thus releasing movable contact finger **69** which again completes the energizing circuit and so on; accordingly movable contacts **58**, **56'** are rotated step by step until they come back to their original position, as above set forth in connection with the speed detecting means E.

Assuming now that the car travels fast enough to leave treadle Q_1 before movable contact **58** reaches the first stationary contact in group **59**, which is now connected to the negative terminal of the source of electrical energy (i. e. in the case considered, stationary contact b_2) the above traced energizing circuit for the coil **52** of relay T_1 is broken at contact **50** so that movable contacts **86**, **58'** are stopped. Relay G_1 has not been energized, so that the braking shoe has remained on the track and is engaged by the car, thus braking it through section S_1. The movable contacts **58**, **88'** are restored to their original position as hereinbefore described. Provision is made for preventing a temporary closing of the energizing circuit of relay G_1 while movable contacts **58**, **58'** are being returned to their original position from taking place or for rendering it inoperative with respect to the braking device. In this connection, as shown on Fig. 3, during the return movement of contacts **58**, **58'**, the circuit including the negative terminal of the main source, conductor **61**, conductor **62**, contact **60** of relay R_2, conductor **63**, stationary contact b_2 of group **69**, movable contact **58**, conductor **64**, contact **78** of relay I_1, coil of relay G_1, and the positive terminal of the main source, is broken at contact **78** because relay I_1 is energized, its coil being inserted in the energizing circuit of the coil **52** of relay T_1 when the latter operates to return the movable contacts **58**, **58'** to their original position.

When, due to the action of the speed detecting means E, relay R_1 is substituted for relay R_2 as above described, stationary contact b_1 is connected to the negative terminal of the main source of electrical energy. If, on the contrary relay R_3 is substituted for relay R_2, the stationary contact connected to the negative terminal of the main source is b_3.

The operation of the other braking sections is similar to that of sections S_1 and need not be explained.

In the modification of Fig. 4, wherein the same references are applied to members already shown on Fig. 3, conductor **13** (broken at **180** between Figs. 1 and 3) is connected to the contact **49** of relay R_n, while another conductor **213** connects said contact with the coil **233** of relay T_1, said coil being connected with the positive terminal of the main source of electrical energy. Similarly, conductor **18** (broken at **101** between Figs. 2 and 4) is connected with the positive terminal of the source through the contact **14** of relay R_1, conductor **218** and the coil **231** of relay T_2.

Relay T_1 operates, through its armature **234** attached to a pawl **235**, a ratchet wheel **236** secured to a shaft carrying three movable contacts x, x', x''. Relay T_2 is similarly constructed and is likewise capable of rotating three movable contacts y, y', y''. The movable contacts are adapted to engage stationary contacts which are interconnected in the following manner: stationary contact **1** in the group B_y associated with relay T_2 is connected with stationary contact $1+p$ in the group B_x associated with relay T_1, stationary contact **2** in group B_y with stationary contact $2+p$ in group B_x and, generally speaking, stationary contact n in group B_y with stationary contact $n+f$ in B_x; in the specific example p is equal to **5**. On the contrary, stationary contact n in group B'_x (whatever be the specific value of n) is connected with stationary contacts $n+p$ in group B'_y (p being in this instance equal to **5**) and finally stationary contact n in group B''_x is connected with stationary contact n in group B''_y.

Movable contacts x, x' and x'' are directly connected to the positive terminal of the main source of electrical energy while movable contacts y, y' and y'' are connected to the negative terminal thereof through the coils of relays Z_1, Z_2 and I respectively. The armature **236** of relay Z_1 is adapted to drive a shaft **239** in the direction of arrow F_a, through its pawl lever **237** and a ratchet wheel **238**; similarly, the armature **240** of relay Z_2 is adapted to turn the same in the direction of arrow F_b. Upon shaft **239** is keyed a movable contact **222** analogous to contact **22** shown on Fig. 3 and two positions of which are shown by the drawing one in solid lines and the other in dotted lines. Relays R_1, R_2, R_n are now connected to successive stationary contacts adapted to be operatively engaged by movable contact **222**. When either relay Z_1 or relay Z_2 receives an energizing impulse, movable contact **222** is rotated to engage the next following stationary contact in the direction of arrow F_a or arrow F_b respectively. The operation is as follows:

Assuming that, as explained with reference to Figs. 2 and 3, an electrical impulse is received in the coil **233** of relay T_1 from the speed detecting means E through conductor **18**, the armature **234** is picked up and movable contacts x, x' and x'' are moved in the direction of the arrow a distance equal to the interval between two successive stationary contacts. Should an impulse be received in the coil **231** of relay T_1, then movable contacts y, y' and y'' are moved in the same direction and the same distance.

Assuming now that movable contacts x, x' and x'' have been brought ahead of movable contacts y, y' and y'' a distance corresponding to five successive stationary contacts, for instance if y, y' and y'' are in the positions shown by solid lines while x, x' and x'' are in the positions shown by dotted lines (i. e. if T_1 has received five impulses while T_2 has received none) the coil of relay Z_1 is energized by a circuit including the positive terminal of the main source, movable contact x, conductor **242**, movable contact y, the coil of relay Z_1 and the negative terminal of the main source; thereby relay Z_1 picks up its armatures and, on the other hand, the following stick circuit it closed; positive terminal of the main source, contact **243** of relay I, conductor **244**, contacts **245** and **246** of relay Z_1, the coil of relay Z_1, and the negative terminal of the source. On the other hand, armature **236** is picked up and rotates ratchet wheel **238** one step forward in the direction of arrow F_a and movable contact **222** passes from the position shown in dotted lines to the position shown in solid lines, so as to engage the next stationary contact in group a_1, $a_2 \ldots a_n$. Furthermore, the energizing of relay Z_1 has caused contacts **247**, **249** to be closed. A circuit including the negative terminal of the main source, contacts **247**, **248**, contact **249** of relay T_2 and the positive terminal it then closed, and relay T_2 is energized to cause movable contacts y, y', y'' to advance step by step until contact y'' reach stationary contact 16 in group B''_y connected through conductor 250 with stationary contact 16 in group B''_x, which is now engaged by movable contact x''. At this time, a circuit including the positive terminal of the main source of energy, movable contact x'', conductor 250, movable contact y'', the coil of relay I and the negative terminal is closed; thus relay I is energized and cuts at 243 the stick circuit of relay Z_1; in view of the fact that contact 247, 248 is broken and relay Z_1 is no longer energized, the energizing circuit of relay T_2 is broken.

Similarly, it will be seen that if the movable contacts of relays T_1 and T_2 are in the positions shown in solid lines, and if the coil 231 of relay T_2 receives from the speed detecting means, five successive impulses whereby movable contact y assumes the position shown in dotted lines, relay Z_2 receives an impulse and rotates shaft 239 in the direction of arrow F_b.

The movable contacts x, x', x'' and y, y', y'' are restored to homologous or corresponding positions in the same manner as above described.

As to the remainder of the arrangement it is identical to that described with reference to Figs. 2, 3 and needs not be again explained.

The present application is a continuation of my prior application Ser. No. 131,478, of March 17, 1938.

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