July 7, 1942. J. A. McGREW 2,289,203

LOCOMOTIVE

Filed Jan. 29, 1940 2 Sheets-Sheet 1

FIG. 1.

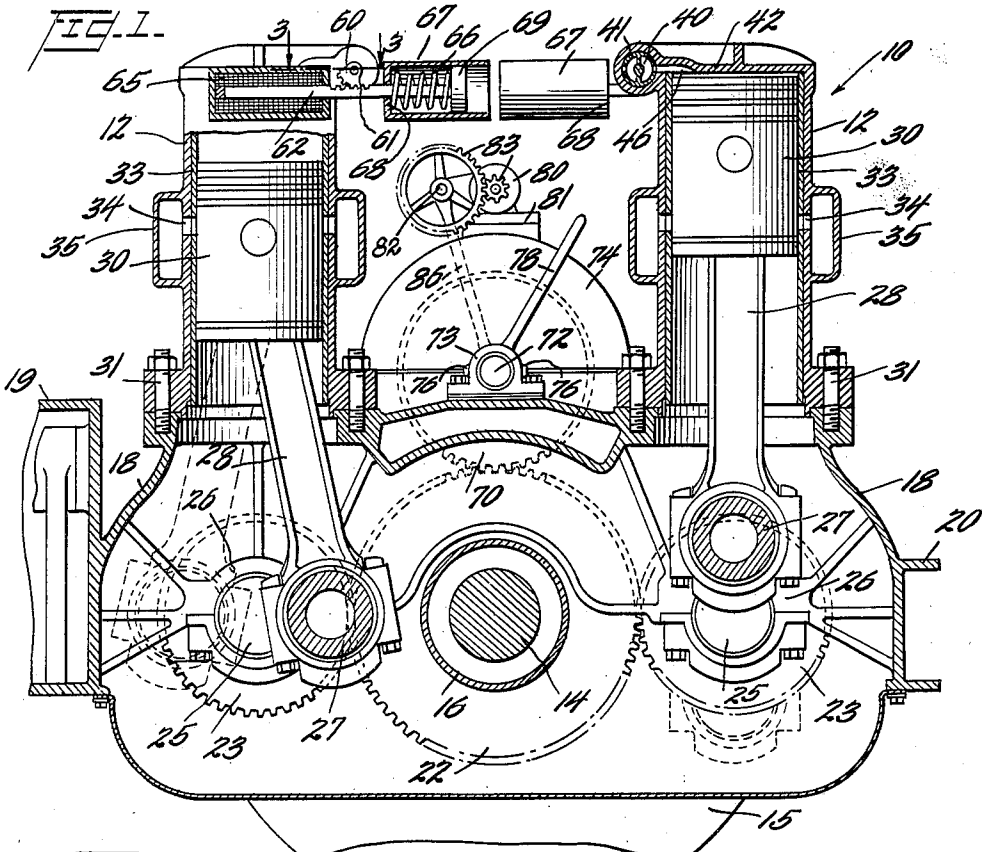
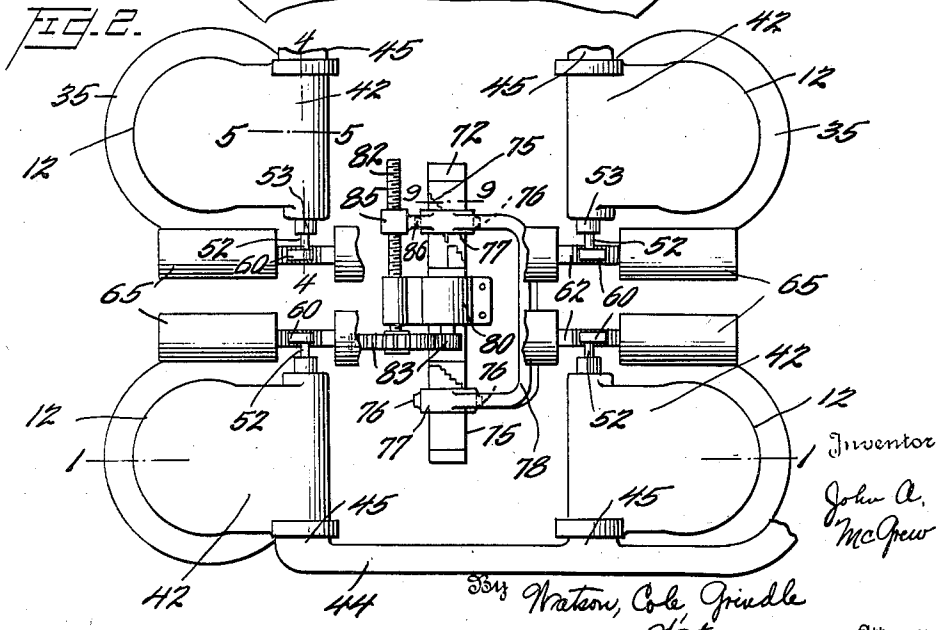


FIG. 2.



Inventor
John A. McGrew

Watson, Cole, Grindle & Watson
Attorneys

July 7, 1942. J. A. McGREW 2,289,203

LOCOMOTIVE

Filed Jan. 29, 1940 2 Sheets-Sheet 2

FIG. 3.

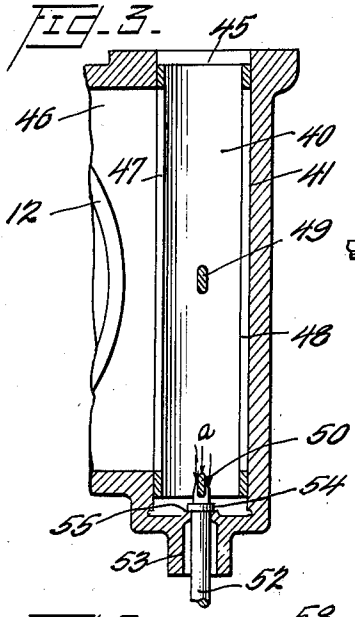


FIG. 4.

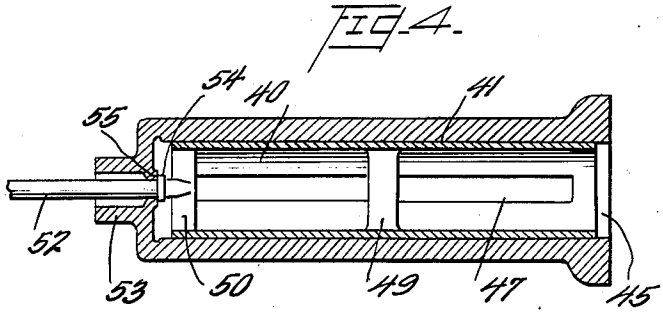


FIG. 8.

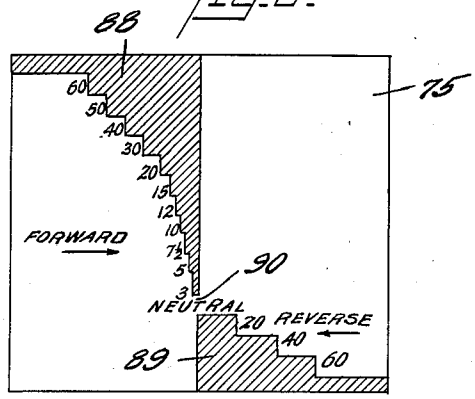


FIG. 5.

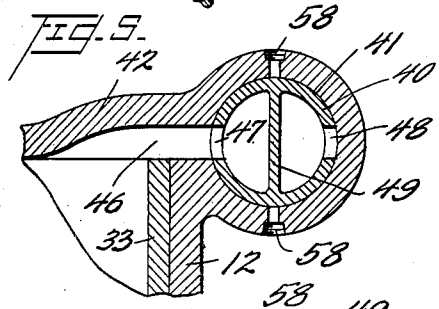


FIG. 9.

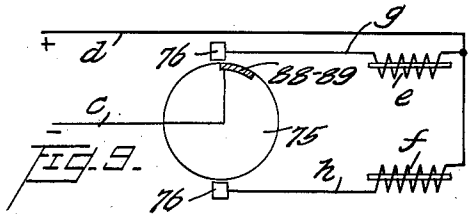


FIG. 6.

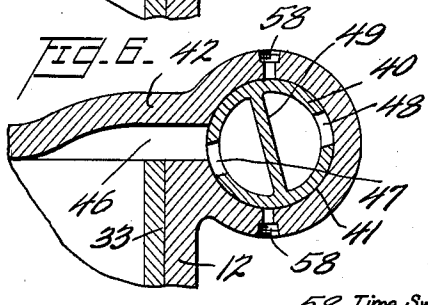


FIG. 10.

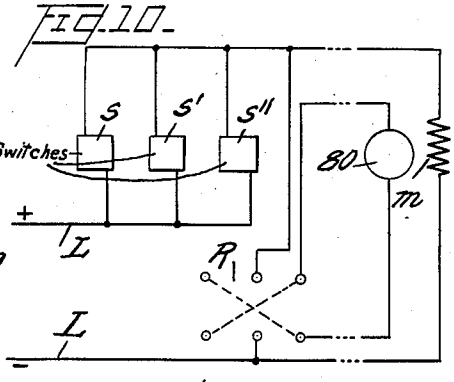
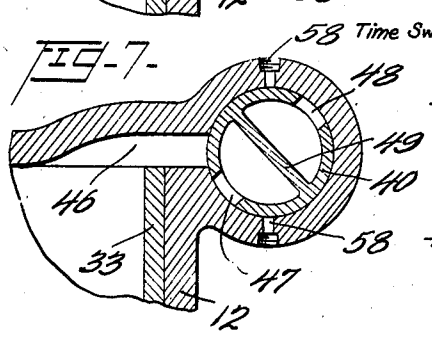


FIG. 7.



Inventor
John A. McGrew

By Watson, Cole, Grindle & Watson

Attorneys

Patented July 7, 1942

2,289,203

UNITED STATES PATENT OFFICE

2,289,203

LOCOMOTIVE

John A. McGrew, Albany, N. Y.

Application January 29, 1940, Serial No. 316,243

10 Claims. (Cl. 121—148)

This invention relates to railroad locomotives, more particularly to locomotives of the multi-engine type, and has for its object the provision in a locomotive of this class of novel engine units and improved controlling means therefor.

It is the general object of the invention to provide a novel and improved power plant, particularly applicable to use in multi-engined high speed locomotives. Numerous advantages result from the employment of such multi-engined locomotives, among which may be briefly recited the higher tractive effort and horsepower developed in the lower speed ranges, thus affording better acceleration; the improved steam plant design permitted by the novel boiler and firebox supports; the elimination of the "dynamic augment" problem by the use of a gear drive; the flexible mounting which makes for better operation on curves; the lower steam rate; the lower fuel rate; and the lower maintenance costs.

Not the least important features of the new high speed locomotive are the improved driving engines and their controlling means, and these comprise the subject matter of the present application. These engines are by preference of the uniflow type, and are somewhat similar in general arrangement and disposition to those illustrated and described in my copending application Serial No. 248,345, filed December 29, 1938, now Patent No. 2,214,424; but they embody certain novel features, including improved balanced rotary admission valves and electro-magnetic means for rapidly actuating them in timed sequence and in accordance with the cut-off desired.

A suggested arrangement for such a locomotive, might be to provide a locomotive and tender unit of the 6—6—8—8 type, having a leading truck which is a load carrying truck only, the engines all being mounted on the trailing truck and the tender trucks; one four cylinder engine being adapted to drive each axle. However, the present invention in its broader aspects is not limited to such specific arrangement of the engines nor to the stated number of cylinders, but is susceptible of other uses, arrangement, and modifications in construction within the scope of the subjoined claims.

In its preferred embodiment the invention contemplates the provision of a high speed uniflow single acting engine of one or more cylinders, in which the steam admission is controlled by novel inside admission, balanced, rotary valves which are particularly adapted for electrical operation. Each valve is operatively connected to the movable core of a solenoid, the core and the valve being urged in one direction—preferably to close the valve—by means of a spring, the solenoid being intermittently energized to move the valve to open position in opposition to the force of the spring.

A rotating variable contact drum is driven in synchronism with the engine crank shaft, and the timing and duration of the energizing of the solenoid—and thus the regulation of the cut-off—is determined by the adjustment of movable contact brushes which are selectively positioned with respect to the peripheral contact areas of the drum by an electric motor or other means under the control of the engine man in the cab.

The ease of control of the engines which is afforded by these electrical devices and the extreme rapidity of actuation is an important feature of the invention, especially in combination with the rotary balanced admission valves. There have been prior proposals looking toward the actuation of reciprocating valves by means of electromagnets, but such proposals have encountered difficulties in reduction to practical devices, and would be entirely inadequate for use in the valve mechanism of engines of the present type, which in order to drive the locomotives at a speed of 110 miles per hour must develop a crank shaft speed of about 900 R. P. M., or fifteen revolutions per second. By the proper balancing of the steam pressure on the novel rotary valves, together with the rapid response afforded by the electrical actuation, all possibility of sticking and delayed operation is avoided.

Other objects and features of novelty will be apparent from the following specification when read in connection with the accompanying drawings, in which one embodiment of my invention is illustrated by way of example.

In the drawings:

Figure 1 is a view in vertical longitudinal section of a multiple cylinder uniflow steam engine embodying the principles of the invention, the section being taken substantially on line 1—1 of Figure 2;

Figure 2 is a somewhat fragmentary plan view of the engine, certain parts being omitted for the sake of clearness of illustration;

Figure 3 is a fragmentary horizontal sectional view taken on line 3—3 of Figure 1, and showing one of the oscillating rotary admission valves of the engine;

Figure 4 is a vertical sectional view of the valve taken on line 4—4 of Figure 2;

Figures 5, 6 and 7 are transverse sectional

views taken on line 5—5 of Figure 2, and showing the valve in different positions of operation;

Figure 8 is a diagram representing the development of the peripheral cylindrical surface of a contact drum employed in the control of the admission valve, upon a plane;

Figure 9 is a wiring diagram showing the valve actuating circuit, the timing drum being shown diagrammatically in transverse cross-section as taken substantially on line 9—9 of Figure 2; and

Figure 10 is a wiring diagram showing the control circuits for the valve timing device in one form of the invention.

As disclosed most clearly in Figures 1 and 2 of the drawings, the engine designated generally by the reference numeral 10 comprises four cylinders 12 disposed symmetrically about the wheel axle 14, upon either end of which driving wheels are mounted, one of these wheels being shown in Figure 1 at 15. The wheel and axle assembly is preferably driven from the engine through the intermediary of the driving quill 16, which surrounds the axle and is provided with resilient driving connections with the wheels 15, all substantially in the same manner as shown in my Patent No. 2,214,424. A main supporting crank case casting 18 houses the driving gearing and is suitably supported from the trucks as by means of the bracket portions 19 and 20 formed at the ends of the casting. Suitable bearings (not shown) are provided between the intermediate portion of the casting and the quill 16.

At an intermediate point transversely of the locomotive, the quill 16 carries a gear 22 to which it is adapted to be automatically clutched for affording a driving connection in either direction, and for permitting over-running of the axle and quill when the speed of the locomotive is greater than that of the engine. One such clutching mechanism is fully described in my above mentioned copending application. The gear 22 is continually in mesh with the driving gears 23 carried upon the crank shafts 25, which are supported upon bearings 26 in the crank case. The crank portions 27 of the crank shafts are provided with suitable connecting rods 28 which are pivotally connected by conventional means to the pistons 30 which are adapted to move within the engine cylinders 12. The cylinders 12 are bolted to the main supporting casting 18 as shown at 31. It will be seen from the first two figures of drawings that the cylinders and pistons upon one side of the center line of the axle are associated with one of the crank shafts and the pistons working in the two cylinders on the other side are connected to the other crank shaft. The cranks of each of the crank shafts are disposed at an angle of 180° with each other and the opposite cranks of the two crank shafts are 90° out of phase. This, of course, means that there will be four strokes or impulses delivered by the engine, 90° apart, during each crank shaft revolution.

As already pointed out, the engine is of the single stroke uniflow type, and it will be seen that each cylinder 12 and lining 33 is provided with a series of registering exhaust ports 34 which provide communication between the interior of the cylinder and the exhaust manifold 35 when the ports 34 are uncovered by the piston 30 at a point in its downward stroke. Admission of motive fluid is controlled by a novel balanced rotary admission valve 40 which is received within a cylindrical chamber or seat 41 formed in the head 42 of each of the cylinders 12. Live steam manifolds such as indicated at 44 in Figure 2 of the drawings provide access for the steam to the openings 45 in one end of each of the chambers 41. Horizontally elongated slots or ducts 46 formed in the cylinder heads 42 provide communication between the valve chamber 41 and the interior of the cylinder.

The valves 40 themselves are in the form of hollow cylinders open at the ends and provided with oppositely disposed elongated slots 47 and 48 in their walls. Transverse intermediate strengthening webs or braces 49 are formed within the cylindrical valve body and a similar bracing rib 50 is provided at the inner end of the valve 40 remote from the steam inlet 45. Formed rigidly with this cross brace 50 is the valve shaft 52 which projects through the stuffing box 53 of the cylinder head casting, the valve shaft 52 is provided with suitable packing (not shown), and a collar 54 on the shaft preferably seats against an annular shoulder 55 formed at the base of the box 53.

In Figure 5 of the drawings the slot 47 of the valve 40 is in full registry with the admission duct 46, and obviously in this position the admission valve is wide open and steam is being admitted to the cylinder. In Figure 6 the valve 40 is shown in partly closed position in which the slot 47 is partly in registry with the duct 46 and partly overlying the inner wall of the recess or seat 41. In Figure 7 the valve is closed, the slot 47 being completely covered by the inner wall of the seat 41 and communication being completely cut off with the interior of the cylinder. Under all these conditions the valve 40 is in a completely balanced state radially, on account of the balancing effect of the oppositely disposed slots 47 and 48. No matter whether the interior of the hollow cylindrical valve member 40 is subject to the static pressure of the steam as in Figure 7 or subject to any reaction pressures of the admission flow of the steam as in Figures 5 or 6, the slot or opening 47 is always balanced by the opposite opening or cut-away portion 48 of equal size and dimensions.

Furthermore, under these same conditions the only unbalanced surface of the valve subjected to axial steam pressure is that indicated by the small arrows *a* in Figure 3. This area is quite negligible and the slight pressure tending to move the valve body axially will only aid in maintaining the collar 54 against the shoulder 55 and holding the valve in its properly seated position. The numerals 58 indicate openings in the cylinder wall for the application of a pressure lubrication system of any suitable or conventional type.

The means for operating the valves in timed sequence and in accordance with the desired cut-off, will now be described. Each of the valve shafts 52 projects from the cylinder heads as clearly shown in Figures 1 and 2 of the drawings and carries upon its end the gear segment 60 which meshes with the rack teeth 61 formed on the reciprocatable shaft or bar 62. This shaft 62 forms the movable core of the solenoid magnet 65 which, when energized, serves to reciprocate the shaft 62 against the resistance of the return spring 66 which is contained within the cylindrical housing 67 and is adapted to be seated between the head 68 of this housing and the disc 69 carried by the end of the shaft 62. The rack teeth 61 of the shaft 62 meshing with the segment 60 carried by the valve shaft 52 cause the valve to be rotated to open position upon ener-

gizing the solenoid 65. Upon de-energizing the solenoid the spring 66 serves to immediately return the valve to closed position. The electromagnetic properties of the solenoid and the resilient characteristics of the spring 66 are so selected that very rapid cycles of opening and closing movement of the rotary valve are permitted.

Timing devices for intermittently and successively operating the four valves of the engine at their proper phase intervals—which in this case are 90°—are provided as follows. A timing gear 70 is disposed above the gear 22 and in mesh therewith, the gear 70 being of the same diameter as the driving gears 23 carried by the crank shafts. The gear 70 is centered upon a timing shaft 72 which is supported for rotary movement in either direction as by means of the bearings 73, the gear 70 and the intermediate portion of the shaft 72 being enclosed within the housing 74.

The shaft 72 is provided with two cylindrical portions or drums 75 upon the periphery of which are provided areas of conducting and non-conducting materials. Pairs of diametrically opposed brushes or contacts 76 are respectively carried by the rings 77 which surround each of the drum portions 75 and are connected by the U-shaped yoke 78 for synchronous movement axially of the drums. An electric motor 80, which may be conveniently supported upon the casing 74 as at 81 is adapted to rotate the screw shaft 82 by means of the gears 83. A threaded sleeve or traveler 85 is carried by the screw shaft 82 and is rigidly connected with one or both of the rings 77 as by means of the arm 86. It will be readily perceived that upon actuation of the electric motor 80 for predetermined periods of time, the contact carrying rings 77 will be moved longitudinally of the drums 75 for corresponding predetermined distances.

One arrangement of conducting and non-conducting patterns on the drums 75 is shown in Figure 8 of the drawings which illustrates one of the drums 75 as developed upon a plane. A stepped conducting area 88 provides contact means for actuating the valves at varying percentages of cut-off in a forward direction, and a stepped conducting area 89 is provided for performing a similar function for reverse speeds of the engine.

The percentage of the working stroke during which the steam is admitted is indicated opposite each of the steps of the areas 88 and 89 and it will be seen that upon a movement of the contact brushes 76 longitudinally of the drums 75 they may be brought opposite any desired one of these steps. It will be noted that the brushes 76 upon a given ring 77 are disposed 180° apart and wires will of course be carried from these brushes or contacts to the respective valve actuating solenoids of the cylinders upon one of the respective crank shafts 25. It will also be noted that the contact patterns upon the respective drums 75 are arranged 90° out of phase so that the timing of the valves of the cylinders on opposite crank shafts will be accordingly effected. A space 90 is provided between the contact areas 88 and 89 on each of the drums 75 which affords a neutral zone which when occupied by the contacts 76 will ensure that all of the solenoids are de-energized and all of the valves are closed.

In Figure 9 there is shown a wiring diagram in which one of the main leads *c* is connected with the contact areas 88 and 89 on the drum 75 and the other lead *d* is connected with one end of each of the windings *e*, and *f* of one pair of solenoids, and the wires *g* and *h* connect the respective brushes 76 with the other ends of the solenoid windings.

It is obvious that with the electrical controls which have been described, all of the engines of the locomotive may be very conveniently controlled from the cab of the locomotive by means of a series of push-buttons or other electrical switching arrangements. In Figures 10 of the drawings a suggested diagrammatic installation is shown in which each of the controlling motors 80, of the several engines of the locomotive may be operated to any desired exten in either direction along the drums 75 to position the brushes adjacent the contact areas for affording the desired percentages of cut-off. In this diagram, the field coil of a motor is represented at *m*, and the armature winding of the motors may be set for reverse operation by means of the reversing switch indicated at R. For energizing the motors for operation to an extent which will bring the contacts to the desired step on the drums 75, a series of switches S, S', and S'', etc., are provided in each one of the mains L leading to one of the motors, and these switches may be automatically timed by any conventional electrical or mechanical means so that a single manual actuation of a selected switch will cause the motor to run until the contacts 76 have been brought to the desired point along the drums 75 to attain the desired cut-off. Time-delay switches suitable for use in this connection are well known in the art and need no detailed description. Any conventional means for causing the switch to remain closed for a predetermined period such as springs, dash-pots or electrical means are, of course, suitable for use in this connection. Other electrical circuits including "on" and "off" switches may be provided in order to enable the engine driver to selectively cut out any one or more of the engines of the locomotives under certain conditions of operation.

It will be seen that by means of the present invention there has been provided a very effective and novel arrangement for the efficient control of the engines of a multi-engined locomotive, by the provision of electromagnetic timing and actuating devices for a novel balanced rotary admission valve. It will also be noted that special advantages accrue through the combination of these features as well as from the particular novelty and effectiveness of the individual elements thereof.

Various changes and alterations may be made in the embodiments illustrated and described herein without departing from the scope of the invention as defined by the following claims.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. In a locomotive, in combination, a multi-cylinder uniflow steam engine, each cylinder having a rotary balanced admission valve at one end thereof and a piston adapted to reciprocate within said cylinder, driving connections between the pistons and the wheels of the locomotive, solenoids for actuating the admission valves, a commutator adapted to be rotated by said driving connections in synchronism with the cycles of said engine, and adjustable brushes adapted to contact said commutator for intermittently energizing the solenoids, and an electric motor for moving said brushes with respect to said com-

mutator for selectively varying the timing of the energizing of the solenoids to vary the cut-off of said admission valves, and time delay switches disposed so as to be under the control of the engineman and energizing said motor for predetermined periods of time to move the brushes corresponding distances along said commutator to select the timing intervals.

2. In a locomotive, in combination, a plurality of multi-cylinder uniflow steam engines, each cylinder of each engine having an admission valve at one end thereof and a piston adapted to reciprocate within said cylinder, driving connections between the pistons and the adjacent wheels of the locomotive, electromagnets disposed adjacent the admission valves for actuating the same, automatically operated electrical switching means on said engines for intermittently energizing the electromagnets, electrical means also disposed adjacent said engines for selectively varying the timing of said switching means, and a plurality of switches disposed so as to be under the control of the engineman for actuating said electrical means for selectively controlling the operation of any or all of said engines.

3. For use in connection with a steam engine of the class described, which comprises a cylinder and a piston reciprocable therein, an admission valve on said cylinder and an electromagnet for actuating said valves, a source of current for said electromagnets, and an electrical circuit connecting said electromagnets and said source of current; the combination of a variable switching device in said circuit for regularly and intermittently energizing said electromagnet, said device comprising a commutator drum having a conducting surface thereon arranged in a stepped pattern, means for rotating said drum in synchronism with a driven element of said engine, a contact brush adjustable along said drum to make electrical contact with said surface of a timing and duration depending upon the extent of the portion of said conducting surface adjacent which the brush is positioned, means for adjusting said brush along said drum comprising a carrier for said brush, a worm shaft, a traveller connected to said brush carrier and threaded upon said worm shaft, an electric motor for rotating said worm shaft and thus causing the traveller and the brush carrier to move longitudinally of the drum, and remote control means for said motor.

4. In a locomotive of the class described, in combination, a high-speed uniflow steam engine having a pair of cylinders and a piston reciprocable in each, cranks adapted to be driven by said pistons and disposed 180° out of phase, an admission valve on each of said cylinders and an electromagnet for actuating each of said valves, a source of current for said electromagnets, an electrical circuit connecting said electromagnets and said source of current, and a variable switching device in said circuits for regularly and intermittently energizing said electromagnets, said device comprising a commutator drum having a conducting surface thereon arranged in a stepped pattern, means for rotating said drum in synchronism with a driven element of said engine, a pair of contact brushes adjustable along said drum to make electrical contact with said surface of a timing and duration depending upon the extent of the portion of said conducting surface adjacent which the brushes are positioned, each of said brushes respectively connected with one of said electromagnets, said brushes being disposed at 180° intervals around said drum corresponding with the phase relationship of said cranks, and means for adjusting said brushes along said drum.

5. In a locomotive of the class described, in combination, a high-speed uniflow steam engine having four cylinders arranged in pairs, a pair of crank shafts, means operatively connecting said crank shafts with a driving member, a piston adapted to reciprocate in each of said cylinders, the pistons of each of said pairs of cylinders being connected with cranks on the same crank shaft which are 180° apart, the two crank shafts being positioned at 90° apart, whereby the pistons are adapted to deliver four strokes 90° apart during each complete rotation of said crank shafts, an admission valve disposed at one end of each of said cylinders, electromagnets for actuating said valves, a source of current for said electromagnets, an electrical circuit connecting said electromagnets and said source of current, and a variable switching device in said circuits for regularly and intermittently energizing said electromagnet, said device comprising a pair of axially aligned commutator drums mounted for rotation about their axis in synchronism with said driven member, each of said drums being provided on its cylindrical surface with a peripherally discontinuous conducting area of a stepped pattern, the areas of the respective drums being identical but angularly displaced about the drums through 90°, a pair of diametrically oppositely disposed contact brushes movable longitudinally of each of said drums but held against rotation, and means for adjusting said pairs of brushes along said drums to provide contacts with said conducting surfaces of variable timing and duration, and thus controlling the timing and cut-off of said valves, the brushes of each pair being connected in circuits with the electromagnets associated with the valves of the cylinders adjacent one of said crank shafts.

6. In a steam engine of the class described, in combination, four vertically disposed uniflow cylinders arranged in pairs, a pair of crank shafts, means operatively connecting said crank shafts with a driving member, a piston adapted to reciprocate in each of said cylinders, the pistons of each of said pairs of cylinders being connected with cranks on the same crank shaft which are 180° apart, the two crank shafts being positioned at 90° apart whereby the pistons are adapted to deliver four strokes 90° apart during each complete rotation of said crank shafts, a rotary admission valve disposed at one end of each of said cylinders, a solenoid for rotating each of said valves from closed to open position, a spring for closing each valve, a source of current for said electromagnets, an electrical circuit connecting said electromagnets and said source of current, and a variable switching device in said circuits for regularly and intermittently energizing said electromagnet, said device comprising a pair of axially aligned commutator drums mounted for rotation about their axis in synchronism with said driven member, each of said drums being provided on its cylindrical surface with a peripherally discontinuous conducting area of a stepped pattern, the areas of the respective drums being identical but angularly displaced about the drums through 90° a pair of diametrically oppositely disposed contact brushes movable longitudinally of each of said drums but held against rotation, and means for adjusting said pairs of brushes along said drums to provide contacts

with said conducting surfaces of variable timing and duration, and thus controlling the timing and cut-off of said valves, the brushes of each pair being connected in circuits with the electromagnets associated with the valves of the cylinders adjacent one of said crank shafts.

7. In a steam locomotive of the class described, a driving unit comprising a wheel and axle assembly, a motor frame surrounding said unit, a pair of crank shafts having bearings in said frame and disposed one upon each side of the axle, parallel therewith and geared thereto, a pair of cranks on each of said crank shafts, four vertically disposed uniflow cylinder and piston assemblies secured to said frame and positioned one above each of said cranks and operatively connected therewith, a rotary balanced steam admission valve in each of said cylinders, electromagnetic means for actuating said valves, timing means for energizing said electromagnetic means at proper intervals for the actuation of said valves for the desired cut-off, said timing means comprising commutator means rotatably mounted between opposite pairs of said cylinders, parallel with and geared to said axle assembly to rotate in synchronism therewith, and a remote control means for adjusting said commutator means.

8. In a steam locomotive of the class described, a driving unit comprising a wheel and axle assembly, a motor frame surrounding said unit, a pair of crank shafts having bearings in said frame and disposed one upon each side of the axle, parallel therewith and geared thereto, and set in phase relationship 90° apart, a pair of oppositely extending cranks on each of said crank shafts, four vertically disposed cylinder and piston assemblies secured to said frame and positioned one above each of said cranks and operatively connected therewith, a steam admission valve in each of said cylinders, electromagnetic means for actuating said valves, and timing means for energizing said electromagnetic means at proper intervals for the actuation of said valves for the desired cut-off, said timing means comprising a commutator shaft rotatably mounted between opposite pairs of said cylinders, parallel with and geared to said axle assembly to rotate in synchronism therewith, a pair of axially aligned commutator drums on said shaft, each having a valve timing contact pattern thereon, one of said patterns being angularly offset by 90° from the other, a pair of diametrically opposed brush contacts movable longitudinally of said drum surfaces, a common carrier for said pairs of brush contacts, and an electric motor and transmission for shifting said brush carrier to adjust the cut-off of said valves, the brushes of each pair being respectively in circuit with the electromagnetic operating means for the valves of the cylinders associated with one of said crank shafts.

9. In a steam engine of the class described, in combination, a cylinder and a piston adapted to reciprocate therein, a rotary admission valve in said cylinder, a shaft extending axially from said valve, a gear segment on said shaft, an axially reciprocable rod having rack teeth thereon with which said segment is in mesh, a solenoid winding surrounding said rod, and means for energizing said solenoid winding to reciprocate said rod and actuate said valve.

10. In a steam engine of the class described, in combination, a cylinder and a piston adapted to recprocate therein, a rotary admission valve in said cylinder, a shaft extending axially from said valve, a gear segment on the end of said shaft, an axially reciprocable rod having rack teeth at an intermediate point thereon with which said segment is in mesh, a solenoid winding surrounding one end of said rod, means for energizing said solenoid winding to reciprocate said rod and actuate said valve, and a coil spring operatively engaged with the other end of said rod and adapted to urge the rod in a direction opposite to that in which it moves under the influence of said solenoid winding.

JOHN A. McGREW.