

Jan. 21, 1941.

F. C. PETHICK

2,229,340

CONTROL

Filed Aug. 25, 1938

7 Sheets-Sheet 1

Fig. 1

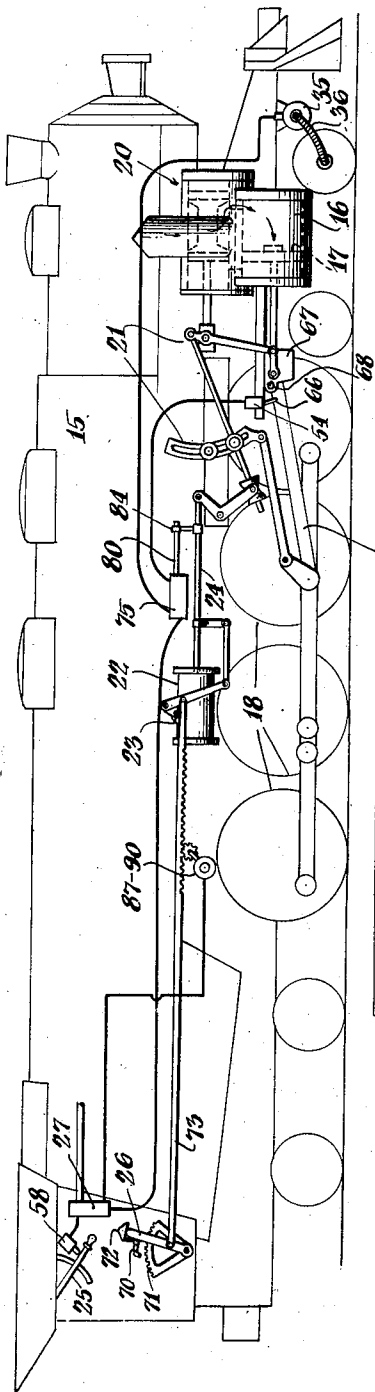
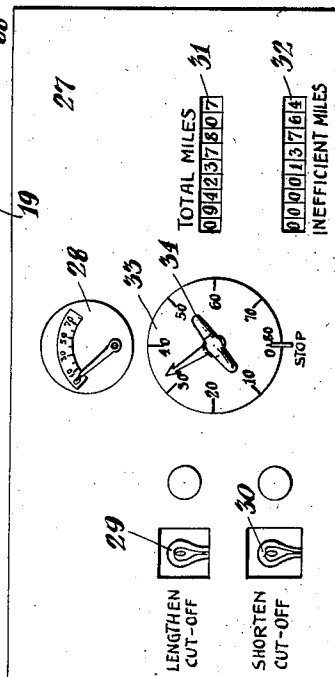


Fig. 1a



INVENTOR
Ford C. Pethick
 BY *Duell, Kane and Smoot*
 ATTORNEYS

Jan. 21, 1941.

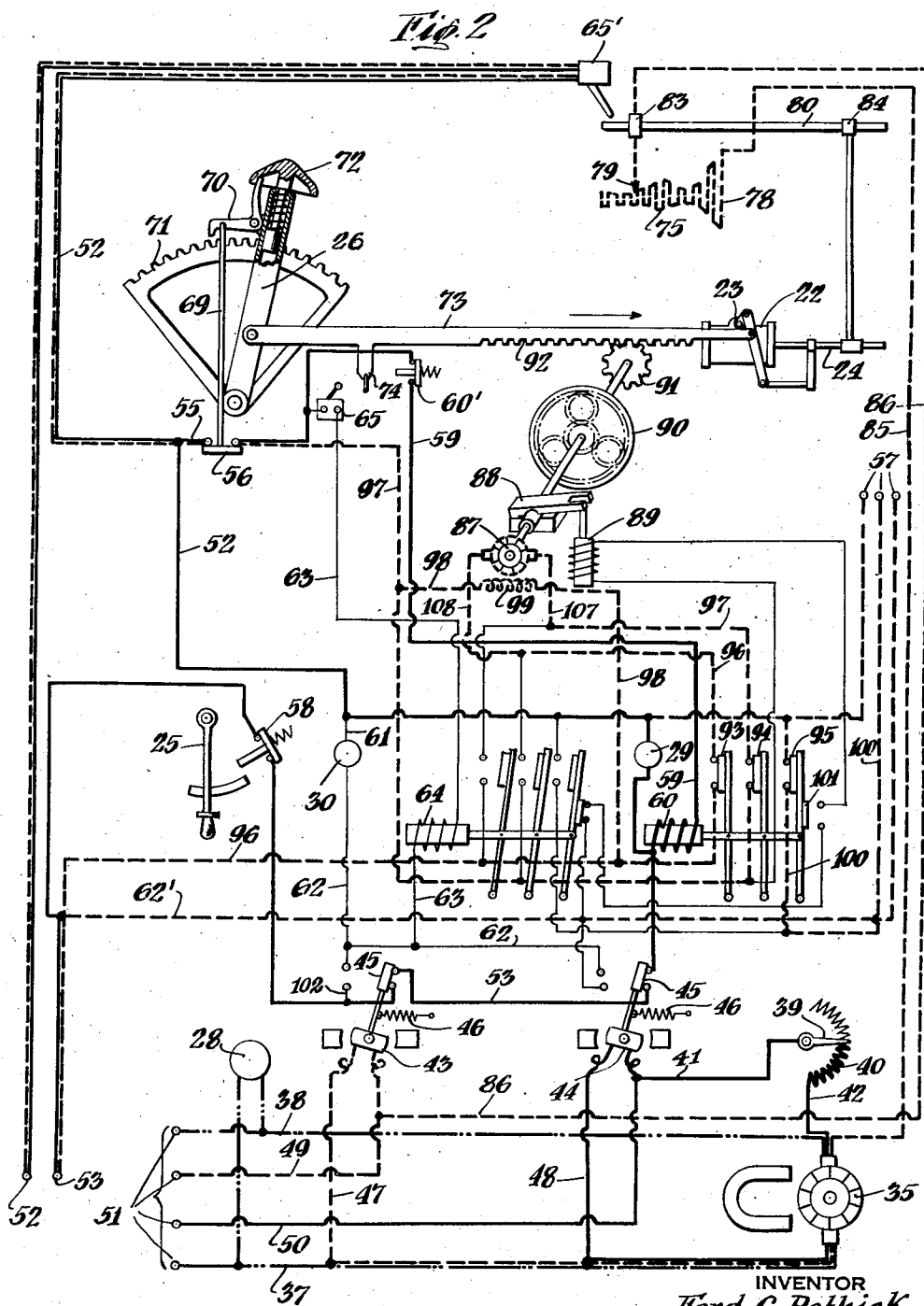
F. C. PETHICK

2,229,340

CONTROL

Filed Aug. 25, 1938

7 Sheets-Sheet 2



INVENTOR
Ford C. Pethick
BY
Duell, Kane and Smoot
ATTORNEYS

Jan. 21, 1941.

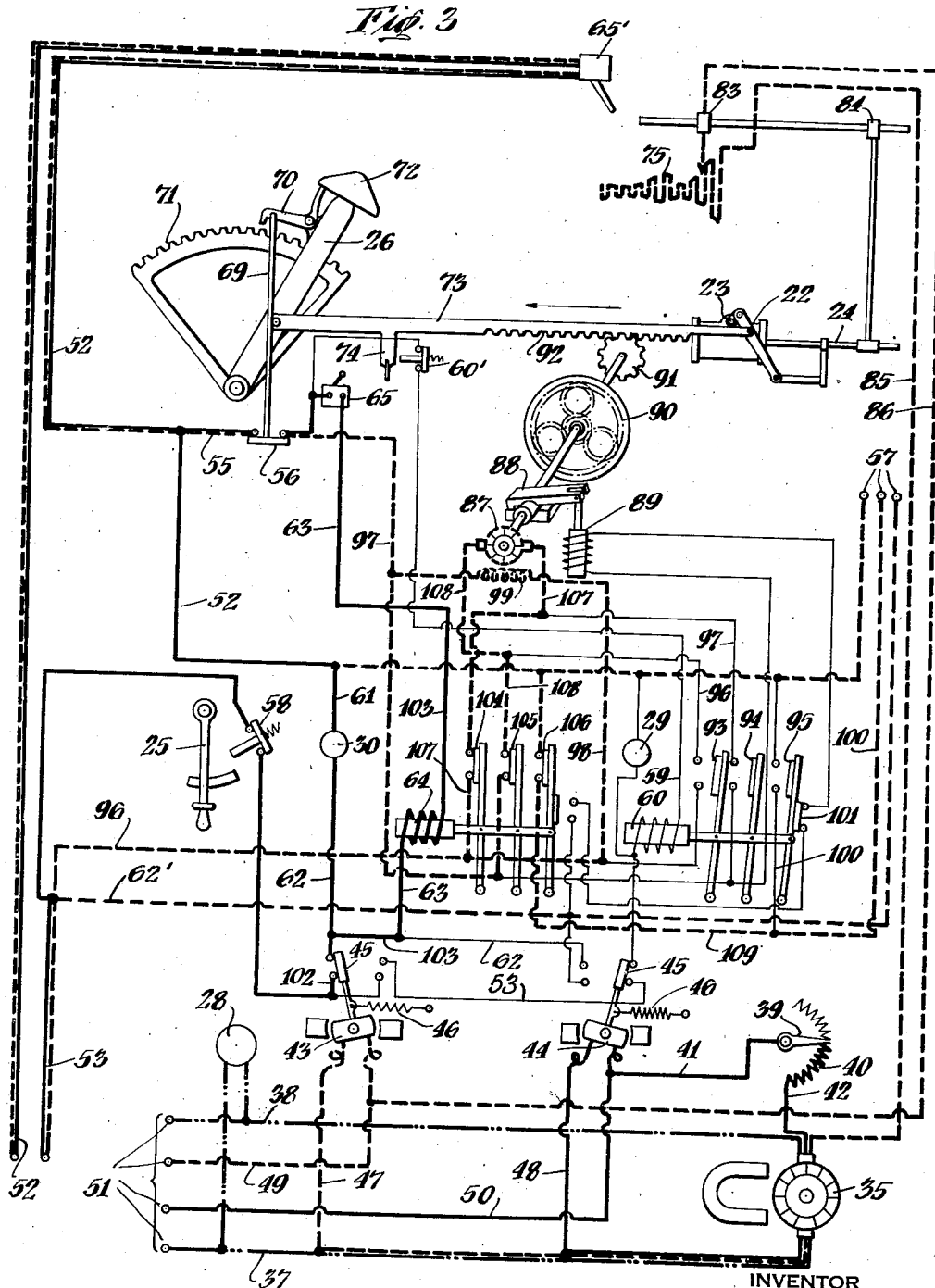
F. C. PETHICK

2,229,340

CONTROL

Filed Aug. 25, 1938

7 Sheets-Sheet 3



INVENTOR
Ford C. Pethick
BY *Suelli, Kane and Smoot*
ATTORNEYS

Jan. 21, 1941.

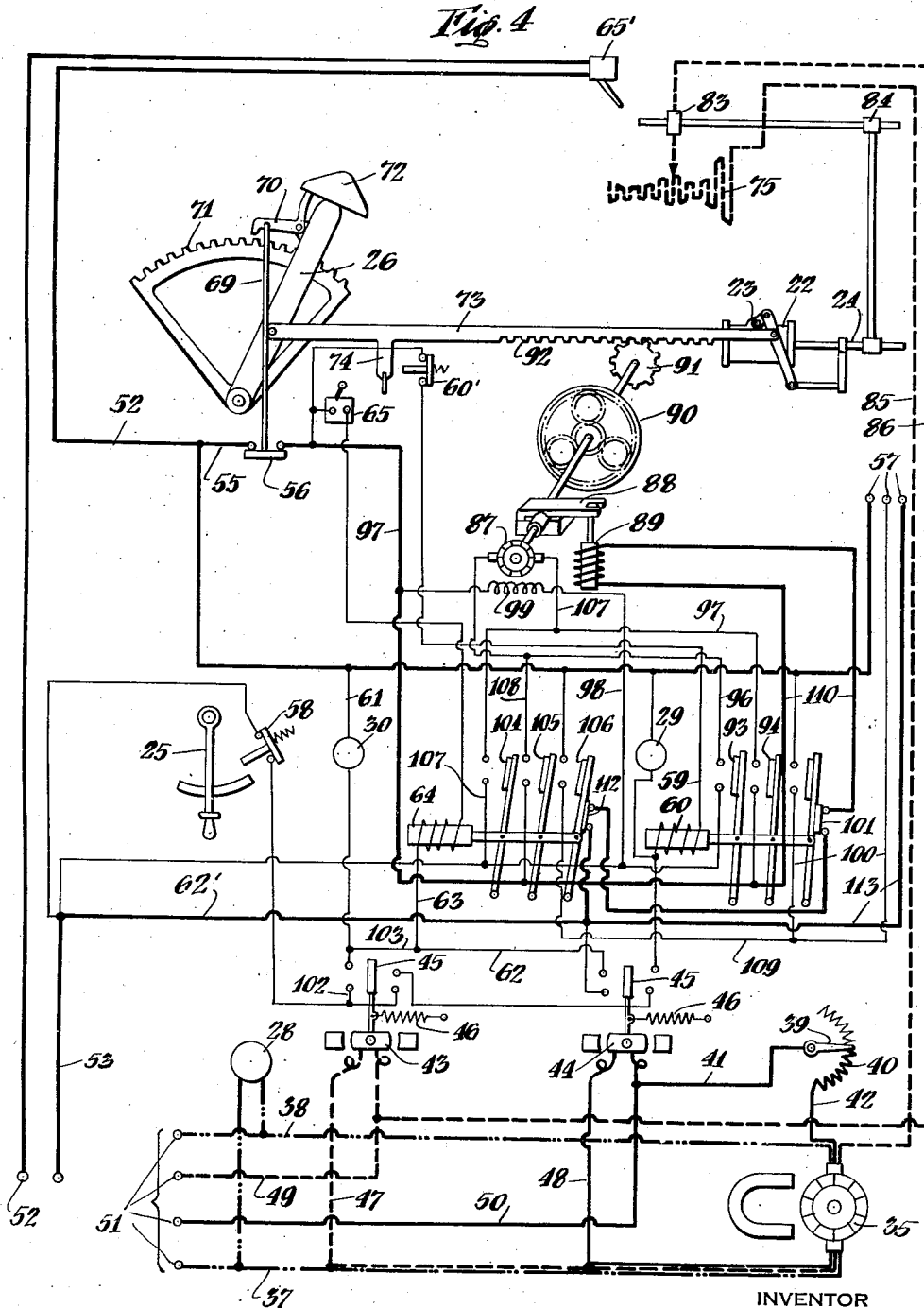
F. C. PETHICK

2,229,340

CONTROL

Filed Aug. 25, 1938

7 Sheets-Sheet 4



INVENTOR

Ford C. Pethick

BY

Suelli, Kane and Smoot

ATTORNEYS

Jan. 21, 1941.

F. C. PETHICK

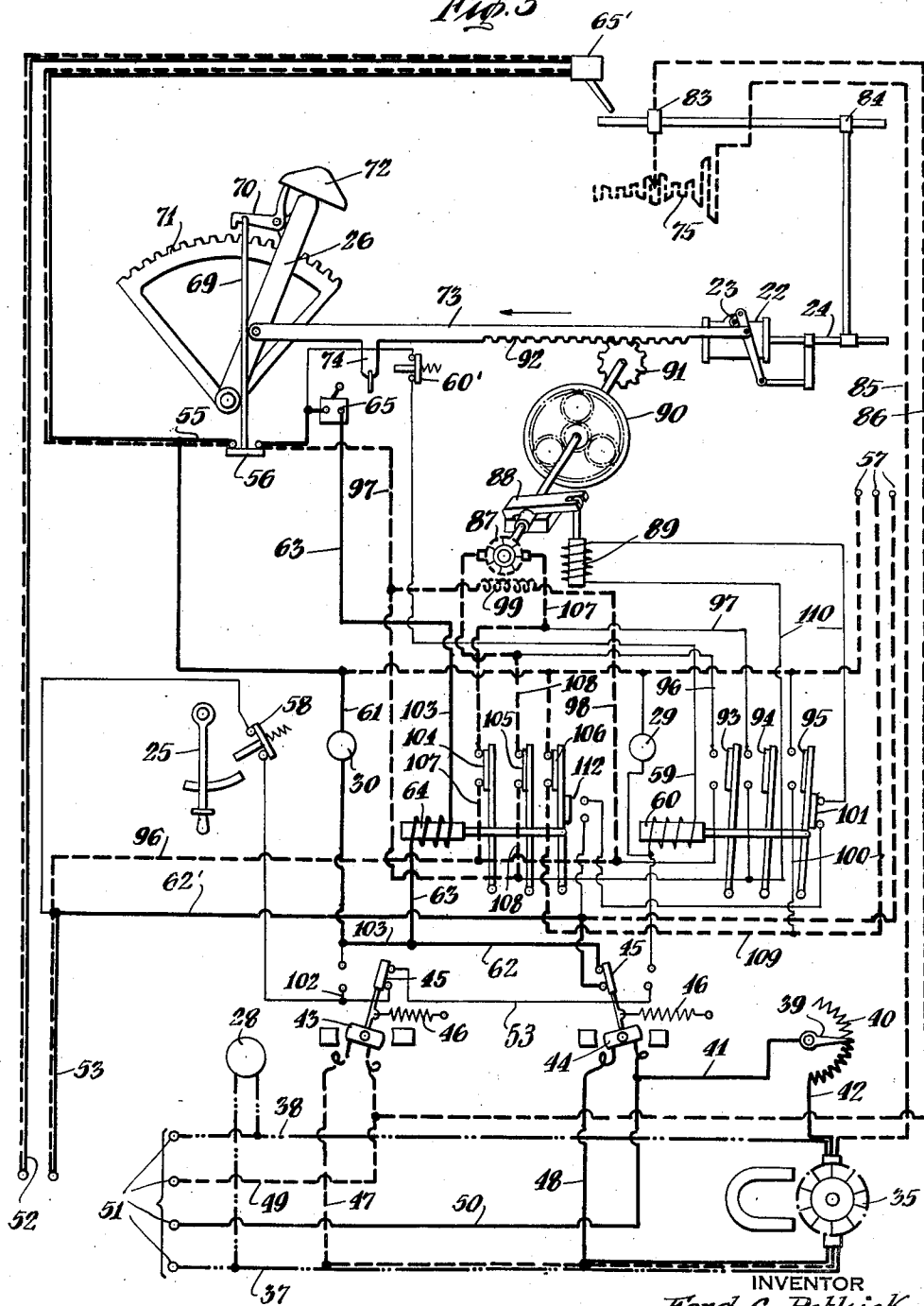
2,229,340

CONTROL

Filed Aug. 25, 1938

7 Sheets-Sheet 5

Fig. 5



INVENTOR

Ford C. Pethick

BY
Swell, Kane and Smoot

ATTORNEYS

Jan. 21, 1941.

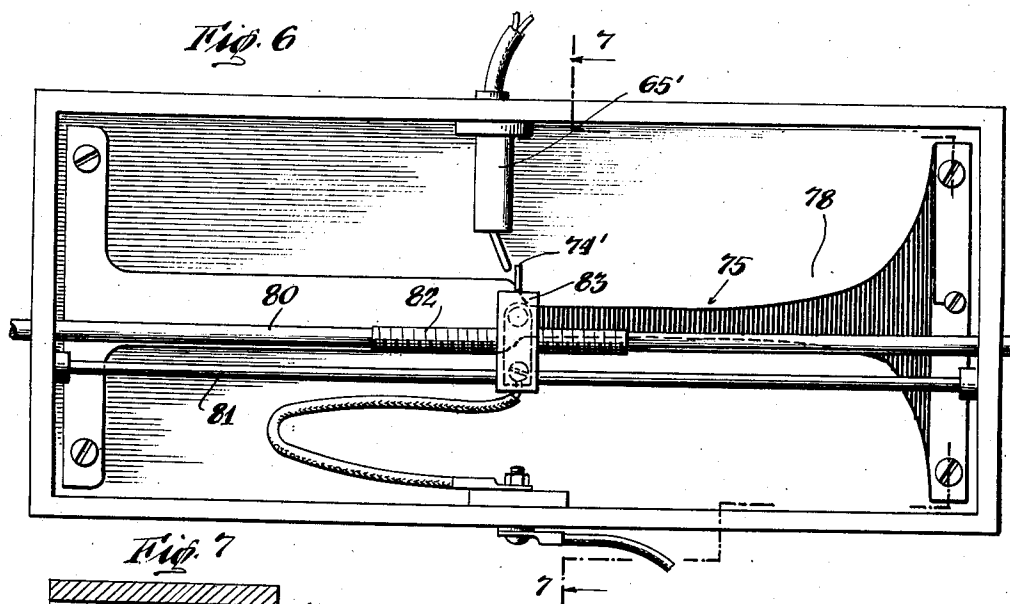
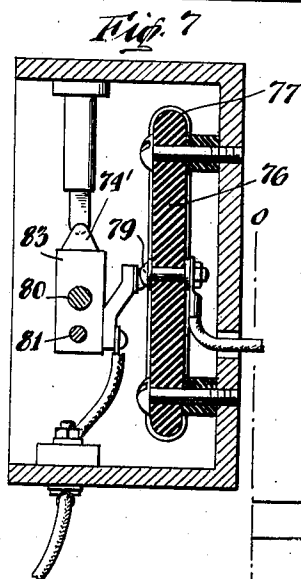
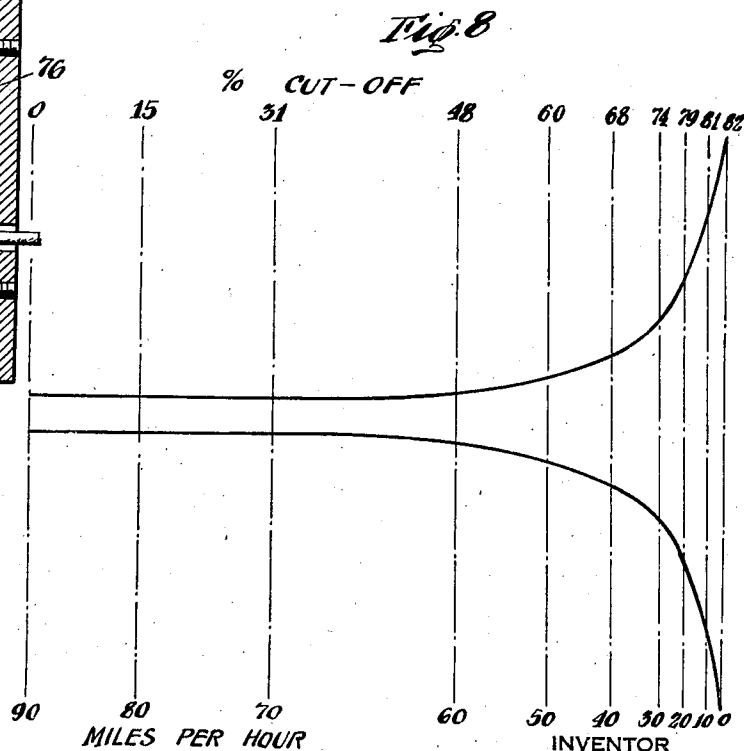
F. C. PETHICK

2,229,340

CONTROL

Filed Aug. 25, 1938

7 Sheets-Sheet 6



INVENTOR
Ford C. Pethick
 BY *Duell, Hane and Smoot*
 ATTORNEYS

Jan. 21, 1941.

F. C. PETHICK

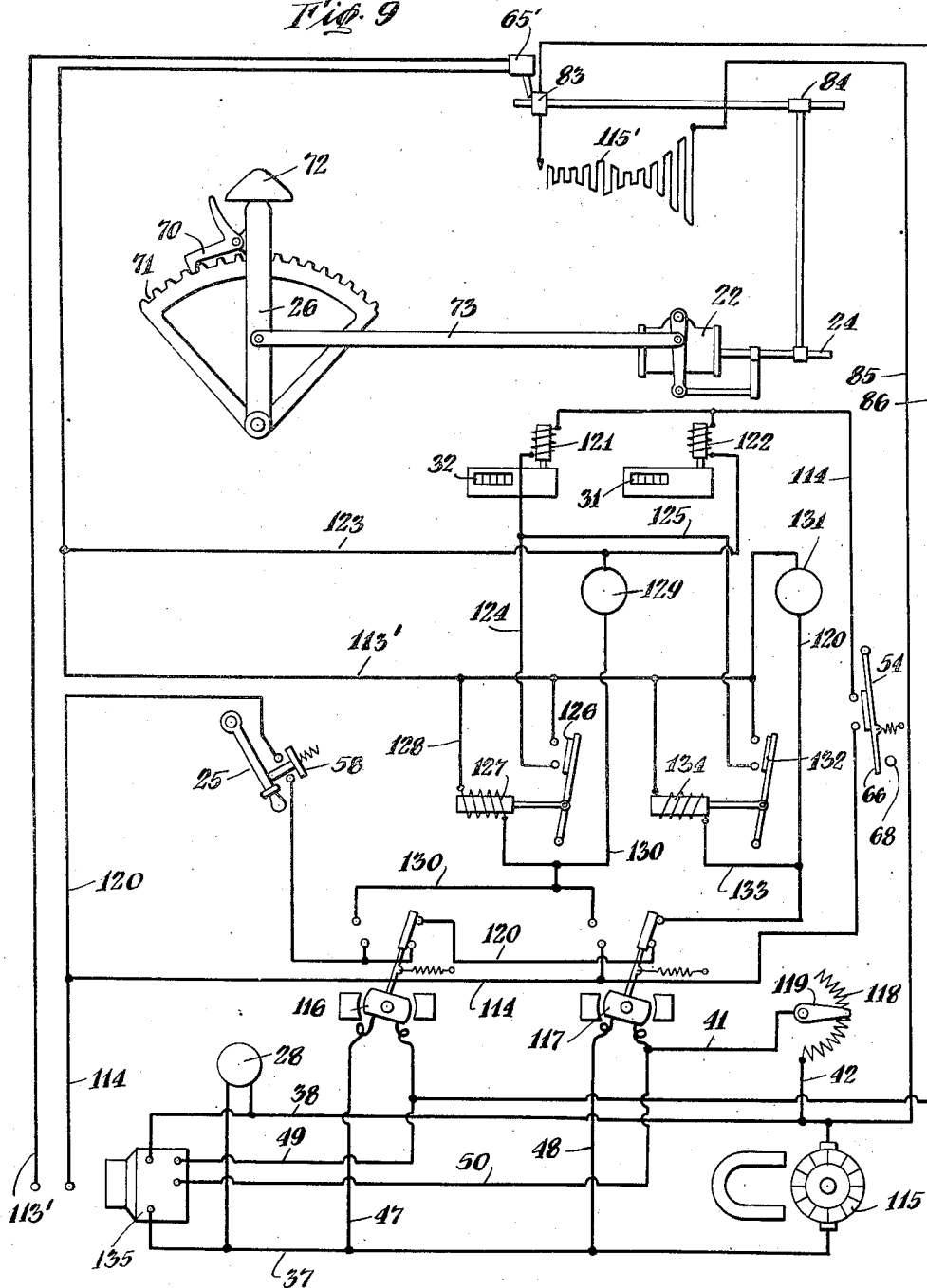
2,229,340

CONTROL

Filed Aug. 25, 1938

7 Sheets-Sheet 7

Fig. 9



INVENTOR
Ford C. Pethick
BY
Duell, Home and Smoot
ATTORNEYS

UNITED STATES PATENT OFFICE

2,229,340

CONTROL

Ford C. Pethick, Scranton, Pa.

Application August 25, 1938, Serial No. 226,765

41 Claims. (Cl. 105—48)

This invention relates to a structurally and functionally improved control, capable of use in various associations but primarily intended for employment in connection with steam locomotives.

It is a well appreciated fact to those skilled in the art that considerable difficulties are experienced in the operation of a locomotive and that one of the main difficulties is that of controlling the steam cut-off. Even conceding that the locomotive is in perfect operating condition and that proper steam pressure is maintained, the operation of such locomotive involves numerous variables. These variables include, for example, the fact that the locomotive will be operated at different sustained speeds and will involve in its operation acceleration and deceleration periods and in traversing a right-of-way will encounter inclines, curves, declines, and other factors which will correspondingly vary the tractive load. As further qualifying the operation of the locomotive, one must consider the conditions involved in a train of maximum length, as against a train of minimum length.

Practically everyone is, of course, conversant with the fact that a locomotive is provided with a control commonly known as "the throttle," by means of which the engineer governs the flow of steam from the boiler to the steam engine portion of the locomotive. However, to properly govern the operations of the locomotive and in a manner such that its efforts will be consistent with the variable conditions encountered, it is customary to provide a secondary control to adjust what is commonly known as the "cut-off." This control governs the operation, or timing, of the valve mechanism by means of which steam is admitted to the locomotive cylinders. By adjusting this mechanism to, for example, one extreme, steam may be admitted during only ten per cent of the working stroke of the piston while in the opposite extreme steam may be admitted to the cylinder during more than eighty per cent of the piston stroke. The former condition, known as "short cut-off," would govern, for example, where the locomotive might be traveling at around its maximum speed, while the latter condition, known as "long cut-off," would come into being under starting conditions, and might continue for a relatively protracted period, especially if a heavy load were involved.

The locomotive is, of course, capable of traveling both forwardly and rearwardly and to this end a "reverse gear" is provided. This gear governs the position of the valve mechanism which

admits steam to the pistons and in the interest of simplicity and economy it has been customary to control the position of the valve cut-off by the same mechanism which controls the reverse gear it being emphasized that in both problems there is involved the question of timing steam admission to the cylinders, as controlled by the valves.

In further considering the invention, the question of reverse operation of the locomotive will be generally ignored. With this thought in mind and returning to a consideration of the adjustment of the valve mechanism or so-called "cut-off," it will be appreciated that the engineer receiving orders to proceed to a given destination under a definite schedule, primarily ascertains the speed at which the locomotive must be operated in order to maintain the desired schedule. In making this calculation he will, of course, visualize the different conditions of trackage which will be encountered, the weight of the train, etc. In acting upon these calculations he will, on starting the train, adjust the valve mechanism so that maximum draw-bar pull results, this being achieved by permitting an admission of steam to the cylinders throughout a prolonged portion of the piston travel, i. e., providing for "long cut-off." Thereupon the throttle is opened and the train will begin to move. Now, as the train picks up speed the cut-off should be shortened. In other words, the valve mechanism should be adjusted so that steam is admitted to the cylinders through only a lesser portion of the piston strokes. This adjustment will be continued as the train accelerates and thus maximum draw-bar pull, consistent with utmost efficiency, will be maintained until the train reaches a speed which the engineer has calculated to be its proper maximum speed. When the locomotive has reached the proper speed the cut-off should be further shortened to keep the locomotive from accelerating beyond the desired speed. This shortening of the cut-off will decrease the power developed by the locomotive and will at the same time reduce the amount of steam consumed by the cylinders and thus conserve fuel and water. Obviously, if an upgrade is encountered or if in any other fashion the load increases—the valve mechanism will have to again be adjusted so as to maintain the desired speed. Conversely, upon a straight portion of track being encountered, care must be taken to be sure that the locomotive does not reach an excessive speed. A condition such as this will of course, be aggravated should the train encounter a down

grade. In either event the cut-off should be further shortened, or in fact the valve mechanism may be rendered inoperative insofar as admission of steam to the cylinders is concerned. If this operation does not sufficiently retard the locomotive, the engineer should close the throttle and if necessary apply the brakes. Various other operating conditions will, of course, be encountered, but it is believed that the foregoing adequately exemplifies the general theory of operation of the valve mechanism.

To the uninitiated the problem presented might appear simple of solution, but when it is realized that the engineer must observe the right-of-way and signals as well as a multitude of gauges, indicating devices, etc., it will be understood that he will frequently neglect to adjust the valve mechanism so that the locomotive will be operating with maximum efficiency. Quite aside from the fact that such failure to adjust is liable to result in loss of power and inability to maintain schedule, a considerable wastage of steam and fuel results, which, multiplied by the number of trains in operation, reaches an appreciable figure.

While various forms of apparatus have been developed in order to assist in a proper operation of the valve mechanism with particular reference to the cut-off, these developments have, in their operation, left much to be desired aside from the fact that they have been very expensive. For this reason it has been usual for an engineer to depend upon his mental impressions to determine whether or not the valve mechanism has been properly adjusted. Having in mind the fallibility of the mind, it may therefore be well appreciated how frequently the cut-off is improperly adjusted with consequent wastage.

Thus, it is an object of the invention to provide a structurally and functionally improved control such, that if the cut-off is not properly adjusted an engineer is immediately made aware of the fact.

A further object of the invention is that of providing a mechanism of this character in which, if desired, no indication need necessarily be given to the engineer, but in which, by automatic mechanism, the cut-off will be regulated and maintained in an adjusted condition compatible with the conditions under which the locomotive is currently operating, so that maximum efficiency results.

A still further object is that of furnishing a control or indicating device in accordance with either of the preceding objects and which may readily and economically be applied to locomotives as heretofore manufactured or as currently produced, such device embodying relatively few parts, each individually simple and rugged in construction and operating over long periods of time with freedom from all difficulties and to achieve the results afore referred to.

Another object is that of providing a mechanism of this type with which there may be associated a recording unit so that the conditions of operation over a given run or period may be accurately checked.

With these and other objects in mind reference is had to the attached sheets of drawings illustrating certain embodiments of the invention and in which:

Fig. 1 is a side elevation of a locomotive, showing the control mechanism applied thereto;

Fig. 1a is a view diagrammatically illustrating a control panel which may be disposed in the engineer's cab;

Fig. 2 illustrates diagrammatically the wiring circuit which may be involved; one condition of operation being embraced in this circuit;

Fig. 3 is a view similar to Fig. 2, but showing a different condition than that exemplified in the preceding figure;

Figs. 4 and 5 illustrate still further conditions which are encountered under locomotive operation;

Fig. 6 is a front elevation of the rheostat which may form a part of the circuits shown in the preceding views;

Fig. 7 is a sectional view taken along the lines 7-7 and in the direction of the arrows of Fig. 6;

Fig. 8 is a graph showing generally the ideal conditions of cut-off which prevail at given speeds in one type of locomotive, and

Fig. 9 shows a wiring diagram of an installation which will serve merely to warn the engineer as to correct or incorrect adjustment of the valve mechanism, but which will not in itself embody mechanism automatically compensating for the latter conditions.

Referring primarily to Fig. 1, the numeral 15 indicates a locomotive of any desired type and provided with cylinders 16 within which pistons 17 travel to operate driver wheels 18 through the medium of a connecting rod 19. Admission of steam into the cylinders is controlled by a valve assembly 20, the operation of which is governed by mechanism generally indicated at 21 and which is controlled by a power reverse gear.

This gear, in accordance with conventional practice, may include a cylinder 22 connected to air or other suitable fluid under pressure through a valve 23, the latter usually serving to permit of the exhausting of air to either side of the piston (not shown) within the cylinder 22 which causes the reach rod 24 to be shifted to correspondingly adjust the gear 21. In one extreme position which the piston within cylinder 22 may assume, the valve gear is adjusted so that the locomotive will drive in a forward direction with full steam cut-off while in the opposite extreme position the locomotive will operate in a similar manner but in a reverse direction, it being, of course, assumed in both that steam will be admitted to the cylinders.

Admission of steam to valve 20 is governed by the throttle control 25 and the position of the valve 23 which controls the admission of fluid into cylinder 22 is governed by the reverse lever 26. It is, of course, to be understood that usually equidistant between the two extreme positions of the latter as before referred to, the valve gear will be in what is generally known as "mid-gear" and with substantially or actually a zero cut-off. In other words, regardless of how far open the throttle control 25 may be, no steam will be admitted to the cylinders. Between this mid-gear position and the two extreme positions afore mentioned, the locomotive operates with greatest efficiency under normal conditions.

In Fig. 1a there is indicated a control board or panel 27 which may conveniently be situated within the cab of the locomotive and this panel may mount a speedometer 28 which will indicate the speed at which the locomotive is moving. The board may also mount signals such, for example, as lamps 29 and 30, which will respectively indicate that conditions of operation are improper and so, that control 26 should be adjusted to lengthen or shorten the cut-off. Additionally the panel may provide a register 31 which will indicate the total distance traveled by the ve-

hicle and a register 32 which will indicate the aggregate number of miles during which the engine has operated below efficiency. Finally, the panel may mount a control 33 provided with a handle 34, or any other suitable structure, so that it may be adjusted to indicate the speed at which the locomotive is scheduled to proceed.

According to the present invention, a speed responsive element is coupled with the locomotive.

While this element may take numerous different forms, it is preferred in the interest of simplicity that it be in the nature of an electrical generator 35 which is driven by a torque cable 36, or otherwise, by one of the wheels or axles of the locomotive, this generator being of course preferably mounted against shocks and jars and being protected against the entrance of foreign matter, moisture, etc.

The speedometer 28 is connected, as shown in Figures 1 to 5, through leads 37 and 38 with the terminals of generator 35. The latter is preferably of the D. C. magneto type, and it will, of course, be understood that the voltage generated varies as the locomotive speed varies. The speedometer may, if desired, be in the nature of a volt meter with its face calibrated to provide a reading of miles per hour. The control 33—34, as shown in Fig. 1, is coupled to the movable arm 39 of a rheostat 40, the effective resistance per unit length of which is a constant, it being noted that the resistance body 40 is connected through a lead 42 to a brush or power terminal of the generator 35. Before departing from a consideration of this particular structure, it will be observed, in Fig. 1a, that the control 33 embraces a dial provided with graduations indicating various speeds and that according to the position of the pointer which traverses this dial, arm 39 is adjusted with respect to the resistance body 40. As afore brought out, visual signalling means may be provided by the lamps 29 and 30. The first of these, when energized, is intended to indicate that the cut-off should be lengthened, while the second indicates that the cut-off should be shortened. In certain respects it is preferred to employ signalling means of this type. However, it will be apparent that audible signalling means might be employed in lieu of the lamps, or supplementary thereto. In the former event the desired results are achieved by simply substituting for the lamps any desired types of buzzers or their functional equivalents, while if the latter condition is desired, such audible signalling means might be provided in shunt with the lamps or other indicating means. These precise alternative structures have not been illustrated in detail in the drawings for the reason that they are well known to even unskilled persons and to include such devices in the illustration would merely serve to confuse the latter.

In any event, to control the functioning of these signalling media, various types of units may be employed. It is preferred, however, as illustrated, to utilize more or less standard contact-making volt meters such as have been indicated at 43 and 44 respectively. Both of these may conveniently include movable contact bridging arms 45 which are normally biased to bridge gaps in a circuit by means, for example, of springs 46. When energized to a certain extent, the arms 45 move out of electrical engagement with the contacts which they normally engage and when energized to a further extent these arms move to bridge the gaps between further contacts. The construction of units of this type is well known and for this

reason is believed to need no further description. In the following claims and with reference to this structure as well as the structure hereinafter described and as illustrated in Figure 9, these units will be referred to as "circuit makers and breakers" and "relaying means." As will be apparent this is the primary function of these units. A lead 47 extends from lead 37 and has interposed within it unit 43, while a lead 48 has interposed within it the unit 44 and has one of its ends connected to lead 37 while its opposite end is coupled by way of lead 41 to arm 39 of the variable rheostat. At this time it will be observed that leads 47 and 48 may have branches 49 and 50 respectively coupled to them at points beyond units 43 and 44, these branch leads, together with leads 37 and 38, being conveniently provided with terminals 51 to which a recording unit (not shown) may be connected for a purpose hereinafter brought out.

Leads 52 and 53 are coupled to a source of electrical current supply such, for example as the wiring extending from the electrical system or generator which is conventionally associated with a locomotive and which is ordinarily driven by a turbine. Lead 52 has interposed within it a switch 55' and is provided with a branch 55 within which a switch 56 is interposed. Lead 52 extends in advance of this branch 55 and is coupled to one of a group of terminals 57, the purpose of which will be hereinafter brought out. Lead 53 has interposed within it a switch 58 and is provided with gaps which are bridged when the contact-making portions or arms 45 of the volt meters are in their normal biased positions. At points beyond such gaps, lead 53 as arranged in series with it the signalling unit or lamp 29 and extends thence to a point at which it is coupled to lead 52 in advance of branch 55. Branch 55 beyond the switch 56 is provided with a branch 59 within which exists a gap normally bridged by a switch 60' and beyond which the branch is connected to the operating coil 60 of a relay. The other side of coil 60 is connected to lead 53 after it has passed through the gaps normally bridged by arms 45.

By a branch 61 lead 52 is also coupled to the signalling device 30 and the other side of the latter is coupled to lead 62. Lead 62' which branches off of lead 53 before the same passes through switch 58, is coupled to lead 62 through a gap capable of being bridged by the contact bridging arm 45 of the volt meter 44 when the latter is fully energized. Also that portion of lead 53 which extends immediately beyond switch 58 is coupled to lead 62 through a contact bridging portion 45 of the volt meter 43, when the latter is fully energized. This is referred to as branch 102. It will additionally be observed that a branch 63 may be coupled to leads 62 and have interposed in it the coil 64 of a further relay, this lead extending to a toggle switch 65, in turn coupled to branch 55 beyond switch 56.

Now returning to a consideration of Fig. 1, as well as Fig. 2, it is to be observed that a switch 54 is mounted adjacent the cross-head 67 of the locomotive, and is provided with an operating arm 66 which conveniently extends adjacent such cross-head so that it may be engaged by a pin 68 each time the head 67 reciprocates. Also, switch 56 is conveniently associated with the reverse gear lever 26 and any suitable form of construction may be employed to assure of a closing switch 56 when the lever is potentialized for automatic rather than manual operation.

One convenient form of structure may include an operating rod 69 attached to the switch and having its outer end coupled to a manually releasable pawl or latch 70 which is engageable with the quadrant 71. A spring retracted cap 72 may be associated with the lever and be engageable with the hand engaging portion of the latch so as to be capable of retaining the latter in inoperative position. In such position it is apparent that the switch 56 is closed although it will be likewise apparent that by simply releasing the latch the switch will remain in open position. The reverse gear lever 26 is coupled to the valve 23 by a link or rod 73 and as shown in Fig. 2 an actuating arm 74 may depend from this arm so that when the lever 26 is in one of its extreme positions, switch 60' will be opened while if the lever is moved past a mid-gear position, the arm 74 will engage the arm of toggle switch 65 to actuate the latter. Thereupon, this switch will remain in open condition until the reverse lever is again shifted to a point along the right hand side of quadrant 71, as viewed in Fig. 2. At that time the actuating portion or arm 74 will again engage the operating part of toggle switch 65 to close the latter.

Before further considering the structure which is involved, it is to be understood that the present illustrations have been restored to in order to exemplify one practical embodiment of the invention. In such embodiment the reverse lever has been shown as occupying a customary position and moving in the usually accepted manner. In other words, this lever when shifted forwardly to an extreme position, causes the valve controlling mechanism to be shifted to a position at which the valve is maintained in open position for a maximum period of time throughout each stroke of the piston 17. When shifted to a position equidistant from the ends of quadrant 71, the parts are controlled so that the valve mechanism is in effect inoperative. In other words, no steam is admitted to the cylinders. When shifted to the left portion of the quadrant, the valve mechanism is governed to cause the admission of steam so that the locomotive will be driven in a reverse direction and with increasing length of the valve opening period, the further the lever is moved to the left. In order to avoid undue illustration, the present control has not been shown as operative with the locomotive driving in a reverse direction. This is for the reason that ordinarily a locomotive is operated in such a direction throughout only short periods of time and therefore the application of the control need not ordinarily be carried over to govern during such a driving. However, it will be obvious to those skilled in the art that in the first instance the control might be adapted without difficulty to locomotives which do not involve the precise operation of the reverse gear lever which, has herein been assumed, and also that by mere duplication or otherwise the control might be applied to reverse as well as forward driving of the locomotive.

Additionally, it is to be understood that in Fig. 1 the parts have been illustrated in a condition such that it is to be assumed the locomotive is standing still with the throttle closed and the reverse lever set for forward operation of the locomotive, while in Fig. 2 the parts have been shown in a position which they would assume if the locomotive were moving forwardly and below a speed which the engineer had calculated

as being desirable for the run. Additionally the parts in this figure illustrate a condition where the cut-off of the valve is too short to develop maximum draw-bar pull and the automatic mechanism (to be hereinafter described) which seeks to correct this condition is operating to lengthen the cut-off. Also, in this view the inactive portions of the circuit have been shown in light lines while the initially active portions of the circuit have been shown in heavy lines, it being noted that what might be termed the secondary acting portions of the circuit have been indicated in dash lines. This same method of illustration has been followed in succeeding views and in these, together with Fig. 2, those portions of the circuit which are constantly energized have been shown in dot-and-dash lines, dash-and-dash lines, or solid lines as the case may be.

Now, with continuing reference to Figs. 1 and 2, as well as Figs. 6 and 7, it will be observed that a variable rheostat generally indicated at 75 may conveniently be mounted by the locomotive at a point adjacent the valve gear and preferably in proximity to the reach rod 24. This rheostat may include a suitable di-electric body 76, the edges of which are rounded as at 77 and the body being wrapped with or encircled by a coil of resistance wire 78. A contact 79 traverses the resistance 78 and is shifted longitudinally of body 76 by being mounted upon rods 80 and 81. Conveniently, the rod 80 may be screw threaded as at 82 to engage with corresponding threads formed in the bore of block 83 which mounts the arm carrying contact 79. Rod 81 merely has sliding contact with a second bore formed through block 83, this rod serving to stabilize the block and contact as they move transversely of the convolutions of the resistance. Rod 80 may be adjustably coupled as at 84 to the reach rod 24 and it will be understood that by rotating rod 80 with reference to block 83 the latter may be adjusted to a proper position with reference to the range through which the valve mechanism is operating.

Having in mind that in the embodiment illustrated the control has not been shown as operative during reverse movements of the locomotive, the resistance 78 is shown as terminating at a point midway of the extremes of travel of block 83 and as the latter moves in response to movements of the reach rod 24. There has been diagrammatically shown at 74' an actuating arm or finger similar to the actuating portion 74 shown in Fig. 2. Also, there has been indicated at 65' a toggle switch similar to switch 65 heretofore described. This structure may be used in addition to the actuating portion 74 and toggle switch 65, or in certain instances it may be substituted for the latter structure—the purpose of this apparent duplication being hereinafter brought out. As is obvious, switch 65 being interposed in leads 55-63, it follows that when gear lever 26 is moved to the left beyond zero cut-off position this switch will be opened, thus opening the lead to coil 64. Also during a return movement of the reverse gear lever, switch 56 will be closed, thus closing the lead to coil 64. Likewise, switch 65' will be engaged by arm 74' when the reverse gear lever is moved to a substantially neutral position and when moved beyond such position the switch will be actuated to open the circuit through lead 52, thus disconnecting lead 52 from the external power source. A movement of block 83 in response to an adjust-

ment of lever 26 to a forward drive will, of course, result in the switch again being closed.

Referring to Fig. 8, it will be observed that there has been diagrammatically shown an ideal condition of cut-off as governing the operation of one type of locomotive and in which, for example, when the locomotive is operating under perfect conditions, the cut-off governs the valve mechanism so that steam is admitted during 82% to 81% of piston travel, while the locomotive reaches a speed of from zero to ten miles per hour. As further indicated, the percentage of cut-off should, for example, be decreased as shown to approximately 70% when this particular type of locomotive reaches a speed of around 35 miles per hour, substantially 61% at around 46 miles an hour, 48% at 60 miles an hour, 31% at 70 miles an hour, and so towards zero cut-off position as 90 miles an hour (the maximum theoretical speed of the locomotive) is approached. The characteristics of the percentage of cut-off as afore reviewed and in relation to the speed of forward motion of the locomotive are followed in connection with the resistance values embodied in the windings 78 and thus by moving a contact over these windings and passing a current through the elements the registered value of the resultant current will be harmonized with the percentage of cut-off most desirable to the given speed of a particular type of locomotive.

Specifically at this point it should be observed that Fig. 8 is a graphical representation of the physical shape or contour of the resistor element 78 for use with the particular type of locomotive under consideration. For example, if resistance wire be wound on a body 76 of a definite thickness and having a face shaped as shown by the curves of Fig. 8, and if the locomotive to which this control has been applied is travelling at say 20 miles per hour, then in order for rheostat 78 to insert sufficient resistance in series with relay 43 to reduce the voltage generated by 35 (at 20 miles per hour) to an amount just enough to balance relay 43 in its center position, (as shown in Fig. 4) then contact 79 would have to be moved to a point on resistor 78 corresponding to the vertical line marked 79 (cut-off)—20 (miles per hour). Thus, a portion of rheostat is inserted between the full cut-off end of the rheostat and the position of contact 79 in the circuit. This indicates that the valve 20 of the locomotive is set to cause the locomotive to develop maximum draw-bar pull at the given speed of 20 miles per hour. This will be further discussed at a later point.

Now, to connect the parts so that the desired harmonious relationship will be established, it is to be observed that a lead 85 extends from one of the terminals of generator 35 and is coupled to the outermost convolution of resistance 78, and a lead 86 extends from the contact making volt meter 43 to contact 79. It has heretofore been noted that suitable provision for initial adjustment of contact 79 with reference to the rheostat is made at the time of the application of the control apparatus to the locomotive, such adjustment being conveniently achieved by shifting rod 80 with respect to block 83 and also by means of the coupling 84, adjusting the rod with reference to the reach rod 24. Of course, any desired type of variable resistance 75 may be substituted for the one heretofore described and if this resistance involves a wire, the latter may be suitably anchored against displacement. However, it will be noted that the contact 79 will

occupy a position with reference to the resistance corresponding to the ideal percentage of cut-off which should prevail at a given speed, to develop maximum draw-bar pull. This occurs due to the fact that a shifting of rod 73 results in a shifting of reach rod 24 to adjust the valve mechanism so that a given percentage of cut-off will be established. Actuating rod 30 being rigidly coupled or otherwise suitably connected to reach rod 24, it follows that the contact must assume the desired position with reference to the resistance.

In order to furnish a mechanism which will automatically correct the percentage of cut-off in proportion to the speed of the locomotive, I may employ a direct current shunt wound motor which has been indicated at 87 and the shaft of which is provided with a brake 88 actuated by an electromagnet 89; the brake being applied when electromagnet 89 is energized. This motor may function through a straight line helical planetary type gear reduction unit 90 to drive a gear 91, the teeth of which mesh with the teeth of a rack portion 92 forming a part of rod 73. It should be noted that the planetary type gear reduction unit is reversible. That is, if the rod 73 is manually shifted by means of reverse lever 26, then the gear unit 90 will turn the armature of motor 87, which will rotate freely and thus cause no undue resistance to the manual operation of lever 26. The electro-magnets 60 and 64 of the two relays afore referred to, control what, in effect, is a reverse switch, supplying motor 87 and also control the electromagnet 89 in addition to performing other functions hereinafter brought out. Suffice it to say, with particular reference to Fig. 2, that contact bridging members 93, 94 and 95 are controlled by the electromagnet 60. This magnet is energized by current flowing through leads 53 and 59, and accordingly the circuits with which elements 93, 94 and 95 are associated are closed. A branch 96 extends from lead 53, in advance of switch 58 and has a gap which is bridged by contact member 93, this branch extending through to one pole of the motor 87. A branch 97 extends from, for example, switch 56 and has a sub-branch 98 within which the shunt winding 99 of motor 87 is interposed. This branch 98 is connected to lead or branch 96. Lead 97 extends beyond branch 98 and has its gap bridged by contact member 94 and is connected to the second pole of motor 87 by branch 107. Finally, it will be noted that lead 52 is provided with a branch 100 having a gap which is bridged by contact portion 95, this branch extending in common with lead 52 to one of the terminal members 57. It is also to be noted that lead 62' extends to one of the terminal members 57.

Thus referring to Fig. 1a, one is to assume that the engineer has, for example, set the control handle 34 for a speed which he has decided upon as being proper and has thereupon opened the throttle to permit switch 58 to close and the locomotive is now moving forward, but below a speed at which the pointer associated with control 33—34 has been set and which is evidenced by the position of contact arm 39 with reference to resistance 40. The position of the reverse lever 26 in Figs. 1 and 2 substantially corresponds. Having reference to the conditions traversed in Fig. 8, it is apparent that the position of this lever does not provide for a sufficiently long cut-off, to develop maximum draw-bar pull for the condition of locomotive operation which is desired in

order to accelerate the locomotive to the desired speed as quickly as possible.

Accordingly, contact-making volt meters 43 and 44 remain biased by their springs 46. The position of each relay indicates respectively that the locomotive cut-off is too short to cause the locomotive to develop maximum draw-bar pull and that the speed of the locomotive is less than desired. Thus, as illustrated, current flows from lead 53 through switch 58 to energize coil 60 and thence through lead 59, switch 60' and so through lead 55 to lead 52. The signalling unit 29 being interposed within branch 53 it follows that it will be energized to indicate to the engineer that the cut-off must be lengthened. Of course, with an automatic compensation or correction for such a condition—such as is provided by the motor 87—it is not necessary that such a signal be given. However, it is ordinarily preferred to furnish the engineer with indication of a condition which requires correction so that if, due to conditions which may not be anticipated, the apparatus does not automatically adjust for that condition, he may be aware that a failure has occurred. Quite aside from whether or not signalling provision is resorted to, it will be observed, that the energization of coil 60 causes current to be supplied through leads 96 and 97 to the terminals of the motor 87; field coil 99 already being energized through lead 98, to drive the same in a clockwise direction. This will result in a shifting of rod 73 in the direction indicated by the arrow in Fig. 2 to cause a lengthening of the valve cut-off. Such lengthening—as afore brought out—occurs incident to shifting of the reach rod 24 and a corresponding movement of rod 80 will follow to adjust contact 79 over the resistance and the flow of current through leads 85 and 86 will accordingly be controlled to in turn control the operation of contact making volt meter 43. It is obvious, remembering that generator 35 is generating voltage, this control will result in a sufficient flow of current through the same to cause the contact bridging portion 45 thereof to interrupt the circuit through lead 53 when the cut-off has been adjusted to a position such that maximum draw-bar pull compatible with the speed of the locomotive is reached, such speed being of course determined by the generator 35. With a movement of the volt meter 43 as described, the current flow through the signalling device 29 is of course interrupted while a current flow through the signalling device 30 still does not result. Accordingly, the engineer will know that his locomotive is operating with maximum draw-bar pull, due to the fact that neither signalling device will be functioning. Under these circumstances it is of course understood that circuit bridging portions or contacts 93, 94 and 95 move to circuit opening positions and the motor 87 is no longer driven. Simultaneously, a contact bridging portion 101 is rendered operative to cause—in a manner hereinafter brought out—an energization of electromagnet 89 to prevent further and accidental movement on the part of motor 87. Of course, under ordinary conditions of operation current surges and variations will occur and it would not be desirable that the contact-making volt meters follow instantly and precisely every one of these current surges. To that end there may be associated with the volt meters any one of numerous units or structures which will dampen the action of the latter and prevent a chattering of the same.

The purpose of switch 60' becomes apparent when one considers that as shown in Fig. 2, the rod 73 is being shifted outwardly and under certain conditions it is conceivable that the cut-off would tend to lengthen beyond the limits of the structure so that damage to the parts might result. As will be apparent, before such a condition is reached the actuating portion 74 will open switch 60' and the circuit through lead 59, this resulting in de-energization of electromagnet 60 which will, of course, de-energize motor 87 and cause the brake of the latter to be set as will be hereinafter described.

Now, referring to Figure 3, it will be observed that a condition has been illustrated wherein the locomotive is still moving forward and below the speed for which the control or rheostat 39—40 has been set, as indicated by the spring biased position of relay 44. The cut-off is too long to develop maximum draw-bar pull as indicated by the fully energized position assumed by relay 43, and the motor 87 is shortening such cut-off. Thus, it is again to be understood that the generator 35 is supplying current to the speedometer 28 and to the contact closing volt meters. Under the conditions set forth volt meter 44 will remain biased by its spring to close the gap in the circuit 53. However, sufficient current is now flowing through volt meter or relay 43 to cause the latter to be attracted to the opposite extreme position from that shown in Fig. 2. Under these circumstances and still considering Figure 3 current will flow through lead 53 and switch 58, and thence through branch 102 through the contact closing portion 45 of unit 43 and the signalling unit 30 which is interposed in leads 62—61 which are extended from lead 102, thence to lead 52 as in Fig. 2. The condition of unit 44 may be disregarded because current flow thereto is interrupted. Incident to the position of unit 43 current will also flow through the branch lead 103 extending from lead 102 at a point beyond unit 43 and thence through coil 64 to switch 65 and so to branch 55 and lead 52. The energization of coil 64 results in the switch elements 104, 105 and 106 controlled thereby being moved to circuit closing positions. Consequently since lead 107 is connected to lead 96 in advance of the gap in the latter bridged by arm 93 current flowing through lead 96 from lead 53 will pass into branch lead 107 and so to one of the terminals of motor 87, the current additionally flowing through branch 98 and shunt field 99 to lead 97 and thence to branch 55 and lead 52. Incident to the closing of switch 105 current will also flow from lead 52 and branch 55 to switch 56 to branch 97 through lead 108 connected thereto and so to the second terminal of motor 87 thus actuating the latter. It is to be noted, however, that the current flow is thus controlled to cause a driving of the motor in a reverse direction from that which occurred in Fig. 2 and consequently the rod 73 is moved in the direction indicated by the arrow in Fig. 3 to cause a shortening of the cut-off. Lead 100 is still energized under these conditions, incident to the fact that the extension 109 which lies beyond the same has its gap closed by the circuit breaker 106 so that current flows from lead 52. It should be noted that lead 62' since it is permanently attached to lead 53 is energized at all times, during which the external source feeding lead 53 is supplying power.

Now referring to Fig. 4, a condition has been illustrated in which it is assumed that the loco-

motive is moving in a forward direction and the speed is equivalent to that for which rheostat 40 has been set, as indicated by the relay or voltmeter 44 balancing the arm 45 between the two sets of contacts. In this figure also the cut-off is adjusted for maximum draw-bar pull, which fact is indicated by the voltmeter 43 balancing arm 45 in the center between the two sets of contacts. In other words, under these circumstances no movement of lever 26 should occur. Therefore, generator 35 will balance against variable rheostat 75 and rheostat 40 in a manner such that the current through units 43 and 44 will be adequate to maintain them in a balanced condition, or in other words in a condition such that their contact making portions 45 will not engage any of the pairs of terminals disposed adjacent the same.

Consequently, current will flow from lead 52, branch 55, switch 56, branch 97 through the branch 110 thereof and through coil 89 to energize the latter and operate brake 88 to hold the motor shaft against movement. Of course, this will hold rod 73 against movement and the reverse gear will accordingly be maintained in the position to which it is adjusted. Beyond the coil 89 branch 110 continues and is provided with the gap which is bridged by a contact engaging portion 101. This portion may conveniently be associated with the arm which mounts contact bridging portion 95 so that the circuit through lead 110 is closed when coil 60 is not energized. Lead 110 continues beyond portion 101 and is provided with a further gap bridged by a portion 112 conveniently associated with the arm which supports the contact bridging portion 106 and which portion 112 is operative when coil 64 is de-energized. Beyond portion 112 lead 110 is continued and connects with lead 53 by way of lead 62'.

At this time it is to be observed that lead 62' is continued in the form of a branch 113, the end of which is defined by the third terminal 57. Thus, the adjustment of the parts is maintained and both signalling means 29 and 30 are rendered inoperative, it being of course understood that incident to the dampers associates with the contact making volt meters, the latter will not function to energize any portions of the circuit, despite the fact that small fluctuations in the current supply flowing from generator 35 might be evidenced through the circuit, due to minor and rapid movements on the part of the rheostat and such as might occur incident to thrust upon the reach rod 24 or due to vibration.

Now referring to Fig. 5 there has been illustrated a condition in which the locomotive is continuing to move forward, but such forward movement is at a speed greater than that for which the rheostat 40 has been set as evidenced by relay 44 being energized to such an extent that arm 45 bridges the normally open set of contacts. Also, the cut-off is too short to develop maximum draw-bar pull. However, due to the fact that such maximum draw-bar pull is not needed to maintain speed, the control will, under these circumstances function to shorten the cut-off and thereby increase the efficiency with which the locomotive is operating.

Thus: the condition of balance as set forth in Fig. 4 will be disturbed and consequently the current developed by generator 35 will act to cause the contact-making volt meter or relay 44 to be energized in a manner such, that its contact bridging portion 45 will be moved to an

extreme position against the bias developed by spring 46. However, the volt meter or relay 43 will remain in engagement with the terminals defining the gap in lead 53. Accordingly, current will flow through lead 52 and branch 55 5 through switches 56 and 65, through leads 63 and 103 including coil 64 and thence through lead 63, lead 62 through contact bridging portion 45 and so through lead 62' to lead 53. A second initially energized portion of the circuit will, of course, be established through lead 53, lead 62', contact-bridging portion 45 of relay 44, lead 62, lead 103, and through lead 61, and so back to lead 52. In flowing through lead 61 the current will, obviously, energize the signalling unit 30 to indicate that the cut-off requires to be shortened so that the engineer will receive an indication to this effect, should it be desired to provide him with a signal.

In flowing through coil 64 the current will, of course, cause an energization of the latter, so that contact bridging portions 104, 105 and 106 are shifted to circuit closing positions. In such shifting contact bridging portion 112 will, obviously, be moved to circuit opening position and the brake will be released. Accordingly, current will flow through lead 53 and lead 96 to lead 107, through contact bridging portion 104 and so to one terminal of motor 87. Current will also flow through lead 96, branch 98 and through shunt coil 99 to lead 97. Current will additionally flow through lead 97 to branch 108, the gap of which is bridged by contact portion 105, and thus to the second terminal of the motor 87. This will, of course, cause the circuit through the motor to be completed and the current will flow in a direction such that rod 73 will be moved as indicated by the arrow in Fig. 5 to shorten the cut-off.

Thus, due to the fact that the speed of the locomotive is equal to or above that for which rheostat 40 has been set it will be noted that relay 44 has drawn bridging arm 45 against the bias of spring 46 away from the gaps normally bridged by such arm. This de-energizes coil 60 and allows the motor 87 to shorten the cut-off of the locomotive to a point considerably less than that required to develop maximum draw-bar pull. This will decrease the amount of steam used and greatly increase the efficiency of the operation of the locomotive. As the cut-off is shortened the speed will decrease. This will decrease the voltage developed by generator 35 and incident to this the relay 44 will cause arm 45 to assume a central position between the two sets of gaps as shown for relay 44 in Fig. 4 to indicate that the locomotive is travelling at the desired speed. It might be well to observe at this point that with the locomotive travelling at the desired speed and the arm 73 and lever 26 set for a cut-off much less than that required to develop maximum draw-bar pull, relay 43 will have its arm 45 biased by spring 46 to the position shown in Fig. 5 due to the fact that so great an amount of resistance has been inserted into leads 85-86 that the voltage produced by generator 35 is not sufficient to overcome both the resistance of rheostat 75 and the bias 46 of relay 43. This latter position of relay 43 will however, have no effect on the circuit since lead 53 to coil 60 and device 29 is opened by the normally biased breaker of relay 44.

Assuming that the locomotive is operating on say a level section of track at the speed desired but with the cut-off set so as to develop less than maximum draw-bar pull, then relay 44 will be

balanced in the center. Now should the speed of the locomotive decrease for any cause, relay 44 would close its normally biased contacts to energize coil 60 and device 29 to lengthen the cut-off.

- 5 The lengthening of the cut-off will increase the draw-bar pull of the locomotive and thus increase the speed of the locomotive and again balance relay 44 in the center.

- 10 Now should the speed of the locomotive increase above the speed desired, the condition illustrated in Fig. 5 would result and the cut-off would be shortened to decrease the speed of the locomotive.

- 15 In other words, to sum up, the operation of the equipment shown in Figs. 2 and 3 is such as to maintain a cut-off which will develop maximum draw-bar pull. In both these cases the speed is assumed less than that desired and the maximum draw-bar pull operates to increase the speed.

- In Fig. 5 and the condition above described, where the cut-off is adjusted so as to give less than maximum draw-bar pull, the desired speed is assumed to have been reached and then the cut-off has been shortened to a point less than that required to develop maximum draw-bar pull but the cut-off is adjusted so as to develop just enough power to maintain the desired speed.

- 25 This last consideration is very important in that after the locomotive has gotten up to speed, just enough steam and thus just enough coal and water is used to keep the locomotive operating at its greatest possible efficiency.

- If the locomotive is going forward at a speed greater than that for which rheostat 39-40 is set, the signalling device 30 will be energized regardless of whether throttle 25 is open or closed and regardless of the position of lever 26 as long as this lever is not in the reverse position. The circuit which establishes this is as follows: 40 from lead 52 through switch 65', through lead 61 to device 30, thence through lead 62 and gaps which are bridged by bridging arm 45 of relay 44, when this relay is highly energized, and thence to lead 62' and lead 53.

- 45 This arrangement provides a means for advising the engineer whenever the speed of the locomotive becomes too great, regardless of whether it is coasting or under power.

- Now in Fig. 9 there has been illustrated a set-up of apparatus such as is employed where no automatic correction is desired but rather dependence is placed upon a signal indication to the engineer who—it is assumed—will thereupon correct the improper operation as evidenced by the signalling means. With the parts in the position shown, a condition is approximated wherein the locomotive is stationary and the throttle is closed. With the throttle 25 closed, the switch 58 is, of course, opened and accordingly current flow 50 through lead 113' to lead 114 is interrupted, thus deenergizing, with the excepting of the portion hereinafter noted, substantially all portions of the apparatus. A rheostat 115' of variable character and corresponding to rheostat 75 is employed and the slide traversing this rheostat is coupled in the manner hereinbefore described to the reverse control. A generator 115 corresponds to generator 35 and is coupled to the contact making volt meters or relays 116 and 117 70 (corresponding to relays 43 and 44 respectively) as well as to a rheostat 118 traversed by a pointer 119 (each corresponding to rheostat 40 and pointer 39) in turn connected to the unit 117. Current supplied by generator 115 of course energizes the volt meters or relays as well as the 75

speedometer 28 and a recorder which will hereinafter be referred to.

The switch 58 is interposed in a branch 120 of lead 114 which latter extends across the control apparatus and has in series with it the cross-head switch 54. Lead 114 after it passes through switch 54, also connects to the counters 121 and 122; the latter being provided with electromagnets such that impulses transmitted by lead 114 cause energization of one or both of these registering units. Counter 121 operates register 32 and counter 122 operates register 31. Counter 122 is connected by a lead 123 with lead 113' and it follows that every time switch 54 is closed this counter will be energized. Counter 121 is connected to leads 124 and 125. The former has a gap in it capable of being bridged by contact closing portion 126 mounted upon an arm, the position of which is controlled by a coil 127, and this lead is coupled to lead 113'. Extending from the latter is a lead 128 which is connected to coil 127. The other side of coil 127 is connected to lead 130. One side of signalling unit 129 (corresponding to lamp 30) is connected to lead 123, the other side being connected to lead 130. Lead 130 is connected to two sets of gaps, one of which is bridged by the contact portion of unit 116 when the latter is fully energized to connect lead 130 with lead 120. The second gap connected to lead 130 is bridged by the contact-making portion of unit 117 when the latter is fully energized and is coupled at a point beyond the same to branch 114.

Branch 120 in addition to being provided with gaps, normally bridged by the contact-making portions of units 116 and 117, when the latter are biased to their extreme positions by the springs or other structure associated therewith, has interposed in it a signalling unit 131 of any desired type, corresponding to lamp 29. The extreme end of lead 120 after passing through unit 131 is connected to lead 113'. Lead 125 is furnished with a gap bridged by contact portion 132 and beyond the latter is coupled to lead 113'. Lead 120 is also furnished with a branch 133 within which the coil 134 which actuates contact-bridging portion 132 is interposed, and this branch is coupled to lead 113'.

As will be apparent, as soon as throttle 25 is opened, switch 58 will close, and accordingly the various circuits will become energized. With the parts adjusted to the position shown, it is of course apparent that no powerful forward movement of the locomotive can occur until the reverse gear lever 26 is shifted to a position beyond that shown in Fig. 9, because in such showing a zero cut-off is occurring, or in other words, the valve mechanism will not admit a great deal of steam to the cylinders even although the throttle be opened. Consequently, assuming that the rheostat 118 has been adjusted for a predetermined maximum speed and with the lever 26 shifted slightly to permit the admission of steam, the locomotive will begin to move forward and the apparatus will function to cause a signalling indication, such that the engineer will be aware that lever 26 is adjusted to a position where steam is being admitted to the cylinders for an insufficient portion of their piston stroke to cause the locomotive to develop maximum draw-bar pull. This condition is desired during the starting or accelerating period in order that the locomotive may be accelerated as quickly as possible. Under these circumstances he will shift lever 26 provide for a longer cut-off. In the interim, sig-

nalizing device 131 and coil 134 will be energized, thus both counters 121 and 122 will be functioning, due to the fact that the cross-head switch 54 will periodically close the circuit to transmit impulses through lead 114. Of course, as the cut-off is adjusted, the effective resistance of rheostat 115' will be decreased. As the resistance is decreased the amount of current flowing through relay 116 will be increased and the relay or voltmeter 116 will be energized to a sufficient extent to open lead 120. As a consequence, signalling unit 131 will be de-energized and the engineer will no longer receive an indication that the cut-off needs to be lengthened. Simultaneously, coil 134 will be de-energized in order that contact bridging portion 132 will open the gap in lead 125, resulting in an inoperative condition on the part of counter 121. However, 122 will of course, continue to function. Thus, total mileage will continue to be tabulated upon the indicating panel 27, but inefficient mileage will no longer be tabulated. If, of course, the speed of the locomotive continues to increase without further adjustment of lever 26, unit 116 will function to close the gap, which its contact-bridging portion may span, between lead 120 and lead 130. This will forthwith result in a closing of the circuit through signalling unit 129 and also an energization of coil 127. Contact bridging portion 126 will close the circuit through lead 124 thus again causing a re-actuation of counter 121, during continuing operation of counter 122. Thus, the engineer will first be made aware of the fact that the cut-off needs to be shortened and secondly there will be registered through unit 121 any further mileage during which the locomotive operates under these inefficient conditions. As the speed of the locomotive increases to a further extent, the engineer will have to shorten the cut-off again and again to keep signalling unit 129 and coil 127 from being energized, until eventually the maximum desired speed is attained. This will be evidenced by the current output of generator 115 and when a pre-determined condition between this generator and rheostat 118 is reached, unit 117 will function to move its contact-bridging portion to interrupt the circuit in the gap of lead 120.

Under these circumstances it will be understood that the reverse gear lever 26 will still be in proper position to cause the locomotive to develop maximum draw-bar pull, and therefore no indication should be transmitted to the engineer. Let us assume, however, that under these circumstances the locomotive continues to pick up speed, in which case it will be apparent that unit 117 will be energized to an extent such that its contact-bridging portion will close the gap between lead 114 and 130. When this occurs, current will flow from lead 114 through lead 130 and coil 127 to lead 113'. This results in a movement of the contact closing portion 126 to close the circuit between lead 113' through lead 124 and lead 114. Due to such closing of the circuit, counter 121 will again begin to function as cross-head switch 54 is operated. Simultaneously, current will flow through the lead in which signalling unit 129 is interposed, to cause an indication that the cut-off should be shortened. By doing this, the engineer will, of course, maintain the necessary draw-bar pull, in order to retain the desired speed, but will operate the locomotive with increased efficiency. Assuming now that an up-grade is encountered, this will be evidenced in a slowing down of the locomotive and generator

115, causing units 116 and 117 to assume the positions which have been illustrated in Fig. 9, thereby resulting in an energization of signalling device 131 as well as counter 121, the former serving to indicate the necessity of again lengthening the cut-off.

It will, of course, be understood by those skilled in the art, that the difference between cut-off to develop maximum power and that required to maintain speed, is a variable quantity, depending upon the draw-bar pull required to maintain speed. If the draw-bar pull is very light, the difference is great. If the draw-bar pull is heavy, there is very little difference and in fact it may be necessary to maintain a condition of operation on the part of the valves such that steam is admitted through a maximum or substantially maximum portion of piston travel in order to maintain speed.

In certain instances it may be desired to associate a recording device with the control and so that at the end of a run a supervisor may be in a position not alone to establish the ratio between total miles operated and inefficient mileage, which ratio can be established from the readings of registers 122 and 121, but also to know those portions or areas of the run during which efficient and inefficient operation occurred. To this end and as shown in Fig. 9, a recorder 135 may be connected to the lead extending between the voltmeters or units 116 and 117, the rheostat 118 and generator 115. This recorder is of a type which may be purchased on the open market and for this reason will not be described in detail. Suffice it to say that with the connections as provided the recorder might conveniently embrace a plurality of styli traversing a movable tape. The latter could either have a constant movement in relation to given time intervals, or might be variable as desired. One of the styli, controlled by leads 37 and 38, would record upon the tape the actual speed of the locomotive, another, controlled by leads 37 and 50, would show speeds in excess or below the one initially determined by the rheostat setting 39-40, or 119-118 as the case may be, and the third, controlled by leads 37 and 49, would indicate whether the cut-off was too long or too short. While a unit of this character has not been shown in Figs. 2 to 5, the leads 38, 47, 49 and 50 having terminal portions 51 have been shown and the method of connecting the recorder to these is obvious. Before departing from a consideration of Fig. 9, it will be understood that in many respects this layout of apparatus may be most desirable for the reason that ample signal indication will be provided and with such indication the engineer should be in a position to properly control the reverse lever so that efficient operation results. Also, it will be understood that a considerable saving in construction expense will be involved in a layout of apparatus such as this, in comparison with the apparatus necessary in Figs. 2 to 5.

Furthermore, the devices 121, 122 and 135 used singly or grouped provide an excellent means of checking on the engineer to determine whether or not he kept the engine adjusted in accordance with the signals given.

Attention is called to the fact that signalling unit 129 provides an over-speed alarm similar to that previously described for device 30. It should be noted that counter 121 also registers whenever the locomotive is travelling at a speed greater than that for which rheostat 118-119 has been set. Thus, it might be best to refer to

counter 121 (or 32) as recording not only inefficient mileage but also improper mileage. The circuit which accomplishes the last two operations is as follows: from lead 114 through normally open breakers of relay 117, through lead 130, through signal device 129, through lead 123 to lead 113' or from lead 130 through coil 127 and lead 128 to lead 113'. The energization of coil 127 causes device 121 to function.

Returning to a consideration of Figs. 2 to 5, the general functioning of the apparatus will be appreciated, it being of course understood that the primary switch may be considered as 58 in that it is associated with the throttle control lever 25 and as such functions to disconnect the apparatus (with one exception) when the throttle is completely closed. Of importance are also the switches 65', 56, 65, and 60' as well as the cross-head switch 54. More particularly switch 65' de-energizes the circuit by interrupting the current flow through lead 52 when the reverse lever is moved beyond mid-gear cut-off position to reverse position. Of course, as afore brought out, the apparatus might be amplified so as to provide signals and/or controls functioning to cause an efficient operation of the locomotive in reverse drive. However, in view of the fact that the locomotive will, as afore brought out, be operating in a forward direction, it is believed that the expense and complication of thus amplifying the mechanism is unnecessary, although the manner in which such amplification may be achieved is obvious. Considering switch 56, it is apparent that if the engineer elects to manually operate lever 26, he will cause an opening of the switch as he releases the latch 70. Thus, while under these circumstances signal indications would be given by units 29 and 30, operation of the motor 87 would not follow.

The equipment comprising switch 56, rod 69, latch 70 and cap 72 may assume three separate positions. During automatic operation, latch 70 is held in the up position shown in Figures 2 to 5. In this case switch 56 is closed. If cap 72 is raised against the retaining spring, latch 70 engages quadrant 72 and switch 56 is opened. Should the engineer wish to move the lever 26 by hand he would grasp the handle and release latch 70 from contact with quadrant 71, but due to the outside of cap 72 being in the way, latch 70 could not be raised sufficiently to close switch 56. Thus, switch 56 remains open during hand operation of lever 26.

Toggle switch 65 which should preferably be employed in addition to switch 65' results—when it is opened—in a de-energization of the coil which controls the reverse operation of the motor. In other words, forward movement on advancing of the gear may occur, although reverse movement of the gear will result only when the engineer manipulates the gear to this end. It is preferable to arrange the equipment so that during reverse movement of rod 73, switch 65 will be opened before switch 65'. Switch 60' of course functions to prevent further forward movement or advancing of the gear with damage to the apparatus when the cut-off has been lengthened to a maximum extent. Consequently, as shown, all equipment is de-energized when the reverse lever is set for backward movement, and switches 60' and 65 operate to limit movements of the parts in one direction, although permitting such movement in a proper and opposite direction. Of course, these switches might, in certain instances, be dispensed with incident to the switch

or switches associated with variable rheostat 75, although it is desirable to employ all of the switches afore noted.

The exception afore noted, in connection with deenergization of the circuit and when switch 58 is open occurs due to the fact that lead 110 (see Fig. 4) will remain energized, thus maintaining a current flow through coil 89 to lock motor 87 against movement. Also, lead 113 will remain energized. Counters 31 and 32 corresponding to the counters 121 and 122 in Fig. 9 are connected with the terminals 57 extending from leads 100 and 52 as well as lead 113. Lead 113, after leaving terminals 57, has interposed in it switch 54.

After passing through switch 54, lead 113 connects to the operating coils of registers 31 and 32. The other side of operating coil of register 31 is connected by means of one of the terminals 57 to lead 52 while the other side of operating coil of register 32 is connected by means of one of the terminals 57 to lead 100.

Cross-head switch 54 is disposed in series with both of these counters and it thus follows that under all circumstances and even with the throttle closed total mileage will be registered if the locomotive is coasting. Also, of course as switch 54 closes and according to the condition of the parts, the total inefficient mileage will be registered, it being understood that the counters are calibrated according to the diameter of the driving wheels of the locomotive so that the strokes of the cross-head may be translated into mileage.

In both forms of the invention, it will be appreciated that the electrical resistance device, coupled to and adjustable with the valve mechanism of the locomotive, in effect provides a gauge showing and embracing the various ranges of valve gear operation which should occur at various speeds of the locomotive. Also, as afore brought out, the generator responds to and indicates the current speed of the locomotive, while the signalling means shows whether the reverse gear is in properly adjusted position, compatible with the then current locomotive speed. The signalling means may be in the form of lamps, or any other desired mechanism which will respond to the variable factors, afore mentioned. As shown in Fig. 9, this may comprise the entire set-up of apparatus, while, as shown, in Figs. 2 to 5 inclusive, a motor mechanism may be provided which will act to automatically adjust the position of the reverse gear, in the event that the cut-off should be lengthened or shortened.

From the foregoing it will be understood that among others, the several objects of the invention as afore noted are achieved. Obviously, numerous changes in construction and rearrangements of the parts might be resorted to without departing from the spirit of the invention as defined by the claims.

Having described my invention, what I claim as a new and desire to secure by Letters Patent is:

1. A control for a locomotive including, in combination, a source of electrical energy the value of which varies in accordance with the speed of movement of the locomotive, a variable rheostat connected to said source, and to be set to occupy a position corresponding to a speed which has been predetermined, circuit makers and breakers connected to and governed by the electrical source as qualified by said variable rheostat, a further variable rheostat to be connected to the locomotive reverse gear to offer a resistance to current flow proportionate to the adjustment of the gear, further circuit makers

and breakers connected to and governed by the electrical source as qualified by said further rheostat, and means connected to said circuit makers and breakers to assume positions indicative of said rheostats being in a balanced condition and out of balance with respect to each other.

2. A control for a locomotive including, in combination, a source of electrical energy the value of which varies in accordance with the speed of movement of the locomotive, a variable rheostat connected to said source, and to be set to occupy a position corresponding to a speed which has been predetermined, circuit makers and breakers connected to and governed by the electrical source as qualified by said variable rheostat, a further variable rheostat to be connected to the locomotive reverse gear to offer a resistance to current flow proportionate to the adjustment of the gear, further circuit makers and breakers connected to and governed by the electrical source as qualified by said further rheostat, means connected to said circuit makers and breakers to assume positions indicative of said rheostats being in a balanced condition and out of balance with respect to each other, a further source of electrical current supply for operating said last named means, and means conditioned upon the position of said further rheostat for interrupting the flow of current from said further supply.

3. A control for a locomotive, having an adjustable reverse gear including, in combination, a source of electrical energy the value of which varies in accordance with the speed of movement of the locomotive, a variable rheostat connected to said source, and to be set to occupy a position corresponding to a speed which has been predetermined, circuit makers and breakers connected to and governed by the electrical source as qualified by said variable rheostat, a further variable rheostat to be connected to the locomotive reverse gear to offer a resistance to current flow proportionate to the adjustment of the gear, further circuit makers and breakers connected to and governed by the electrical source as qualified by said further rheostat, a source of further current supply, motor means controlled by a number of said current makers and breakers and energized by said further current supply, and means for connecting said motor means with such reverse gear, whereby to automatically adjust the same to assume a position compatible with the speed of movement of the locomotive.

4. A control for a locomotive, having an adjustable reverse gear including, in combination, a source of electrical energy the value of which varies in accordance with the speed of movement of the locomotive, a variable rheostat connected to said source, and to be set to occupy a position corresponding to a speed which has been predetermined, circuit makers and breakers connected to and governed by the electrical source as qualified by said variable rheostat, a further variable rheostat to be connected to the locomotive reverse gear to offer a resistance to current flow proportionate to the adjustment of the gear, further circuit makers and breakers connected to and governed by the electrical source as qualified by said further rheostat, a source of further current supply, motor means controlled by said circuit makers and breakers and energized by said further current supply, means for connecting said motor means with

said reverse gear whereby said motor means may adjust the latter to a position compatible with the speed of said locomotive, and means also controlled by said circuit makers and breakers for rendering said motor means inoperative when the condition of said reverse gear is proper with reference to the speed of the locomotive, as determined by said first named source of current.

5. A control to be applied to a locomotive and including a generator to be coupled to a locomotive so as to be driven at a speed proportionate to the speed of movement of the locomotive, circuit makers and breakers coupled to said generator, means coupled to the reverse gear of the locomotive and connected to said generator and circuit makers and breakers, said means being adjustable with, and to positions corresponding to the positions of said reverse gear, said means coupled to the reverse gear also being arranged to qualify the operation of said circuit makers and breakers as fundamentally governed by said generator and signalling means operated by said circuit makers and breakers to indicate whether or not said reverse gear is in a properly adjusted position for maximum draw-bar pull compatible with said means coupled to the reverse gear and the speed of the locomotive as determined by the speed of movement of said generator.

6. A control to be applied to a locomotive and including a generator to be coupled to a locomotive so as to be driven at a speed proportionate to the speed of movement of the locomotive, circuit makers and breakers coupled to said generator, means coupled to the reverse gear of the locomotive and connected to said generator and circuit makers and breakers, said means being adjustable with, and to positions corresponding to the position of said reverse gear, said means coupled to the reverse gear also being arranged to qualify the operation of said circuit makers and breakers as fundamentally governed by said generator signalling means operated by said circuit makers and breakers to indicate whether or not said reverse gear is in a properly adjusted position for maximum draw-bar pull compatible with said means coupled to the reverse gear and the speed of the locomotive as determined by the speed of movement of said generator, and a control means coupled to said generator to provide a factor determining the speed in excess of which the locomotive should not be operated.

7. A control to be applied to a locomotive and including a generator to be coupled to a locomotive so as to be driven at a speed proportionate to the speed of movement of the locomotive, circuit makers and breakers coupled to said generator, means to be coupled to the reverse gear of the locomotive and connected to said generator and circuit makers and breakers, said means being adjustable with, and to positions corresponding to the position of said reverse gear said means coupled to the reverse gear also being arranged to qualify the operation of said circuit makers and breakers as fundamentally governed by said generator, a second set of circuit makers and breakers coupled to said generator, and means controlled by both sets of said circuit makers and breakers, and connected to said reverse gear and functioning in the event of said reverse gear not occupying a position harmonious with the requirements of the locomotive as determined by said first named means, said circuit makers and breakers and by the

speed of the locomotive to adjust said reverse gear to a proper position.

8. A control to be applied to a locomotive and including a generator to be coupled to a locomotive so as to be driven at a speed proportionate to the speed of movement of the locomotive, circuit makers and breakers coupled to said generator, means to be coupled to the reverse gear of the locomotive and connected to said generator and circuit makers and breakers, said means being adjustable with, and to positions corresponding to the position of said reverse gear said means coupled to the reverse gear also being arranged to qualify the operation of said circuit makers and breakers as fundamentally governed by said generator, a second set of circuit makers and breakers coupled to said generator, and means controlled by both sets of said circuit makers and breakers and connected to said reverse gear and functioning in the event of said reverse gear not occupying a position harmonious with the requirements of the locomotive as determined by said first named means, said circuit makers and breakers and by the speed of the locomotive to adjust said reverse gear to a proper position, and means for locking said last named means when the reverse gear has been adjusted to a position compatible with the speed of movement of the locomotive.

9. A control to be applied to a locomotive and including a generator to be coupled to a locomotive so as to be driven at a speed proportionate to the speed of movement of the locomotive, circuit makers and breakers coupled to said generator, means to be coupled to the reverse gear of the locomotive and connected to said generator and circuit makers and breakers, said means being adjustable with, and to positions corresponding to the position of said reverse gear said means coupled to the reverse gear also being arranged to qualify the operation of said circuit makers and breakers as fundamentally governed by said generator, a second set of circuit makers and breakers coupled to said generator, and means controlled by both sets of said circuit makers and breakers and a second set of circuit makers and breakers coupled to said generator, means controlled by said second set, and connected to said reverse gear and functioning in the event of said reverse gear not occupying a position harmonious with the requirements of the locomotive as determined by said first named means, said circuit makers and breakers and by the speed of the locomotive to adjust said reverse gear to a proper position, and means causing said last named means to be rendered inoperative to further advance said gear upon the same having been adjusted to a position of maximum advance.

10. A control to be applied to a locomotive and including a generator to be coupled to a locomotive so as to be driven at a speed proportionate to the speed of movement of the locomotive, circuit makers and breakers coupled to said generator, means to be coupled to the reverse gear of the locomotive and connected to said generator and circuit makers and breakers, said means being adjustable with, and to positions corresponding to the position of said reverse gear, said means coupled to the reverse gear also being arranged to qualify the operation of said circuit makers and breakers as fundamentally governed by said generator, a second set of circuit makers and breakers coupled to said generator, signalling means operated by said circuit makers and breakers to indicate whether said reverse gear is in a properly adjusted position compatible with the requirements of the locomotive as determined by said first named means, said circuit makers and breakers and by the speed of the locomotive as determined by the speed of movement of said generator, a current supply line coupled to said signalling means to energize the same, a switch to be mounted adjacent to the cross-head of the locomotive and connected to said current supply line, and to be opened and closed according to the position of said cross-head, and a counter arranged in a series circuit with said cross-head switch and contacts under control of a multiplicity of said circuit makers and breakers whereby said counter functions in response to operations of said switch and said circuit makers and breakers.

circuit makers and breakers to indicate whether said reverse gear is in a properly adjusted position compatible with the requirements of the locomotive as determined by said first named means, said circuit makers and breakers and by the speed of the locomotive as determined by the speed of movement of said generator, motor means controlled by said circuit makers and breakers and coupled to and functioning in the event of said reverse gear not occupying said properly adjusted position harmonious with the speed of the locomotive to adjust said reverse gear to a proper position, and means acting to render said last named means inoperative to further retract said gear upon the latter having been retracted to a predetermined point.

11. A control to be applied to a locomotive and including a generator to be coupled to a locomotive so as to be driven at a speed proportionate to the speed of movement of the locomotive, circuit makers and breakers coupled to said generator, means to be coupled to the reverse gear of the locomotive and connected to said generator and circuit makers and breakers, said means being adjustable with, and to positions corresponding to the position of said reverse gear, said means coupled to the reverse gear also being arranged to qualify the operation of said circuit makers and breakers as fundamentally governed by said generator, a second set of circuit makers and breakers coupled to said generator, signalling means operated by said circuit makers and breakers to indicate whether said reverse gear is in a properly adjusted position compatible with the requirements of the locomotive as determined by said first named means, said circuit makers and breakers and by the speed of the locomotive as determined by the speed of movement of said generator, a current supply line coupled to said signalling means to energize the same, a switch to be mounted adjacent to the cross-head of the locomotive and connected to said current supply line, and to be opened and closed according to the position of said cross-head, and a counter arranged in a series circuit with said cross-head switch and contacts under control of a multiplicity of said circuit makers and breakers whereby said counter functions in response to operations of said switch and said circuit makers and breakers.

12. A control to be applied to a locomotive and including a generator to be coupled to a locomotive so as to be driven at a speed proportionate to the speed of movement of the locomotive, circuit makers and breakers coupled to said generator, means to be coupled to the reverse gear of the locomotive and connected to said generator and circuit makers and breakers, said means being adjustable with, and to positions corresponding to the position of said reverse gear, said means coupled to the reverse gear also being arranged to qualify the operation of said circuit makers and breakers as fundamentally governed by said generator, a second set of circuit makers and breakers coupled to said generator, signalling means operated by said circuit makers and breakers to indicate whether said reverse gear is in a properly adjusted position compatible with the requirements of the locomotive as determined by said first named means, said circuit makers and breakers and by the speed of the locomotive as determined by the speed of movement of said generator, a current supply line coupled to said signalling means to energize the same, a switch to be mounted

adjacent to the cross-head of the locomotive and connected to said current supply line, and to be opened and closed according to the position of said cross-head, and a plurality of registering devices connected to said cross-head switch and said signalling means, one of said registering devices functioning in response to each operation of said cross-head switch and the other of the same functioning in response to operation of the switch accompanied by an operation of one of the signalling means.

13. A control to be applied to a locomotive and including a generator to be coupled to a locomotive so as to be driven at a speed proportionate to the speed of movement of the locomotive, circuit makers and breakers coupled to said generator, means coupled to the reverse gear of the locomotive and connected to said generator and circuit makers and breakers, said means being adjustable with, and to positions corresponding to the position of said reverse gear, said means coupled to the reverse gear also being arranged to qualify the operation of said circuit makers and breakers as fundamentally governed by said generator, signalling means operated by said circuit makers and breakers to indicate whether or not said reverse gear is in a properly adjusted position for maximum draw-bar pull compatible with said means coupled to the reverse gear and the speed of the locomotive as determined by the speed of movement of said generator, a current supply line for operating said signalling means, and a throttle controlled switch interposed in said supply line and rendering the same inoperative to supply current to said signalling means when said throttle is in closed position.

14. A control to be applied to a locomotive and including a generator to be coupled to a locomotive so as to be driven at a speed proportionate to the speed of movement of the locomotive, circuit makers and breakers coupled to said generator, means coupled to the reverse gear of the locomotive and connected to said generator and circuit makers and breakers, said means being adjustable with, and to positions corresponding to the position of said reverse gear, said means coupled to the reverse gear also being arranged to qualify the operation of said circuit makers and breakers as fundamentally governed by said generator, signalling means operated by said circuit makers and breakers to indicate whether or not said reverse gear is in a properly adjusted position for maximum draw-bar pull compatible with said means coupled to the reverse gear and the speed of the locomotive as determined by the speed of movement of said generator, and recording means coupled to said control for indicating the periods of time and duration of such periods during which said reverse gear has been properly and improperly adjusted.

15. A control to be applied to a locomotive and including a generator to be coupled to a locomotive so as to be driven at a speed proportionate to the speed of movement of the locomotive, circuit makers and breakers coupled to said generator, means coupled to the reverse gear of the locomotive and connected to said generator and circuit makers and breakers, said means being adjustable with, and to positions corresponding to the position of said reverse gear, said means coupled to the reverse gear also being arranged to qualify the operation of said circuit makers and breakers as fundamentally governed by said generator, signalling means operated by said circuit makers and breakers to indicate whether or

not said reverse gear is in a properly adjusted position for maximum draw-bar pull compatible with said means coupled to the reverse gear and the speed of the locomotive as determined by the speed of movement of said generator, a current supply line coupled to said signalling means to operate the latter, a switch controlled by the cross-head of the locomotive and coupled to said current supply line, and a registering device also coupled to said current line and governed by the operations of said switch and a multiplicity of said circuit makers and breakers.

16. A control including, in combination, a generator to be coupled to a locomotive and driven at a speed proportionate to the speed of locomotive movement, a variable electrical element to be set to a position to correspond to the maximum speed at which said locomotive is to be operated and coupled to said generator, a relay also coupled to said generator and said element and operating in response to the current flow as determined by the speed of movement of the generator and the position of said element, a source of electrical current supply, signalling means governed by said relay and energized by said source, registering devices also connected to said source of current supply, and a switch operated periodically and at a rate proportionate to the speed of the locomotive for interrupting the flow of current from said source to said registering devices one of said registering devices also being under control of said relay.

17. A control, including a generator to be coupled to a locomotive and to be driven at a speed proportionate to the speed of the locomotive, elements coupled to the generator, both of said elements being variable and one of the same being adapted to be set to positions corresponding to the maximum speed at which said locomotive should move, the other of the same being coupled to the reverse gear of said locomotive to correspond to the position occupied by said gear, relays coupled to and controlled by said generator and said elements, an electric motor engaging said reverse gear to shift the same, a source of electrical current supply, and a switch structure controlled by said relays and coupling said motor to said source of current supply to operate said motor and thus to shift the position of said reverse gear when said gear occupies a position incompatible with the speed of the locomotive.

18. A control device for steam locomotives comprising a source of electrical energy the value of which varies as the speed of said locomotive varies, a variable resistance connected to be varied as the cut-off of said locomotive is regulated, relaying means under the control of said source of electrical energy and said resistance device, and signalling means under control of said relaying means.

19. A control device for steam locomotives comprising a source of electrical energy the value of which varies as the speed of said locomotive varies, an electrical energy controlling device arranged to be regulated as the cut-off of said locomotive is regulated, relaying means under control of said source of electrical energy and said controlling device, a second relaying means under control of said source of electrical energy, and signalling means under control of the plurality of said relaying means.

20. A control device for steam locomotives comprising a source of electrical energy the value of which varies as the speed of said loco-

motive varies, an electrical energy controlling device arranged to be regulated as the cut-off of said locomotive is regulated, relaying means under control of said source of electrical energy and said controlling device, a second electrical energy controlling device, a second relaying means under control of said source of electrical energy and said second controlling device, and signalling means under control of a plurality of said relaying means.

21. A control for steam locomotives comprising a supply of electrical energy, an electrical switch which operates each time said locomotive has traveled a predetermined distance, electrical relaying means operating whenever said locomotive is being driven in a predetermined manner, and an electrical totalizer forming a part of said control and operative to record whenever said switch and said relaying means both operate simultaneously.

22. A control for a steam locomotive comprising a direct current generator which generates a voltage proportional to the speed of said locomotive, a three position contact making voltmeter operated from said generator, a variable rheostat connected in series with said voltmeter, means for connecting said rheostat with the valve gear of the locomotive so as to cut resistance out of said series circuit as the cut-off of said locomotive is lengthened, and a plurality of signalling means under control of said contact making voltmeter.

23. A control for a steam locomotive comprising a direct current generator which generates a voltage proportional to the speed of said locomotive, a contact making voltmeter operated from said generator, a variable rheostat connected in series with said voltmeter and arranged to cut resistance into said series circuit as the cut-off of said locomotive is shortened, a second contact making voltmeter operated from said generator, and two signalling means under control of said two contact making voltmeters.

24. A control for a steam locomotive having a reverse lever, said control comprising a means arranged to operatively function when both the speed of said locomotive is less than desired, and the reverse lever is set for a cut-off which is shorter than required to cause the locomotive to develop maximum draw-bar pull, a second means arranged to operatively function whenever the reverse lever is set for a cut-off which is longer than required to cause the locomotive to efficiently develop maximum draw-bar pull, a third means arranged to operatively function whenever the speed of said locomotive exceeds a predetermined speed, and a power mechanism under the control of said three means whereby, when said first means functions, the cut-off will be automatically lengthened, and whereby, when either said second or third means function the cut-off will be automatically shortened.

25. A control for a steam locomotive comprising an electrical generator unit, the voltage of which varies as the speed of said locomotive varies, a variable rheostat coupled to the reverse gear of said locomotive and adjustable with the adjustment of said gear to provide increasing and decreasing resistance, and an electrical energy consuming instrument connected in series with said rheostat, both said rheostat and instrument being energized from said generator.

26. A control for a steam locomotive having an adjustable cut-off, said control comprising a source of electrical energy, an electric motor

operatively coupled to adjust said locomotive cut-off, electrical switches arranged to connect said motor, for operating in either direction, to said source of electrical energy, and means for controlling said electrical switches whereby the cut-off will be automatically lengthened whenever both the locomotive speed is less than desired and the cut-off is set to cause the locomotive to develop less than maximum draw-bar pull, and means whereby the cut-off will be automatically shortened when either the cut-off is longer than desired or when the speed of the locomotive is higher than desired.

27. A control for a steam locomotive having a cut-off, said control comprising a set of arms and gaps which are arranged to operatively function whenever the speed of said locomotive is less than desired, a second set of arms and gaps which are arranged to operatively function whenever the cut-off is less than that required for the locomotive to develop maximum draw-bar pull, a third set of arms and gaps which are arranged to operatively function whenever the speed of said locomotive is greater than desired, a fourth set of arms and gaps which are arranged to operatively function whenever the cut-off is greater than that required for the locomotive to develop maximum draw-bar pull, and a power mechanism for automatically adjusting said locomotive cut-off under the control of a multiplicity of said arms and gaps whereby whenever said first two sets of arms and gaps function simultaneously said cut-off will be lengthened by said power mechanism and when either said third or fourth set of arms and gaps function said cut-off will be shortened by said power mechanism.

28. A control to be applied to a locomotive and including a variable electrical resistance, preformed to provide a gauge establishing the proper setting and timing of the valve mechanism of said locomotive, means connecting said resistance to said locomotive valve mechanism and whereby said resistance offers an electrical value corresponding to the setting of said valve mechanism, current generating means to be driven at a speed corresponding to that of the locomotive, and signalling means coupled to said resistance and generating means for indicating whether the operation of said valve mechanism is properly timed with reference to the current speed of the locomotive.

29. A control to be applied to a locomotive and including a variable electrical resistance, preformed to provide a gauge establishing the proper setting and timing of the valve mechanism of said locomotive, means connecting said resistance to said locomotive valve mechanism and whereby said resistance offers an electrical value corresponding to the setting of said valve mechanism, current generating means to be driven at a speed corresponding to that of the locomotive, signalling means coupled to said resistance and generating means for indicating whether the operation of said valve mechanism is properly timed with reference to the current speed of the locomotive, a further source of current supply extending to said signalling means, and switch means operative upon the reverse gear being shifted beyond a pre-determined point to disconnect said further source from said signalling means.

30. A control to be applied to a locomotive and including a variable electrical resistance preformed to provide a gauge establishing the

proper setting and timing of the valve mechanism of said locomotive, means connecting said resistance to said locomotive valve mechanism and whereby said resistance offers an electrical value corresponding to that at which said valve mechanism is set, current generating means to be driven at a speed corresponding to that of the locomotive, means coupled to said resistance and generating means for indicating whether the operation of said valve mechanism is properly timed with reference to the current speed of the locomotive, and registering mechanism connected to said indicating means and functioning to indicate the intervals during which said valve mechanism is improperly timed.

31. A control to be applied to a locomotive and including a variable electrical resistance preformed to provide a gauge establishing the proper setting and timing of the valve mechanism of said locomotive, means connecting said resistance to said locomotive valve mechanism and whereby said resistance offers an electrical value corresponding to that at which said valve mechanism is set, current generating means to be driven at a speed corresponding to that of the locomotive, means coupled to said resistance and generating means for indicating whether the operation of said valve mechanism is properly timed with reference to the current speed of the locomotive, registering mechanism connected to said indicating means, and switch means coupled to said mechanism and periodically operated by the locomotive driving mechanism as the latter functions to register the intervals during which the operation of the valve mechanism is improperly timed.

32. A control to be applied to a locomotive and including a variable electrical resistance preformed to provide a gauge establishing the proper setting and timing of the valve mechanism of said locomotive, means connecting said resistance to said locomotive valve mechanism and whereby said resistance offers an electrical value corresponding to that at which said valve mechanism is set, current generating means to be driven at a speed corresponding to that of the locomotive, means coupled to said resistance and generating means for indicating whether the operation of said valve mechanism is properly timed with reference to the current speed of the locomotive, a further resistance connected to said indicating means and means for manually adjusting said further resistance to occupy a position such that it will provide a resistance corresponding to the maximum speed at which said locomotive should be operated and whereby said indicating means will register the need for further adjustment of said valve mechanism until the locomotive attains such speed.

33. A control to be applied to a locomotive and including a variable electrical resistance, preformed to provide a gauge establishing the proper setting and timing of the valve mechanism of said locomotive, means connecting said resistance to said locomotive valve mechanism and whereby said resistance offers an electrical value corresponding to the setting of said valve mechanism, current generating means to be driven at a speed corresponding to that of the locomotive, signalling means coupled to said resistance and generating means for indicating whether the operation of said valve mechanism is properly timed with reference to the current speed of the locomotive, a switch connected to said control and when operated serving to ren-

der the latter substantially inoperative, and means for coupling said switch with the throttle control of said locomotive whereby said switch will be operated when said throttle control occupies a pre-determined position.

34. A control to be applied to a locomotive and including a variable electrical resistance preformed to provide a gauge establishing the proper setting and timing of the valve mechanism of said locomotive, means connecting said resistance to said locomotive valve mechanism and whereby said resistance offers an electrical value corresponding to that at which said valve mechanism is set, current generating means to be driven at a speed corresponding to that of the locomotive, motor means for adjusting the position of said valve mechanism, and means coupled to said resistance and generating means for energizing said motor means when the operation of said valve mechanism is improperly timed with reference to the current speed of the locomotive.

35. A control to be applied to a locomotive and including a variable electrical resistance preformed to provide a gauge establishing the proper setting and timing of the valve mechanism of said locomotive, means connecting said resistance to said locomotive valve mechanism and whereby said resistance offers an electrical value corresponding to that at which said valve mechanism is set, current generating means to be driven at a speed corresponding to that of the locomotive, motor means for adjusting the position of said valve mechanism, means coupled to said resistance and generating means for energizing said motor means when the operation of said valve mechanism is improperly timed with reference to the current speed of the locomotive, and brake means associated with said motor means for holding the latter and said gear against substantial movement when the operation of said valve mechanism is properly timed with reference to the current speed of the locomotive.

36. A control to be applied to a locomotive and including a variable electrical resistance preformed to provide a gauge establishing the proper setting and timing of the valve mechanism of said locomotive, means connecting said resistance to said locomotive valve mechanism and whereby said resistance offers an electrical value corresponding to that at which said valve mechanism is set, current generating means to be driven at a speed corresponding to that of the locomotive, motor means for adjusting the position of said valve mechanism, means coupled to said resistance and generating means for energizing said motor means when the operation of said valve mechanism is improperly timed with reference to the current speed of the locomotive, and switch means coupled to said motor means for rendering the latter inoperative upon said valve mechanism being manually adjusted.

37. A control to be applied to a locomotive and including a variable electrical resistance preformed to provide a gauge establishing the proper setting and timing of the valve mechanism of said locomotive, means connecting said resistance to said locomotive valve mechanism and whereby said resistance offers an electrical value corresponding to that at which said valve mechanism is set, current generating means to be driven at a speed corresponding to that of the locomotive, motor means for adjusting the position of said valve mechanism, means cou-

pled to said resistance and generating means for energizing said motor means when the operation of said valve mechanism is improperly timed with reference to the current speed of the locomotive, and means for rendering said control inoperative upon said valve mechanism being manually adjusted to a position beyond a certain predetermined position.

38. A control to be applied to a locomotive and including a variable electrical resistance preformed to provide a gauge establishing the proper setting and timing of the valve mechanism of said locomotive, means connecting said resistance to said locomotive valve mechanism and whereby said resistance offers an electrical value corresponding to that at which said valve mechanism is set, current generating means to be driven at a speed corresponding to that of the locomotive, motor means for adjusting the position of said valve mechanism, means coupled to said resistance and generating means for energizing said motor means when the operation of said valve mechanism is improperly timed with reference to the current speed of the locomotive, and switch means for interrupting the operation of said motor means in the event that the latter shifts said valve mechanism beyond a predetermined position.

39. A control to be applied to a locomotive and including a variable electrical resistance preformed to provide a gauge establishing the proper setting and timing of the valve mechanism of said locomotive, means connecting said resistance to said locomotive valve mechanism and whereby said resistance offers an electrical value corresponding to that at which said valve mechanism is set, current generating means to be driven at a speed corresponding to that of the locomotive, motor means for adjusting the position of said valve mechanism, means coupled to said resistance and generating means for energizing said motor means when the operation of said valve mechanism is improperly timed with reference to the current speed of the locomotive, and a further resistance to be manually adjusted and connected to said current generating means to provide a resistance corresponding

in value to the maximum speed at which said locomotive should function.

40. In combination a steam locomotive having a power reverse gear, a crosshead, and running wheels; and a control comprising a direct current generator driven at a speed proportional to the speed of one of said locomotive wheels, a variable rheostat connected to and adjustable with said power reverse gear, a contact making voltmeter energized from said generator and under control of said rheostat, a second variable rheostat which may be manually adjusted, a second contact making voltmeter energized from said generator and under control of said second rheostat, a pair of signal lamps controlled by the multiplicity of said contact making voltmeters, a switch operated by said locomotive cross-head, and a pair of totaling counters, one of said counters being under control of said switch and the other counter being under control of the combination of said switch and said contact making voltmeters.

41. In combination a steam locomotive having a power reverse gear, a crosshead, and running wheels; and a control comprising a direct current generator driven at a speed proportional to the speed of one of said locomotive wheels, a variable rheostat connected to and adjustable with said power reverse gear, a contact making voltmeter energized from said generator and under control of said rheostat, a second variable rheostat which may be manually adjusted, a second contact making voltmeter energized from said generator and under control of said second rheostat, a pair of signal lamps controlled by the multiplicity of said contact making voltmeters, a source of direct current electric power supply aside from said generator, a direct current motor energized from said source and arranged to control said power reverse gear, a reversing controller arranged to start, stop, and reverse said motor, and an electric brake arranged to keep said power reverse gear stationary except when it is being moved by said motor, said reversing controller being under control of the multiplicity of said contact making voltmeters.

FORD C. PETHICK.