UNITED STATES PATENT OFFICE.

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TRACTION-POWER SYSTEM.


To all whom it may concern:

Be it known that I, RICHARD VOSBRINK, a citizen of the United States, and a resident of Oakland, county of Alameda, and State of California, have invented a new and useful Traction-Power System, of which the following is a specification.

A consideration and study of the present steam locomotive as a common carrier presents certain conditions which are indicative of the economic limitations of this type of equipment. The limitations of the steam locomotive are to a certain extent being taken care of by electrification and by the motor truck as a transportation medium.

No particular one of these methods of transportation has inherently the ability to supersede entirely requirements of the other, and therefore they represent an enormous economic waste which it is proposed to modify to some extent by a new type of common carrier which will embody in its design and in its construction certain features permitting its operating and its use over a much wider latitude or range of usefulness. Together with a very large reduction in the cost of upkeep and operation.

The steam locomotive is the only type of equipment at the present time that is suitable for long hauls. The cost of operation however, is very great, and its efficiency, when comparing the power generated to the power utilized, is very low. Owing to the physical limitations it is not practicable to use it for other purposes than those in which it at present occupies the entire field. For short hauls and for city and street railway transportation, electric systems are at the present time most extensively used. Their limitations also represent an economic waste that cannot be overcome in that type of equipment, such as the enormous power loss due to the continuous stopping and starting of electric cars and the consequent drain and loss of power occurring at these times, together with the material depreciation represented by worn brake shoes and other items of upkeep due to the method of operation of this type of equipment.

In the system to be presently described, it is proposed to incorporate certain ideas which will permit this type of equipment being utilized for the long hauls now being made by the steam locomotive, at a very much increased efficiency; that is, the power generated will be applied in useful work to an extent impossible in the present steam locomotive. Its mobility will be increased so that its operation for city and street railway transportation will not only be equal to, but superior to, electric equipment, as there will be no physical limitations barring its use for this purpose and also it will be far more economically efficient as certain features of the system are such as to overcome entirely the economic loss caused by starting and stopping and also the depreciation and consequent cost of upkeep will be very much less, as the wear and tear caused by the braking action, and the enormous torque re-actions that take place when starting and stopping will be obviated.

It is an object of the invention to provide such an improved traction power system as will have an economy and facility of operation so great that its use for short haulage will be such as to enable the system to replace the present trend to utilize motor trucks for short hauls, and to provide an improved system so much more economical that it will be advantageous to lay rails for the system and more inexpensive than it will be to construct and repair concrete highways.

Among the more general objects of the invention are to provide a power plant efficiently operative on a low grade fuel, to reduce the operating cost to a minimum; to provide a power plant having a mechanical efficiency of at least thirty per cent as compared with the present four or five per cent of the steam locomotive; to eliminate the necessity of maintaining a reserve energy such as steam in a boiler as required in operating a locomotive, by the utilization of certain forces to create a reserve energy for starting purposes of the power plant of the system; the application of power in such a manner that all torque re-actions will be absorbed by driving wheels of a locomotive utilized in the system; to accelerate and retard without necessity of inverting to any kind of reduction gearing whatever; to secure retardation with a minimum of wear on brake shoes and other elements of the system. Further it is an object to prevent excessive waste of power in starting by conserving force utilized in bringing the load to a stop and using the force to again put the load in motion; to provide unlimited flexi-
bility of operation in either direction with equal flexibility, and to provide a traction system without physical limitations as to size, gauge, weight, or power thus permitting its use for street cars as well as for passenger and freight service on long and short hauls.

A further object of the invention is to provide, in a system utilizing a locomotive, for ease and simplicity of operation and control equal to that of an electric system.

More particularly it is an object of the present invention to provide in a traction system, a type of locomotive having a power plant of such construction, design and arrangement as to be operative as a prime mover consuming a fuel of minimum cost for the movement of the load as for instance in railway transportation service and which power plant may be utilized as means for absorbing kinetic energy of the moving load and also utilize the force of gravity to serve both as a means for retarding the movement of the load in assistance with the usual or any desired brake mechanism, and as an apparatus for storing air which, it is an object of the invention, to use conversely, for starting the locomotive and its load thereby materially reducing the cost of operation of the locomotive and also reducing the cost of maintenance by decreasing the ordinary wear incident to the application of brakes for the purpose of retarding the movement of the load.

It is another object of the invention to provide for the constant reduction of the temperature of air as it is compressed when the power plant of the locomotive is being utilized as an air compressor so that the air capacity of a receiver may be increased.

It is a further object of the invention to utilize for the normal driving of the locomotive, a power plant having the characteristics of either Diesel or semi-Diesel, or surface ignition or oil engine of any suitable number of units because of their high efficiency and minimum cost of operation, and further to provide in combination means for directly connecting the power plant to driving wheels of a locomotive so that there will be a direct application of power from the plant to the drivers without increment or decrement relatively of the cycles of the units of the plant and of the driving wheels.

A further object in using a power plant of the internal combustion engine type in the propulsion of a locomotive is to increase the operating efficiency of the system by causing the hot exhaust gases coming from the engine to heat suitable means through which air coming from the compressed air receiver passes on its way to the engine and is therefore heated with a resultant increase of the pressure of the air in the air system and the application of a greater force in the starting of the locomotive.

In addition to utilizing in a locomotive a power plant of the oil burning type it is further an object of the invention to provide for the use of an engine operative by compressed air to start the locomotive either in a forward or in a reverse direction of movement, and to provide a simple manually controlled means for selectively controlling the operation of the power plant either as an air compressor operated by kinetic energy of the moving load or to utilize the pressure stored by such energy in again starting the load and to provide for the ready conversion of the power plant from an air operated motor into a combustion engine for normal driving purposes.

It is a further object of the invention to provide for the utilization in the improved traction system of a combination of old and well known and practicable, efficient, substantial and effective means in the control of and for operating the locomotive, and it is therefore an object of the invention to utilize a standard reverse link-train mechanism of the locomotive service type for controlling the direction of drive of the locomotive by the regulation of the position and operation of the valves of the power plant when the latter is serving as an air engine and it is also an object to provide means in combination with such locomotive reverse link-train for preventing the operation of the valves controlling the passage of air to and from the units of the motor when the latter is being utilized for its normal purpose as a combustion engine. Again it is an object of the invention to utilize standard locomotive truck structure and drive means connecting the driving wheels of the locomotive to the power plant.

It is another object of the invention to provide a new combination of means whereby the reciprocating movement of the pistons of the units forming the power plant is translated into oscillating motion and then again translated into rotary motion at the driving wheels of the locomotive. It is a further object of the invention to provide a power plant having a plurality of power units which are so connected to the driving wheels of the locomotive that there will be as many impulses transmitted to the driving wheels during one rotation of the latter as there are power units in the plant, and further it is an object to provide for the prevention of the occurrence of a concurrent dead-center in the transmitting means connected to the driving wheels.

A further object of the invention is to provide a prime mover having a plurality of power units set in a peculiar arrangement to secure a compact organization and a good balance in the distribution of the weight of
the power plant to the frame and running gear of the locomotive and in the distribution of power to the driving wheels.

The invention possesses other objects and features of advantage, some of which, with the foregoing, will be made manifest in the following description of the preferred form of the invention which is illustrated in the drawings accompanying and forming part of the specification. It is to be understood that it is not intended to limit the invention to the embodiment shown by the said drawings and description as variations may be adopted within the scope of the invention as set forth in the claims.

Referring to the drawings:

Fig. 1 is a side elevation of a type of locomotive involving the invention.

Fig. 2 is a plan view of the power plant and running gear of the locomotive.

Fig. 3 is a section on a vertical plane on line 3-3 of Fig. 2.

Fig. 4 is a vertical section on line 4-4 of Fig. 2.

Figs. 5 and 6 are detail sectional views showing the throw-out means of the air valve opening levers.

Fig. 7 is a detail of the valve cam rod.

Fig. 8 is a sectional detail of one of the master air valves showing it in the exhausting position.

Fig. 9 is an elevational view illustrating a form of air cooling means and receiver.

The type of locomotive herein illustrated includes a suitable frame structure indicated at 2 that preferably is connected by means of equalizing springs 3-3 to axles 4 and 5 having suitable journal boxes appropriately mounted in the frame structure 2; the axle 4 in the present case being provided with twin wheels 6-6 rigidly secured by means of the axle so as to turn in unison and which become the drivers to which power is transmitted from the power plant of the locomotive. The front axle 5 is provided with track wheels 7-7 and these may be connected in the usual manner to the driving wheels 6-6 if so desired, but not so here shown. The driving wheels 6 are provided with respective crank pins 8-8 that are disposed with respect to each other at 90 degrees, in an arc concentric to the center or axis of the axle 4, and mounted on the crank pins 8 are main rods or links 9-9 in this case extending forwardly from the driving wheels which may be considered the rear wheels of the illustrated locomotive.

The power plant.

The power plant for driving the driving wheels includes a set of driving arms 10 in the form of levers extending radially from respective shafts 11 and to the outer ends of which arms the driving links 9 are pivotally connected as at 12, the swinging ends of the driving arms 10 moving in respective arcs about the axes of their shafts 11, which are coaxial, the arcs being equal in length to the diameter of the circle or orbit of movement of the crank pins 8 of the driving axle 4.

It is apparent that because of the angular offsetting of the crank pins 8 about the axis of the shaft 4 the rock shafts 11 to which the power arms 10 are connected must be free of each other to oscillate independently to and fro between the positions indicated by the dotted lines, A and B, Fig. 1.

The coaxial rocker shafts 11 constitute parts of independent drivers each including a walking beam of lever 13 rigidly secured or formed on its respective rock shaft 11 which latter is provided with bearings in a chamber or casing 14 constituting a base 85 for the power plant units. Each walking beam or lever 13 is composed of substantially equal, opposite arms 13a the outer ends of which are pivotally connected at 15 to the lower ends of connecting rods 16 at attached at their upper ends to respective pistons 17 operative in cylinders 18 disposed in parallel relation to each other and in tandem relation to the walking beam 13 of rock shaft 11 so that when the pistons are driven by pressure within their respective cylinders 18 the reciprocating motions of the pistons 17 are translated into oscillating motion by the walking beam or lever 13 which constitutes, in connection with the rock shaft 11 and its attached power arm 10, a driver connected by its respective main link 9 to a driving wheel of the locomotive.

The tandem units of a respective driver 105 are disposed in upright position upon the casing 14 the top of which is provided with clearance apertures 14a through which work the connecting rods 16 and, as there are two independent drivers with coaxial shafts 11 110 employed in the illustrated locomotive there is a plurality of pairs of tandem motor units, these pairs being disposed in parallel relation on the top of the casing 14 as clearly seen in Fig. 2, and the casing is divided into 115 separate compartments as by partition wall 14b forming a compression chamber beneath the tandem pistons 17 of each driver.

Preferably the power plant is of the internal combustion unit type and of the 120 Diesel or Semi-Diesel principle of operation in which the pistons 17 operate on the two-stroke cycle and receive a power impulse on one stroke of each cycle.

In the form of engine shown each cylinder 125 der 18 is provided with a water jacket 19 and at suitable points each cylinder has an air intake port 20, and an exhaust gas port
10 these ports being uncovered by the down-
ward movement of piston 17 in a respective
cylinder 18 so that a consumed charge will
be expelled from the cylinder by the ex-
posure first of the exhaust port 21, Fig. 3,
and subsequently a fresh charge of air is
admitted by the downward moving piston
in uncovering the port 20 which is shown as
provided with a duct or communicating
passage-way 22 leading into the compres-
sion chamber within the casing 14. On the
upward stroke of the piston 17 a fresh
charge of air is compressed in the cylinder
after the exhaust port 21 thereof is closed
by the upwardly moving piston and at a
suitable moment a combustible charge of oil
is injected into a combustion chamber of a
unit as by means of a fuel injector 23 in
this case shown as arranged in what is
termed “the hot ball” 24 at which the in-
jected charge of oil is ignited and the ex-
panding gases from combustion pass into
the expansion chamber above the piston 17,
the resultant pressure reacting on the latter,
the power being transmitted through the
driver and power arm 10 to a driving rod
or link 9 of a driving wheel. The speed of
the motor may be controlled in a manner
usual to Diesel engines as for instance by
the use of a manual or automatically con-
trolled throttle for varying the amount of
oil supplied to the fuel injectors by the
usual force pump and may be operated by
suitable connection with any part of the
moving mechanism of the engine in an ob-
vious manner not necessary to be here
shown.

Since the drive wheel crank pins are at
90° to each other, one or the other of the
drive rods will always lead, and as the
power arms 10 are at right angles to their
levers 13 their motions will be relatively
unsymmetrical so that when the pistons of
one pair of units are at the extremities of
their strokes, the other pistons are midway
their strokes.

Starting Apparatus

For the purpose of starting the locomotive
in either a forward or a reverse direction
when utilizing an oil burning engine of the
type as here described preferably a source
of energy, such for instance, as a receiver
for compressed air is employed; the receiver
being so connected to the units of the power
plant that expansive fluid such for instance
as compressed air can be admitted into the
cylinders of the unit to drive the pistons
until the locomotive is started up after
which time the starting apparatus may be
cut out and the motor converted into a type
operative on the combustion principle.

To that end each of the cylinders 18 of the
power plant is provided with head struc-
tures having valve means including inde-
pendently operative inlet and outlet valves
for each cylinder and including means for
mechanically operating the valves which
preferably are of the semi-automatic or self-
seating type. As illustrated in Fig. 4, each
cylinder head 19 is provided with a valve
chamber 25 having on its lower end a seat
28 to be engaged by a valve head 27 having
a stem 28 extending upwardly through a
guide or bearing 29 about which is provided
a spring 30, normally compressed and react-
ing against a collar or member 31 secured
on the upper end of the valve stem 28 so
that the valve head 27 is normally auto-
matically pressed toward its seat 26. The
valve 27 of which there is one in each cylin-
der 18 may be considered a starting pressure
inlet valve, in one of its functions, and also
forms an air suction valve in another of its
functions according to the selected purpose
of the units of the power plant as will be
further set forth. The pressure starting
fluid valve chambers 25 of one set of the
units are connected to a common manifold
32, Fig. 2, in which there is arranged a
master valve 33 which, when set in one posi-
tion, opens communication to the manifold
32 with a service pipe 34 connected to the
storage energy or compressed air receiver
35, Fig. 1, while the starting pressure cham-
bers 25 of the other set of units are similarly
connected to a manifold 36 in which there
is a master valve 37 controlling communi-
cation from a service pipe 34' also connected
to the compressed air receiver 35; the master
valves 33 and 37 including closure members
are provided with levers 38 connected by a
common link 39 that is operable by manual
or mechanical means that may be extended
for instance in the form of a link and lever
mechanism 40 having a part conveniently
disposed for operation by the engineer or
motorman.

Assuming that a suitable degree of pres-
sure of compressed air has been attained
in the receiver 35, as for instance by the
operation of an auxiliary engine and com-
pressor operated thereby, then when it is
desirable to start the locomotive the engineer
or motorman has but to throw the concur-
rently operable master valve levers 38 by
means of the mechanism 39 to open commu-
nication between the service pipes 34—34'
and the manifolds 32—36 admitting air
under pressure to the starting valve cham-
bers 25 with the result that when the start-
ing valves 27 are opened, pressure will be
applied to the respective pistons 17 and
power transmitted therefrom through the
driver to the driving wheels of the locomo-
tive. For the purpose of preventing back
pressure against the pistons when the power
plant is being utilized as an air engine, ex-
haust valve means are provided for each of
the cylinders and such means include a valve
organization in each cylinder head 18 of substantially similar construction as that just described with relation to the starting inlet valves. The starting exhaust valve in each cylinder head includes a chamber 45 having at its inner end a seat 46 to be engaged by the valve head 47. Fig. 3, which is provided with an upwardly extending stem 48 having on its upper end a shoulder 49 against which bears a reacting spring 50 surrounding the valve stem guide or bearing 51 so that the valve head 47 is self-seating.

In the operation of the power plant as an air engine for starting the locomotive, as soon as the master valves 33 and 37 are opened air under pressure enters the cylinders 18 through the air inlet valves 27 until the completion of the power stroke of each of the pistons 17 whereupon the air exhaust valves 37 are mechanically opened to permit the exhaust of air without back pressure.

The starting valve operating mechanisms.

A feature of the present invention is the combination of a well known type of locomotive valve operating mechanisms with and for operating the air inlet and exhaust valves when the engine is being operated as an air power plant and also to utilize such type of link operating mechanism that is capable of being set or adjusted to secure a reversal of the operation of the valves and therefore to control the direction of movement of the locomotive in starting up. One adaptation of a practical and well known type of valve operating linkage is here represented as including link trains for each driving wheel 6 of each of said trains including a small slotted link 55 pivotally interchanging their lengths as at 56 and connected at a swinging end by a connecting rod 57 to an eccentric pin or crank device 58, in this case having an arm 59 rigid with the crank pin 8, one for each driver 6 as above stated. Therefore as the eccentric pin or part 58 rotates with the driver 6 the link 55 is oscillated and this oscillating motion is transmitted by a link 60 to what is termed the combination lever 61, which latter is pivoted at 62 upon the face of the power arm 60 of one of the drivers. The connecting link 60 is pivotally connected at 60' to the lever 61 while the opposite end of the link 60 is provided with a slide 63 shiftable in the oscillating link 55; the slide 63 being movable from either end of the reversing link 55 to a position coincident with the pivot 65 at which time it is obvious that the continued oscillation of the link 55 would occur without actuating the link 60. To shift the slide 63 of the link 60 along the oscillating link 55 there is attached to the link 60 an upwardly extending link 64 which is connected at 65 to one arm 66 of a bell crank 67 pivoted at 68. The bell crank is manually operable through means of a link 69 extending rearwardly to the engineer's station where there is provided a lever 70 for operating the reverse gear. The swinging end of the combination lever 61 is slotted at 61' to receive a pin 72 or be otherwise connected with the lower arm 73 of a lever having an upwardly extending arm 74 which is pivot at 75; the pivot 75 being disposed at a point diametrically opposite to the intermediate portion of the arc through which the pivot 62 of the combination lever 61 swings.

The lever arm 74 is operatively connected with a cam rod 76 as for instance by a pin and slot connection 77 so that the cam rod will be reciprocated in appropriate bearings 78 and cause cams 79 and 80, Fig. 7, to engage adjacent cam rollers provided on the contiguous ends of valve operating rods 81 and 82. There is a pair of these rods for each power unit and obviously a pair of cams 79 and 80 is provided adjacent each end of the cam rod 76 so that each rod is capable of operating two sets of valve mechanisms. The upper end of each valve rod 81 is pivotally connected at 83 to a valve lever 84 having a tappet arm 85 arranged above the upper end of the valve stem 28 for instance, of the air inlet valve of the cylinder of a power unit. In a similar manner the upper end of each valve rod 82 is pivotally connected at 86 to a valve lever 87 having a tappet arm 88 disposed above the contiguous end of an air exhaust valve stem 48.

The cams 79 and 80 of each set are provided with oppositely inclined effective faces than an intermediate portion of the rod exposed having a given length slightly greater than the distance between the centers of the respective rods 81 and 82 so that when the cam rod 76, is reciprocated by the operation of the lever 74, the rod and its cams cause the valve rods 81 and 82 to be alternately lifted and lowered, positively in one direction by the upward lifting action of the cam faces and automatically in the opposite direction by the recoil action of the respective springs 83 and 89 of the valves. It will be apparent that when the slide or block 63 of the valve link gear is set in alignment with the pivot 56 that there will be no movement of the link 60 but inasmuch as this link is connected to the combination lever 61 at a point below the pin 72 of the lower arm 73 there will be a slight oscillating movement of the levers 73-74 during the operation of the driving power arm 10 and it is desirable to negative this oscillating movement of the lever arm 74 when the starting air pressure has been turned off by shutting the master
valves and when it is desired to prevent the operation of the valve heads 27 and 47 in each of the cylinders. This result may be readily effected by mounting the valve levers 84—87 on eccentric portions 90 of respective pivot or rock-shafts 91 provided in bearings 92 on the heads of the engine units. There may be one rock shaft 91 for each tandem pair of power units, as shown in Fig. 2, and to secure the concurrent action of these rock shafts 91 to turn the same a sufficient degree about their axes to lift the levers 84—87 from a position shown in Fig. 6, where they are operative on their respective valve stems, to a position shown in Fig. 6 where the lever becomes inoperative, the rock shafts 91 may be interconnected by any suitable means. Such means may include pinions 93, engaging gears 94, secured on a transverse shaft 95 to which may be attached any suitable manual operating device as a lever for convenient operation by the engineer.

**Air compressing mechanism.**

While it is a feature of the invention to provide a power plant incorporating engine units operative on the internal combustion engine principle and to provide means for converting a combustion engine into an air engine operative by compressed air, it is a further feature of the invention that the kinetic energy in combination, sometimes, with gravity be utilized through means of the engine to store energy in the form of compressed air for starting and braking purposes in the operation of the locomotive and its load, and especially to utilize this energy storing mechanism that it will further serve in co-ordination with the usual brake mechanism of the locomotive and cars that may be attached thereto to reduce the speed of and stop movement of the locomotive and the load. Since in the present mechanisms the power plant is directly connected without an intermediate clutch to the drivers of the locomotive and so connected that there will be a cycle of operation in each power unit for each cycle of the driving wheels it will be seen that if air is admitted into the power unit on the down stroke of the pistons, obviously after the fuel supply mechanism has been set to cut off fuel, the admitted air will be compressed on the return stroke of the pistons driven by the kinetic energy of the load when the locomotive is traveling in a horizontal plane and further driven by the force of gravity if the track-way is inclined downwardly. Therefore means are provided for converting the power plant into an air compressor. This conversion is readily accomplished by the provision of suitable connections with the several valve chambers 45 so that air driven out of these chambers when the valves 47 thereof are open will be delivered into the receiver 35; such means also preferably being arranged in combination with the master valves 33 and 37 whereby, when it is desired to utilize the power plant as an air compressor the valves 33 and 37 will be moved to such position as to uncover ports 33a and 37a at the same time cutting off the admission of compressed air to the service pipes 34 and 34' thereby enabling the admission of air freely to the valve chambers 23 on the downward stroke of the several pistons. On the return or compression stroke of the pistons the valve heads 47 will be positively opened by the valve operating mechanism and the compressed air discharged from the valve chambers 45 into a manifold having a series of branches or arms 96, Fig. 2, converging toward a common valve chamber 97 in which is operable a valve 98 having a lever arm 99 shown as connected to the valve operating link 39. When the units of the power plant are selected for operation as an air compressor the valve 98 permits the discharge of the compressed air from the convergent branches 96 into a common conduit 100 connected to the air receiver 35. From this it will be seen that with the master valves 33 and 37 serving to open the air intake ports 33a and 37a air will be drawn into the chambers 18 on the suction strokes of the pistons 17, the valves 27 closed and the valves 47 opened to permit the discharge of the compressed air by the upward stroke of the pistons; the compressed air passing into the common conduit and thence to the receiver 35. On the other hand when the power plant is utilized as an air engine the master valves 33 and 37 with the valve 98 are so set by movement of the lever and link mechanism 39 as to admit compressed air from the service pipes 34—34' to the cylinders of the power plant and at this time the air ports 33a and 37a are cut off by the master valves but the valve 98 registers with an air exhaust port 101 to permit the ready discharge of exhaust air upon the return stroke of the several pistons when working as engines. As will be seen in Fig. 1, the cams 79—80 are so set on the cam shaft 76 that the respective valve rods 81—82 of a tandem set of power units will be alternately operated, that is, while an inlet air valve rod 81 is closed with respect to one cylinder, the rod 81 of the other cylinder as shown in the left of Fig. 1, is open at which time the valve rod 82 of each cylinder of a tandem set is held in lifted or lowered position in proper sequence with the valve rods 81.

When the power plant is being utilized as an air engine the master valves 33 and 37 are set in the open position by means of the manually controlled mechanism 39—40 and air passes through the service pipes 34—34' through the valves to the cylinders of the
units and at this time the rock shafts 91 of the several valve levers are set to bring the levers to valve operating position so that the levers will be actuated by the cam rod of each set of units to open the inlet and exhaust valves in sequence. When it is intended to utilize the motor for its prime purpose of operating as a combustion engine, the master valves are turned or set at a neutral position cutting off the flow of air from the service pipes 34–34 and cutting off flow through the manifold branches 86 by the neutral position of the valve 98 so that the power units can function properly as an internal combustion motor. When intending to reduce the speed or stop the motion of the locomotive and its load the engineer cuts off the fuel supply and throws the master valves 33 and 37 and the valve 98 to such position as to convert the units of the power plant into air compressors that are operated by the kinetic energy of the load and with the force of gravity in some cases, thereby recovering a portion of the energy consumed in starting the load by compressing air as a reserve of energy produced from the kinetic forces and incidentally causing the action in compressing the air to act as a brake to reduce the speed and stop, if desired, the motion of the locomotive.

**Air cooling and heating means.**

There are certain phenomena occurring with air when acted upon in a manner described, in appreciation of which, I adopt certain devices which will take advantage of these phenomena. For instance, when air is compressed isothermally, all the work which is done in compression is converted into heat and shows it by a rise in temperature of the compressed air. Air expands \(\frac{3}{27}\) of its volume for one degree rise in temperature at 32° Fahrenheit, and increases proportionately for every increase of 1° in temperature. The volume of air also varies inversely as the pressure. Therefore a container or reservoir will hold more air when the air is cold than when the air is hot, at the same pressure. To obtain the maximum holding capacity it becomes necessary to displace the generated heat that occurs when the compressing action is going on, so that the temperature of the air held in compression will be equalized to the surrounding atmosphere.

Different devices may be employed to secure this result, such for instance, as radiating means, or convection, or refrigerating means. For the present purpose it is preferred to disperse this heat by radiation as this method lends itself more readily to the system and as shown in Fig. 5, the air receiver preferably includes an initial compression chamber or tank 25 into which the air is compressed as it comes from the engine unit and passes through an intercooling coil 35 hence into a secondary storage reservoir 35° and through a second intercooling coil 35° and into a final storage receiver or tank 35° from which lead the service pipes 34 and 34°.

The heat which develops during compression and which is given up, or dissipated, is work lost or thrown away. When compressed air is utilized to operate a mechanism it gives up energy equal to the work done. If the air is cooled to that of the surrounding air and is then used for work, its temperature is still further reduced. Consequently the utilization of compressed air for mechanical work shows a great loss of efficiency due to this reduction in temperature. In this locomotive I again wish to take advantage of a natural physical re-action and utilize it for a desirable purpose and in this case I refer to the heat loss represented by the exhaust gases from the main engine. This heat loss represents energy wasted.

Now I just described how there is lost work or energy by dissipating the heat occurring when compressing air by disposing of it by radiation. I now propose to regain this lost energy by utilizing the heat which is represented in the exhaust gases of the engine and, by applying this heat to the compressed air, secure a consequent expansion of volume and a greatly increased efficiency. To do this I construct an exhaust manifold in such a manner that as little heat will be lost by radiation from the manifold as possible. That is, I desire to retain in this manifold as much heat as possible and while there are different methods of insulating manifolds and pipes to maintain heat, one method is to surround each exhaust pipe 105 with a chamber 106 which will be exhausted to a vacuum. This vacuum chamber will act as a non-conductor or insulation to retain the heat within the exhaust pipe. To further maintain this external casing as a vacuum chamber, it is proposed to cover the surface with a vitrified material which will withstand the effect of heat. Other means of insulation incorporate the use of asbestos packing, etc.

Having arranged the exhaust manifolds so as to maintain temperature, I arrange within the exhaust itself a form of superheater consisting of coils or tubes 107 through which, before conducting the starting air from the storage tank to the cylinders, it will have to pass, and therefore will be subject to a considerable rise in temperature before being released as work within the cylinder itself, thereby giving up a very much increased efficiency for the air engine.

The angular relation of the cranks 55 insures such position of the links 55 that there will be a proper selection of inlet air valves by the rods 76 when the control lever 73 is
thrown forward or in reverse so that fluid under pressure will be admitted when starting, to such cylinder 18 whose piston 17 may be on the downward stroke.

If desired, the eccentric 90 can be set so that the valve levers 84 and 87 will be operated slightly by the arms 61 when the slides 63 are on the link centers 56. This provides for a regulation of air and fuel mixture while the plant is being run as an internal combustion engine.

What is claimed is:

1. A system for generating, utilizing and storing energy of elastic fluids which consists of compressing air in a receiver, initially starting a locomotive having a combustion engine by said air pressure operative in said engine, then cutting out the air pressure and operating the said engine by expansion of gases from combustion of fuel therein, and utilizing the kinetic energy of the locomotive and its load to operate said engine as means to compress air in the receiver when connected in such arrangement therewith.

2. A system for generating, utilizing and storing energy of elastic fluids which consists of compressing air in a receiver, initially starting a locomotive having a combustion engine by said air pressure operative in said engine, then cutting out the air pressure and operating the engine by expansion of gases from combustion of fuel therein, and utilizing the kinetic energy of the locomotive and its load to operate the engine as means to compress air in the receiver when connected in such arrangement therewith and retard the movement of the locomotive.

3. A system for generating, utilizing and storing energy of elastic fluids which consists of compressing air in a receiver, initially starting a locomotive having a combustion engine by said air pressure of air in said engine, then cutting out the air pressure and operating the engine by expansion of gases from combustion of fuel therein, converting motion of the engine parts into rotary motion by direct connection to the locomotive driving wheels, and utilizing the kinetic energy of the locomotive and its load, to operate the engine as means to compress air in the receiver when connected in such arrangement therewith.

4. A system for generating, utilizing and storing energy of elastic fluids which consists of compressing air in a receiver, initially starting a locomotive having a combustion engine by said air pressure, then cutting out the air pressure and operating the engine by expansion of gases from combustion of fuel therein, and utilizing the kinetic energy of the locomotive and its load to operate the engine as means to compress air in the receiver when connected in such arrangement therewith and cooling the air as it is compressed by the engine so as to increase the air capacity of the receiver.

5. A system for generating, utilizing and storing energy of elastic fluids which consists of compressing air in a receiver, initially starting a locomotive having a combustion engine by said air pressure, then cutting out the air pressure and operating the engine by expansion of gases from combustion of fuel therein, utilizing the kinetic energy of the locomotive and its load to operate the engine as means to compress air in the receiver when connected in such arrangement therewith, and utilizing the heat of exhaust gases from the motor to increase the temperature of air when starting the motor by compressed air while the motor outlets are heated.

6. A system for generating, utilizing and storing energy of elastic fluids which consists of compressing air in a receiver, initially starting a locomotive having a combustion engine by said air pressure, then cutting out the air pressure and operating the engine by expansion of gases from combustion of fuel therein, utilizing the kinetic energy of the locomotive and its load to operate the engine as means to compress air in the receiver when connected in such arrangement therewith, cooling the air as it is compressed by the engine so as to increase the air capacity of the receiver, and utilizing the heat of exhaust gases from the motor to increase the temperature of air when starting the motor by compressed air while the motor outlets are heated.

7. A system for generating, utilizing and storing energy of elastic fluids which consists of compressing air in a receiver, initially starting a locomotive having a combustion engine by said air pressure, then cutting out the air pressure operative in said engine combustion chamber and operating the engine by expansion of gases from combustion of fuel therein, utilizing the kinetic energy of the locomotive and its load and the force of gravity to operate the engine as means to compress air in said combustion chamber and the receiver when connected in such arrangement therewith.

8. A locomotive having a pair of rigidly connected driving wheels, an oscillating walking beam having a central driving arm connected by a link to the wheels, and motor units connected to the ends of the beam.

9. A locomotive having a pair of rigidly connected driving wheels, an oscillating walking beam having a perpendicular central driving arm connected to the wheels, and a motor directly connected to the driver.

10. A locomotive having a pair of rigidly connected driving wheels, an oscillating horizontal driver having a perpendicular...
driving arm connected to the wheels; the driver having oppositely extending power arms each connected to a piston of a two-cylinder motor.

11. A locomotive having a pair of rigidly connected driving wheels, an oscillating driver having a driving arm connected to the wheels, and a vertical two-cylinder motor connected to the driver; the driver having oppositely extending power arms each connected to a piston of the motor, the driving arm being at a right angle to the power arm.

12. A locomotive having a pair of rigidly connected driving wheels, independent oscillating walking beams each having a right angle driving arm connected to the wheels, and a motor having pairs of power units connected to the walking beams.

13. A locomotive having a pair of rigidly connected driving wheels, drive links attached to the wheels at points spaced 90° about the wheel axis, horizontal oscillating drivers each attached to one of said links and having a common axis, and a motor having vertical pairs of power units connected to the drivers.

14. A locomotive having a pair of rigidly connected driving wheels, drive links attached to the wheels at points spaced 90° about the wheel axis, independent horizontal oscillating drivers each attached to one of said links and having a common axis, and a motor having parallel pairs of vertical units connected to each of the drivers.

15. A locomotive having a pair of rigidly connected driving wheels, drive links attached to the wheels at points spaced 90° about the wheel axis, horizontal oscillating drivers each attached to one of said links and having a common axis, and a motor having twin pairs of vertical units connected to the drivers.

16. A locomotive having a pair of rigidly connected driving wheels, drive links attached to the wheels in such manner as to avoid concurrent dead-center, independent drivers for the links. each driver including a rock shaft, the shafts being coaxial, a power lever with oppositely disposed arms on each shaft; and a motor having a set of units placed with their axes parallel and in quadrangular arrangement, the units being attached to respective power lever arms.

17. A locomotive power plant including a group of parallel engines set in quadrangular arrangement, a pair of coaxial rock-shafts with the axis thereof a diameter of the group, means connecting pistons of the engines to the rock-shafts, and means connecting the said shafts to driving wheels of the locomotive.

18. A locomotive comprising a frame, a pair of internal combustion engine cylinders mounted on said frame, pistons in said cylinders, a rock shaft journaled in said frame, a lever on said shaft and connected at its ends to said pistons, an arm secured to said shaft, a drive wheel and a link connecting the arm and the drive wheel.

19. A locomotive comprising a frame, a pair of internal combustion engine cylinders mounted on said frame, pistons in said cylinders, a rock shaft journaled in said frame, a lever on said shaft and connected at its ends to said pistons, an arm secured to said shaft, a drive wheel and a link connecting the arm and the drive wheel.

20. A locomotive comprising a frame, a pair of vertical internal combustion engine cylinders spaced longitudinally on said frame, pistons in said cylinders, a rock-shaft journaled in said frame, a lever on said shaft and connected at its ends to said pistons, an arm secured to said shaft, a drive wheel and a link connecting the arm and the drive wheel.

21. A locomotive comprising a pair of drive wheels, a frame mounted on said drive wheels, two pairs of internal combustion engine cylinders arranged in tandem on said frame, two aligned rock-shafts, a lever on each rock-shaft, each lever being connected at its ends to the pistons of a pair of cylinders, an arm secured to each rock shaft and links connecting the arms and the wheels.

22. A locomotive having, in combination, a power plant including an internal combustion motor, and means for converting the motor combustion chamber and its piston into a combined air brake and an air compressing system by utilization of compression resistance in the motor, when fuel combustion is interrupted, to retard motion of the locomotive and to store the compressed air.

23. A locomotive having, in combination, an air storage receiver, an internal combustion motor having a single chamber and being directly connected to driving wheels of the locomotive and means for selectively connecting the motor to said receiver so that the motor can be utilized either as a compressed air motor or as an air compressor.

24. A locomotive having, in combination, an air storage receiver, an internal combustion motor having a single chamber and directly connected to driving wheels of the locomotive, and means for selectively connecting the motor to said receiver so that the motor can be utilized either as a compressed air motor or as an air compressor.

25. A locomotive having, in combination, an air storage receiver, an internal combustion motor directly connected to driving wheels of the locomotive, and means for selectively connecting the motor to said receiver so that the motor can be utilized either
as a compressed air motor or as an air compressor by admission of air to combustion chambers of the motor, and means for effecting a reverse when utilizing the motor as a compressed air engine.

26. A locomotive having, in combination, an internal combustion motor, means for converting the motor into an air compressor driven by kinetic energy of the moving locomotive and including valves for the inlet and exhaust of air to and from combustion cylinders of the motor, and means for preventing action of the valves when the motor is functioning as a combustion engine to drive.

27. A locomotive having, in combination, an internal combustion motor of the two-stroke cycle type; means for converting the motor into an air compressor driven by kinetic energy of the moving locomotive and including valves for the inlet and exhaust of air to and from combustion cylinders of the motor, and means for preventing action of the valves when the motor is functioning as a combustion engine to drive.

28. A locomotive having, in combination, an internal combustion motor connected to the driving wheels of the locomotive, means for converting the motor into an air engine and including valves for the inlet and outlet of air to the combustion cylinders of the engine, and a reversing means for the valves to control the direction of motion of the locomotive.

29. A locomotive having, in combination, an internal combustion motor connected to the driving wheels of the locomotive, means for converting the motor into an air engine and including valves for the inlet and outlet of air to the combustion cylinders of the engine, a reversing means for the valves to control the direction of motion of the locomotive, and means for preventing operation of the valves when the motor is functioning as a combustion engine to drive.

30. In a locomotive, drive wheels, an internal combustion engine directly connected to the drive wheels, a source of compressed air, valves for controlling the inlet of compressed air to and exhaust of air from the engine combustion chambers whereby the engine may be caused to function as an air engine, and means for controlling the operation of said valves.

31. In a locomotive, drive wheels, an internal combustion engine, mechanism connecting the engine directly to the drive wheels, means for shutting off the fuel supply to the combustion chambers of the engine, valves for controlling the inlet of compressed air to and exhaust of air from the combustion chambers whereby the engine may be caused to function as an air engine, and means connected to said connecting mechanism for controlling the operation of said valves.

32. In a locomotive, an internal combustion engine of the two-stroke cycle type, auxiliary air valves for the combustion chambers of said engine adapted to be held inoperative during the operation of the engine by the combustion of fuel and means for throwing said valves into operation to permit the engine to operate as an air engine by pressure in the combustion chambers.

33. In a locomotive, an internal combustion engine of the two-stroke cycle type, auxiliary valves for the combustion chambers of the engine adapted to be held inoperative during the operation of the engine by the combustion of fuel and means for throwing said valves into operation and controlling the timing of said valves to permit the engine to operate as an air engine.

34. A locomotive having driving wheels, an internal combustion motor, means for converting the motor into an air engine, power transmitting mechanism connecting the said wheels and the motor, said means including air inlet and outlet valves for the motor when functioning as an air engine, reverse-link means connected to the driving wheels, and means connected to said reverse-link means for operating the air valves.

35. A locomotive having driving wheels, an internal combustion motor, means for converting the motor into an air engine, power transmitting mechanism connecting the said wheels and the motor, said means including air inlet and outlet valves for the motor when functioning as an air engine, reverse-link means connected to the driving wheels, means connected to the said mechanism for actuating the valves in timed relation, and a reverse-link apparatus connected to the driving wheels for varying the degree of action of the last named means.

36. A locomotive having an internal combustion motor for normal driving purposes, driving wheels for the locomotive, driving means including arms connecting the motor to the wheels, air inlet and air outlet valves constructed and arranged to permit the operation of the motor by compressed air, valve operating means connected to said arms, and a reverse-link apparatus connected to the driving wheels and operating and varying the action of the valve operating means.

37. A locomotive having, in combination, a power plant selectively operative as an air compressor and as an internal combustion engine, and means for reducing the temperature of the air as it is discharged from the compressor to a receiver.

38. A locomotive having, in combination, a power plant selectively operative as an air compressor and as an internal combustion engine, means for reducing the temperature...
of the air as it is discharged from the compressor to a receiver, means for converting the plant into an engine driven by compressed air, and means for increasing temperature of the air as it enters the cylinders of the plant to increase the effective pressure.

39. A locomotive having, in combination, a power plant including reciprocating engines operative at will as internal combustion units, an air storage receiver, air valve means for each engine, means connecting the valve means to the said receiver, and concurrently operating master valves in said connecting means for selectively controlling the direction of flow of air in said means, so that the said plant can operate as an air compressor and as an air engine according to the position of the master valves.

In testimony whereof, I have hereunto set my hand.

RICHARD VOSBRINK.