Power

correctly generated
correctly controlled
correctly applied
to the rear
axle

A Complete Description of the STANLEY STEAM CAR

22nd year

1922

A Complete Description of the Stanley Steam Car

THE purpose of this booklet is to explain the working of the parts of the Stanley Steam Car in a way that may be readily understood by one without previous acquaintance with the car. Many persons who know themselves to be entirely competent to operate a gasoline car have, in some unexplained way, been led to believe that the operation of a Stanley car would be difficult for them, or in fact for any one not a skilled steam engineer. This is unfortunate, since the mechanisms of the Stanley Car are very much simpler than those of a gasoline car, and are easier to understand. A beginner would learn the Stanley to the extent of becoming independent of the service station in much less time than would be possible with a gasoline car.

In the early days of the industry the gasoline car seemed simpler than the steam car. The gasoline car of that day had a one-cylinder engine, a simple planetary transmission, and a rather elementary carbureter, that was, however, quite satisfactory for the high quality fuel of that day. But though this gasoline car was simple, its performance was not good, and complications were steadily introduced in the search for better performance. This may be seen in the regular increase in the number of cylinders from 1 to 4, 6, 8, and 12 — in the use of complex valve mechanisms — and in the insertion of another complete power plant, the self-starter.

On the other hand, the performance of the steam car of the Stanley type was good from the beginning, and no basic changes have been found necessary. There has been refinement of detail and genuine simplification, and that is all.

Thus, while the development of the gasoline car has led to greater complication, that of the steam car has led to greater simplification, until now the advantage of simplicity is decidedly with the steam car. The shortcomings of the early steam cars have disappeared. The fuel feed, water feed, steam pressure, and lubrication are all taken care of automatically by exceedingly simple, rugged control devices; stops for water are not necessary; and incidentally there is no show of exhaust steam from the car.

Its makers claim that of all the types of automotive power plants, the steam plant, as exemplified in the Stanley Car, unquestionably gives the best performance. This statement is made advisedly, in full recognition of the present-day vogue of the gasoline car, and is based upon the following:

ADVANTAGES OF THE STANLEY CAR:

1. The cost of operation is considerably less.
2. Its power at ordinary speeds is nearly triple that of gasoline cars of similar size, giving it an overwhelming advantage in acceleration and hill climbing.
3. The power is always under complete and exact control.
4. The power plant is completely free of erratic performance. All the power is there all the time.
5. Power is automatically stored when the load is light for use when the load is heavy.
6. The application of the power to the drive wheels is always perfectly smooth at all speeds.
7. The speed range is complete, from standstill up, enabling the driver to go as fast or as slowly as he likes, with full power, regardless of the road or grade.
8. The car does all its traveling on "high gear," and the work of the driver, as far as the power plant is concerned, is limited to moving the throttle lever, by which starts and stops are made, and the power and speed controlled.
9. The engine always runs at slow speed, and is noiseless and vibrationless.

The performance obtainable from even the best gasoline engine cannot anywhere near measure up to that obtainable from steam. There may be readers who feel that since "a horse-power is a horse-power," it makes no difference whether a car is driven by a gasoline engine or a steam engine. But as a matter of fact there is a difference — a tremendous difference. This difference is primarily a difference in the type of power output, or, as it is commonly called, the power characteristics.

Each cylinder of a gas engine develops at each explosion a limited and fairly fixed amount of power; and the total power output of the engine depends upon the speed with which one of these explosions can follow the other. So the torque, or twisting effort, of the engine depends upon the engine speed. This speed, in other words, must be maintained to maintain the power output, and

any momentary slowing of the engine affects the speed of the explosions and thus reduces the total of power delivered. Thus the power is controlled and limited by the engine speed; and if the engine speed is limited (by the transmission and drive shaft) to the speed of the car, it can be readily seen that the slower the car speed the lower the engine power. This explains why, in high gear, a gas engine cannot deliver its full power, except at the maximum speed attainable by the car. Shifting gears reduces the speed of the car to one-half or one-third of this maximum attainable speed, but even then the car speed controls the output of power from the engine; and the deciding factor is not the driver's wish, but the conditions such as speed, grade, and road surface under which the car is operating.

Whether he knows the cause or not, every gasoline-car driver realizes that his engine does not give him as much power when pulling up a grade as on the level road.

These limitations are not present in the steam engine, and in the Stanley Car full power is available at any car speed. And this power is sufficient at any speed to slip the drive wheels.

This characteristic of the steam engine is, no doubt, one of the chief reasons for the tremendous interest in steam cars, and although the steam engine does not at present predominate in the motor-car field as it does in water and rail transportation, there are indications that it will soon be generally recognized as the best type of motive power in that field as well.

The past few years have seen the elimination of what could be called the one sound criticism of the steam car — the necessity of filling the water-tank at frequent intervals along the road. Early steam cars required about a gallon of water for each mile, and since only thirty or forty gallons could be carried, a day's ride required several stops. The condenser with which the Stanley is now equipped, permits the use of the same water over and over, with very little loss, so that the present 25-gallon tank suffices for 150 to 250 miles. This condenser is an ordinary Mayo radiator.

Before taking up the description of the various parts, it will be well to outline briefly the steam cycle in the Stanley Car.

STEAM CYCLE

Heat and water are the agencies employed. The fuel from the storage tank is automatically fed to a burner beneath the boiler. Here, in an enclosed chamber, it burns in a multitude of blue, intense jets a few inches high, the heat passing through the tubes of the boiler and the products of combustion discharging through a pipe under the car.

The water is fed automatically to the boiler from the water tank. There it is converted into steam, which is made still more active by superheating it in a coil placed in the hottest part of the burner. This high pressure steam then passes to the engine, where it imparts to the crank-shaft the powerful, even, rotation that is characteristic of engines of this type. As the crank-shaft is geared directly into the rear axle, this smooth, steady power is transmitted to the wheels without interruption or intermediate mechanism.

After having done its work in the engine, the steam is discharged into the condensing system, where it is turned back to water. This consists of the feed-water heater, the condenser, and last of all the water tank from which the water was drawn. Thus it can be seen that the complete cycle of the water is simple and easily understood.

Control of the steam as it passes from the boiler to the engine gives direct control of the car, and this is effected by a throttle valve placed in the steam line where it leaves the boiler. This throttle valve is operated by a control lever placed on the steering column just beneath the steering wheel, and called the throttle lever. Reverse is effected by a foot pedal connected to the valve gear on the engine.

FUEL SYSTEM

In the fuel system the same characteristic simplicity is found. It consists of two fairly distinct parts — a main burner and a pilot. The main burner does not burn all the time, as the demands upon the boiler for steam vary with the conditions of the road, and the system is so designed that it adapts itself to these conditions. So the main burner is turned on and off, and up and down while the car is in use, by an automatic device that requires no attention; and this device so controls the burner that the heat from it, and accordingly the rate of steam generation in the boiler, are at all times sufficient to replace the steam used by the engine. Whenever this steam-regulating device turns the main burner off entirely, it is relighted by the pilot which is not turned off in this way, but is kept lighted all the time.

PILOT

The pilot is shown in outline in Figure C. Its burner, which works in conjunction with the main burner, consists of a small, slotted casting placed

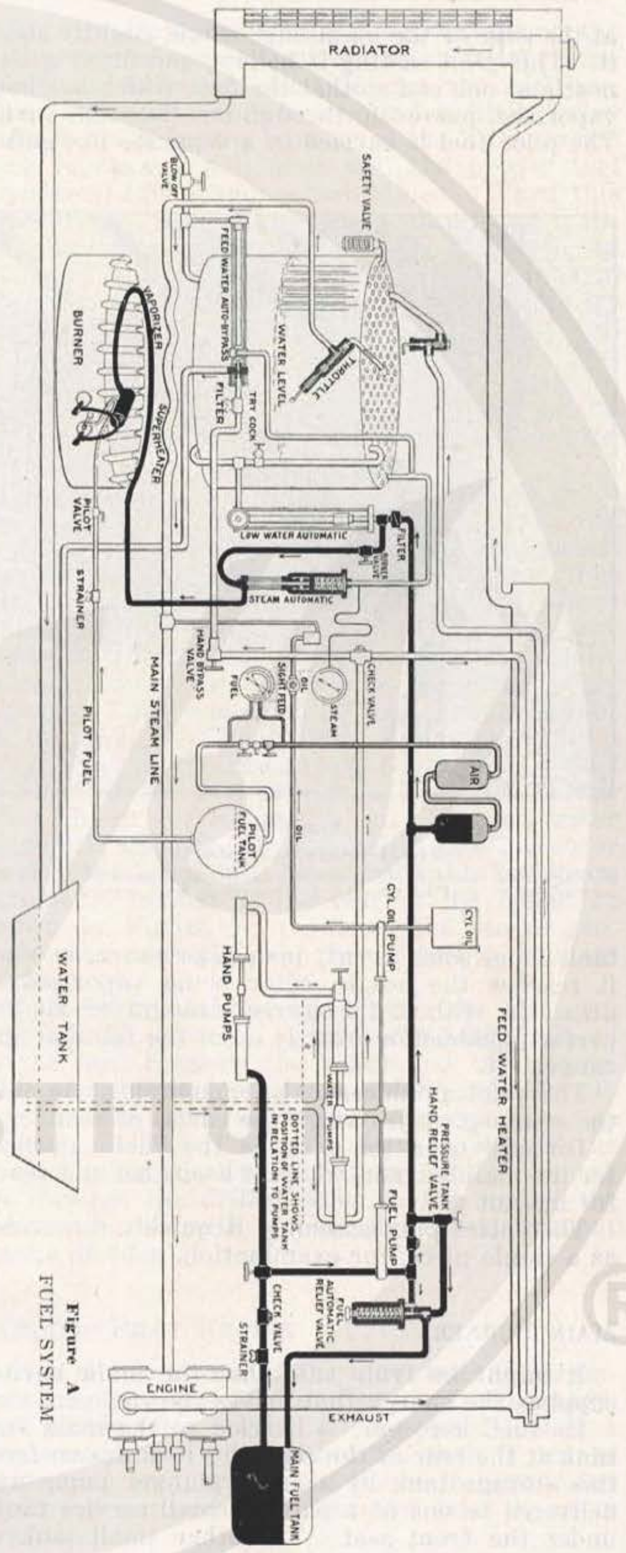


Figure A
FUEL SYSTEM

at the edge of the main burner and slightly above it. This pilot casting is hollow, and fitted with a nozzle at one end so that the fuel, which has been vaporized, passes up through the slots and burns. The pilot fuel is carried in a separate five-gallon

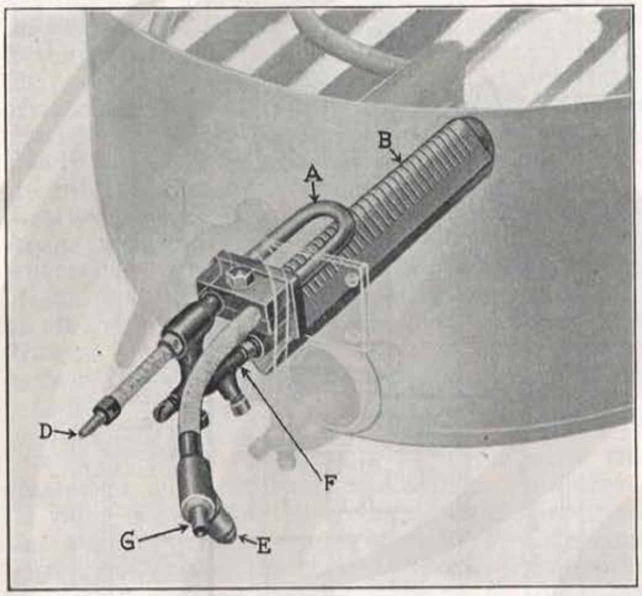


Figure B

PILOT CASTING ASSEMBLY

a—Vaporizing tube. *b*—Pilot casting. *d*—Return connection to switch. *e*—Fuel inlet. *f*—Pilot nozzle. *g*—Connection from battery.

tank under some twenty pounds pressure, so when it reaches the nozzle, after being vaporized, it draws in with it the correct amount of air for perfect combustion exactly as in the familiar gas range.

The pilot produces only enough heat to hold the steam pressure when the car is at rest.

Directly over the pilot is the fuel vaporizer for the main burner, which it keeps hot and ready for instant use.

The entire pilot assembly is quickly removable as a single piece, for examination.

Main Burner

It might be truly said that the main burner supplies the energy that drives the car.

Its fuel, kerosene, is carried in the main fuel tank at the rear of the chassis. It is drawn from this storage tank by a small plunger pump and delivered to one of a pair of small service tanks under the front seat. The other small tank of

this pair acts as an air chamber, stabilizing the fuel pressure, and preventing the pulsations from the pump following clear through the fuel line. The fuel pump supplies the fuel a little faster than required by the burner, so the little service tank is always well filled and the proper fuel pressure—140 pounds—maintained. When this pressure is reached a relief valve beside the pumps opens automatically and the fuel, as pumped, is diverted to the main storage tank in the rear, until more is required by the service tanks. These service tanks give this Stanley system all the advantages of the pressure fuel feed without the inconvenience of keeping pressure in the main tank. The Stanley fuel tank can be opened for filling without affecting the working pressure on the fuel in any way.

The fuel in the service tank is ready to go to the main burner; it is under 140 pounds pressure, and when the line to the burner is open, passes direct through. It is in this line, however, that the fuel controls are placed, so the fuel passes successively through a hand shut-off valve, a low-water automatic valve, and a steam automatic valve. These automatics are described later. Closure of any one of the three valves will shut off the fuel. The hand shut-off is operated by a small lever on the instrument board, and is used to shut off the fuel supply to the main burner when the driver leaves the car. The low-water automatic stops the flow of fuel in case the water level in the boiler falls below normal. The steam automatic, located at the rear of the boiler, as shown in Figure N, regulates the steam generation by controlling the flow of fuel to the main burner.

Just before entering the burner the fuel goes through the vaporizer — a loop of tubing placed in the heat between the boiler and the burner. This converts it into a gas which is discharged immediately into the burner through the two burner nozzles. The air drawn in around the nozzles gives a perfect mixture, which, coming up through the drilled holes in the top of the burner, burns with a blue flame and without smoke or odor.

Electric Pilot Heater

This device is one of the most interesting improvements on the Stanley Car. It is, in reality, part of the pilot. A button is pressed and in a few seconds the pilot is heated; then it can be lighted; in another moment the main burner can be turned on; and a few minutes later steam is available.

The button closes a switch which causes the battery current to heat a tube forming part of the pilot. This vaporizes the fuel. The switch opens again and cuts out the current, automatically, when the pilot tube has reached proper heat. The apparatus is simple — it consists of the thermostatic switch with the push-button and

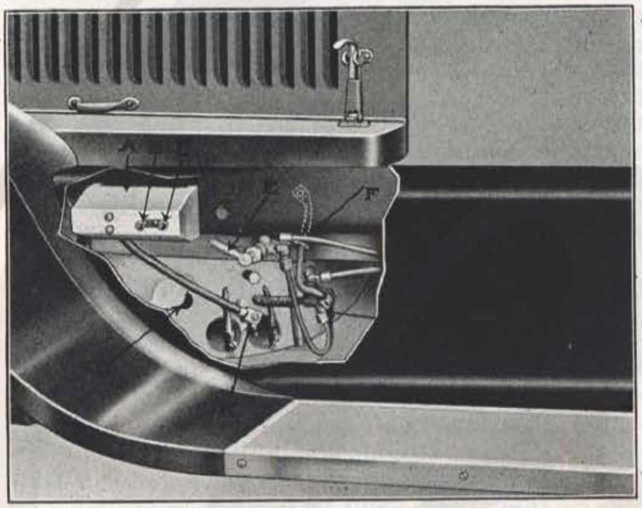


Figure C

PILOT SWITCH ASSEMBLY

a—Pilot light switch box. *b*—Starting button. *c*—Releasing button. *e*—Pilot fuel valve. *f*—Ground connection to frame. *h*—Connection to battery. *j*—Pilot peep-hole. *k*—Connection from switch to outlet of pilot vaporizer. *m*—Pilot fuel inlet.

the vaporizing tube. The current is supplied from the same battery which is carried for the electric lights.

The amount of current used in starting is about the same as that required by an electric self-starter. It must be remembered, however, that the pilot heater is not required after every stop of the car, as is the case with the electric self-starter. Its function is merely to heat the pilot, which, once being lit, should be left burning until the car is put up for some considerable length of time. Owners, customarily, leave their pilots burning continuously for a month or more. So it can be seen that the demands on the battery are very light.

THE WATER SYSTEM

The water system consists of a water tank, pumps to feed the water to the boiler, a feed-water heater to utilize the heat of the exhaust steam, automatics to control the amount of water, and a boiler in which the water is turned to steam for use in the engine.

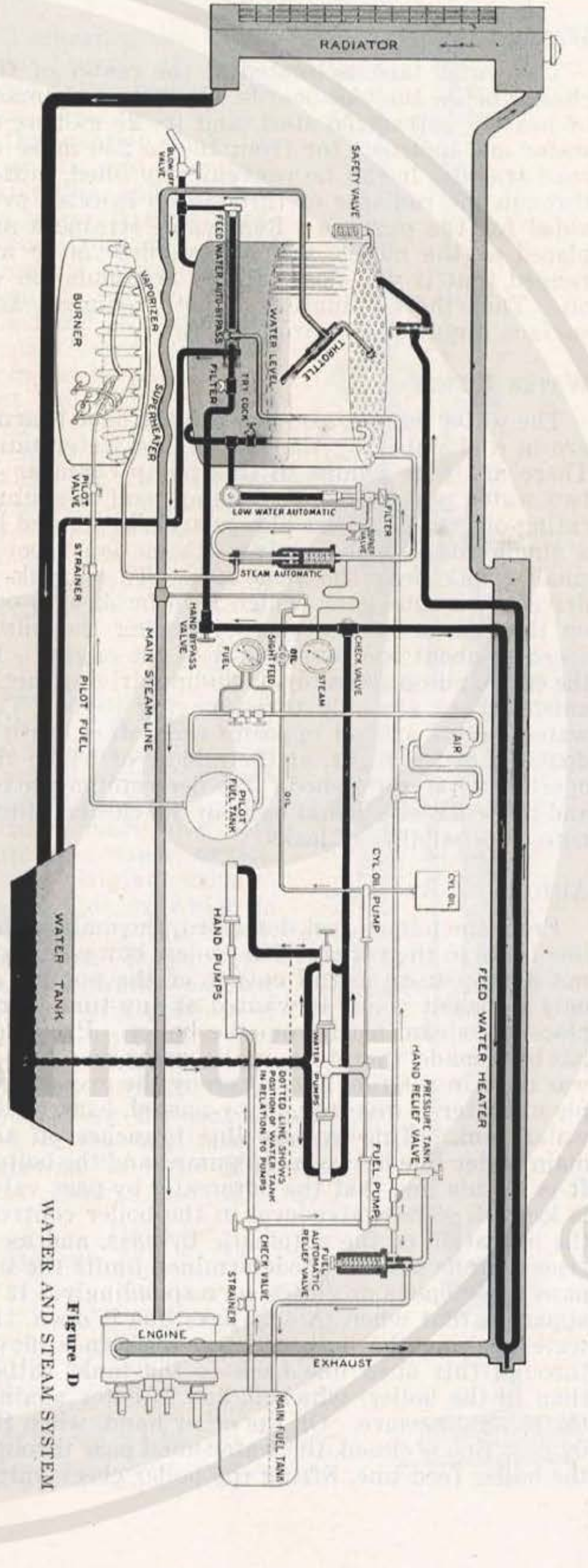


Figure D

WATER AND STEAM SYSTEM

Water Tank

The water tank is located at the center of the chassis below the foot-boards. It is strongly made of heavily galvanized steel, and its 25 gallons of water are sufficient for from 150 to 250 miles of road travel. It can be conveniently filled, either through the radiator or through an injector provided for the purpose. Removable strainers are placed at the outlet, and an overflow is so arranged that it will float off any accumulation of oil. Thus the elimination of both sediment and surface impurities is provided for.

Water Pumps

The water pumps, also beneath the floor boards, are in a chamber by the side of the water tank. There are four pumps in this pump chamber — two water pumps, one fuel pump, and one lubricating-oil pump. These pumps are all operated by a single rod, which receives its motion from a small crank near the rear axle. This crank is driven by a spur gear, which is in mesh with one on the rear axle, the gears reducing the pump speed to about one-fourth that of the engine. In the entire pump assembly, including driving mechanism, there are only three moving parts. The water pumps are set opposite each other, with a double-ended plunger, at the middle of which the operating rod is attached. The deep stuffing boxes and non-corrosive metal balls in the checks, eliminate all possibility of leaks.

Automatic By-pass

From the pumps just described, the main water line leads to the boiler. The boiler, however, cannot always use the full output of the pumps, as only sufficient water is wanted at any time to replace the steam used from the boiler. Provision has been made, therefore, in the water line, just as was done in the fuel line, whereby the excess supply of water is diverted, or by-passed, back to the water tank. This by-pass line branches off the main water line between the pumps and the boiler. It is in this line that the automatic by-pass valve is located. The water-level in the boiler controls the operation of the automatic by-pass, and as it rises or falls beyond predetermined limits the by-pass valve opens or closes correspondingly. It is apparent that when this by-pass line is open, the water, taking the path of least resistance, flows through this open line back to the tank, rather than to the boiler, which it has to enter against the steam pressure. On the other hand, when the by-pass line is closed, the water must pass through the boiler feed line, lifting the boiler check valve,

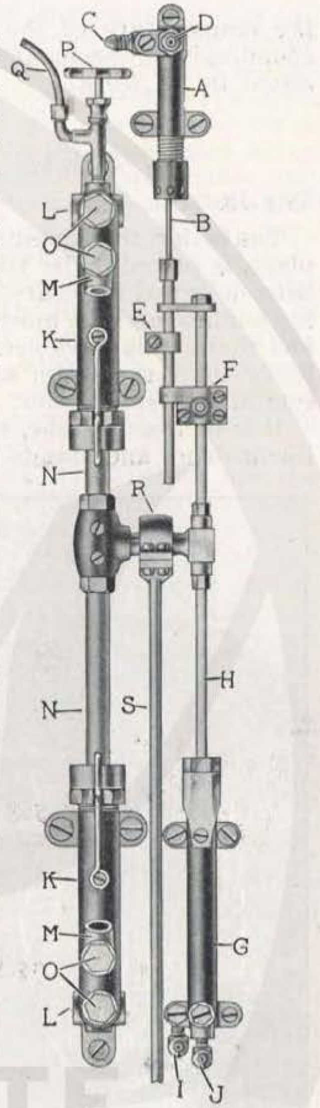
and entering the boiler, even though it moves against the boiler pressure. This check valve is at the junction of the by-pass line and the main water line, and prevents the water flowing backwards from the boiler when the by-pass line is open.

A hand stop-valve, or by-pass valve, is provided in the by-pass line, so that the boiler may be filled above the customary level when desired.

Just before entering the boiler the water must pass through the feed-water heater, where it is raised to almost a boiling temperature.

Feed-Water Heater

The feed-water heater, utilizing the heat from the exhaust steam, preheats the water before it enters the boiler. It is nothing more nor less than an enlarged section of the engine exhaust pipe, inside of which is a length of the feed-water line. It is evident that the water passing through this portion of the feed-water line absorbs heat from the surrounding exhaust steam, thus saving for use a large part of the heat that would otherwise be lost. Moreover



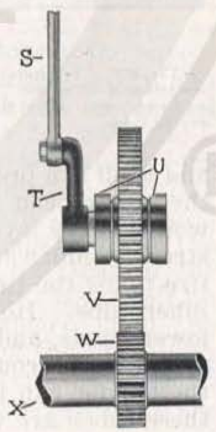


Figure E

FUEL, OIL, AND WATER PUMP ASSEMBLY

a—Oil pump. *b*—Oil pump plunger. *c*—Oil inlet. *d*—Oil outlet. *e*—Adjustment sleeve. *f*—Plunger guide. *g*—Power fuel pump. *h*—Power fuel pump plunger. *i*—Fuel inlet. *j*—Fuel outlet. *k*—Power water pump. *l*—Water inlet. *m*—Water outlet. *n*—Water pump plungers. *o*—Ball check caps. *p*—Hand water pump valve. *q*—Hand water pump connection. *r*—Pump drive crosshead. *s*—Pump drive rod. *t*—Pump drive crank. *u*—Pump drive shaft bearings. *v*—Pump driven gears. *w*—Pinion pump drive gear. *x*—Rear axle shaft.

the temperature of the exhaust steam is correspondingly lowered, and the condenser thus assisted in its work.

STEAM SYSTEM

The Boiler

The boiler, the largest unit in the Stanley power plant, is placed under the hood of the car. It has been designed to secure the largest possible heating surface and the most rapid steaming qualities, and these ends have been attained without sacrificing the large water and steam capacity so essential to stored power.

It is of the fire-tube, water-level type — shaped like a drum and stands on end. The lower head

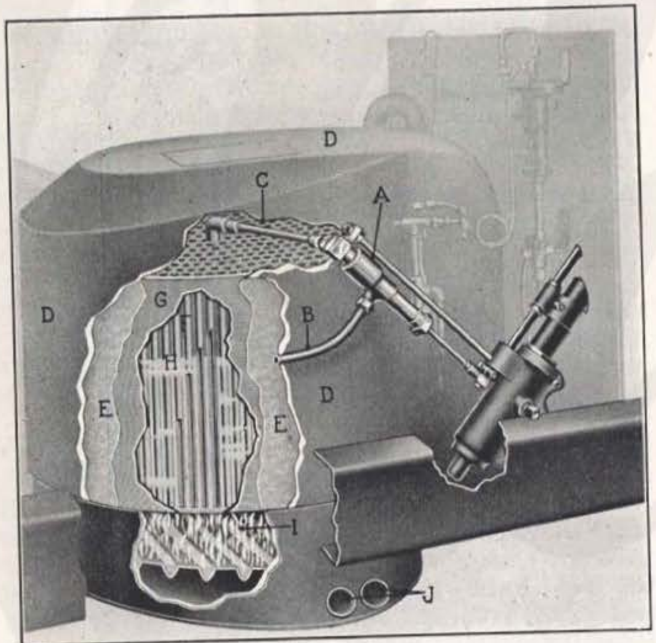


Figure F

SECTIONAL VIEW OF BOILER

a—Throttle. *b*—Outlet to superheater. *c*—Steam outlet from boiler. *d*—Asbestos covering. *e*—Galvanized iron covering. *f*—Boiler tubes. *g*—Piano wire. *h*—Water level. *i*—Main burner flame. *j*—Main burner mixing tubes.

and shell are pressed from one piece of steel with the upper head welded in. Around the shell are wound three layers of piano wire, which take the stress in much the same way that the casing of a tire takes the pressure of the air enclosed by the inner tube. Holes are drilled in the upper and lower heads, and tubes, one-half inch in diameter, are passed through these holes, so that heat from the burner can pass through. The lower ends of these tubes are welded into the lower head of the

boiler, and the upper ends are expanded into the upper head, so that the joints are steam and water tight. The result of this arrangement is a hollow cylinder of great strength with some 700 open tubes running up through it. These tubes serve a double purpose: they tie the upper and lower heads together in the manner of stay bolts; and they expose a very large total surface to the heat from the burner which passes up through them. The water, of course, is inside the drum or shell, and circulates around between the tubes. The total surface exposed to the heat is somewhat in excess of 100 square feet, so the mission of the tubes can be appreciated when it is remembered that the diameter of the lower surface is but 23 inches, and the area of this lower surface less than three square feet.

Opposed to this type of construction are the "water-tube" and "flash" boilers, wherein the relative positions of the heat and water are reversed — the water inside the tubes and the fire applied to the outside. These boilers have rapid enough steam generation, but lack the water capacity and steam reserve, that are exclusive characteristics of the fire-tube boiler, yet are so essential to the stored power demanded in automobile service.

The fire-tube boiler of the Stanley type offers further advantages. It offers the largest possible free water surface for the release of the steam; and it delivers a drier steam than is possible with the other types of boiler. The last point is quite important, as there is, in this construction, little likelihood of free water being carried out with the steam to the engine, which would not be harmful in itself, but would lower the efficiency.

Superheating

The main object in superheating the steam is to save fuel. In any self-powered automobile the energy that drives the car is derived from heat generated by the combustion of fuel. Economy, therefore, consists in getting as much energy as possible out of the fuel. Inasmuch as the superheater requires no additional burner ability and fuel consumption, any gain which can be secured from superheating the steam is a net gain and a direct economy. The superheater is simply a loop in the steam line, as shown in Figure G, which is right over the main burner where it is exposed to the greatest heat. Here the temperature of the steam is raised far above that of the steam in the boiler, and its activity is greatly increased. Steam not superheated begins to condense upon the slightest cooling, but that is not the case with superheated steam, as it is apparent that it must lose all the additional heat which has been imparted to it before it can condense. Superheating, therefore, gives a distinct economy in steam consumption, as it insures that the steam will not only reach the engine without condensation loss,

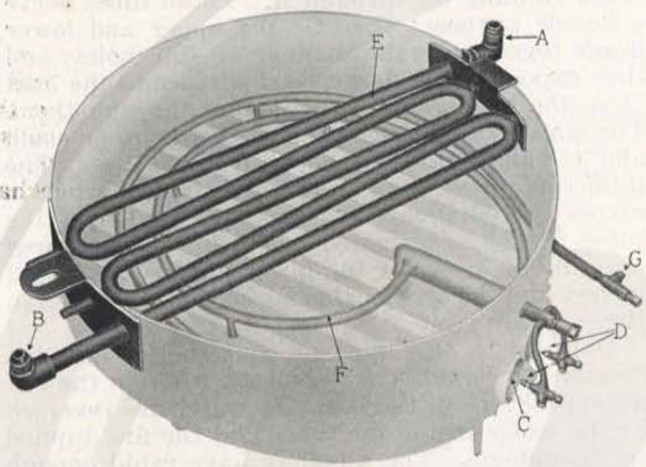


Figure G

SUPERHEATER

a—Outlet to engine. *b*—Steam from throttle. *c*—Main burner mixing tubes. *d*—Main burner nozzles. *e*—Superheater. *f*—Fuel vaporizing coil. *g*—Fuel inlet.

but will do its work there with less condensation loss than would be otherwise possible. Superheating also increases the volume of the steam, thus enabling a given amount of it to supply the engine for a greater number of strokes than if it were not superheated.

The Engine

The Stanley engine is under the rear compartment of the car, and is a unit with the rear axle. It is hung horizontally; the front end suspended from the frame by a laminated steel strap, and the rear end bolted solidly to the rear axle housing. It has two cylinders, placed side by side, and lying lengthwise of the car. Thus the crankshaft is parallel with the rear axle, and is actually geared direct into it. The driving ratio is 1½—1; a 40-tooth spur gear on the engine shaft engaging with a 60-tooth gear on the axle, and these two gears are the whole of the transmission.

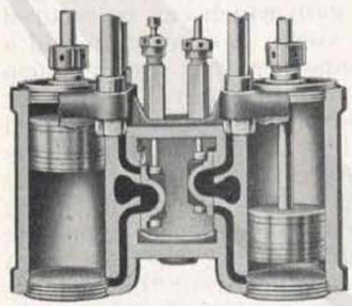


Figure H

The cylinders are of 4-inch bore and 5-inch stroke, but as the engine is

double-acting, it corresponds to a single-acting engine of four cylinders.

Flexible connections have been provided for both the steam intake and steam exhaust lines, so any slight movement of the engine and the

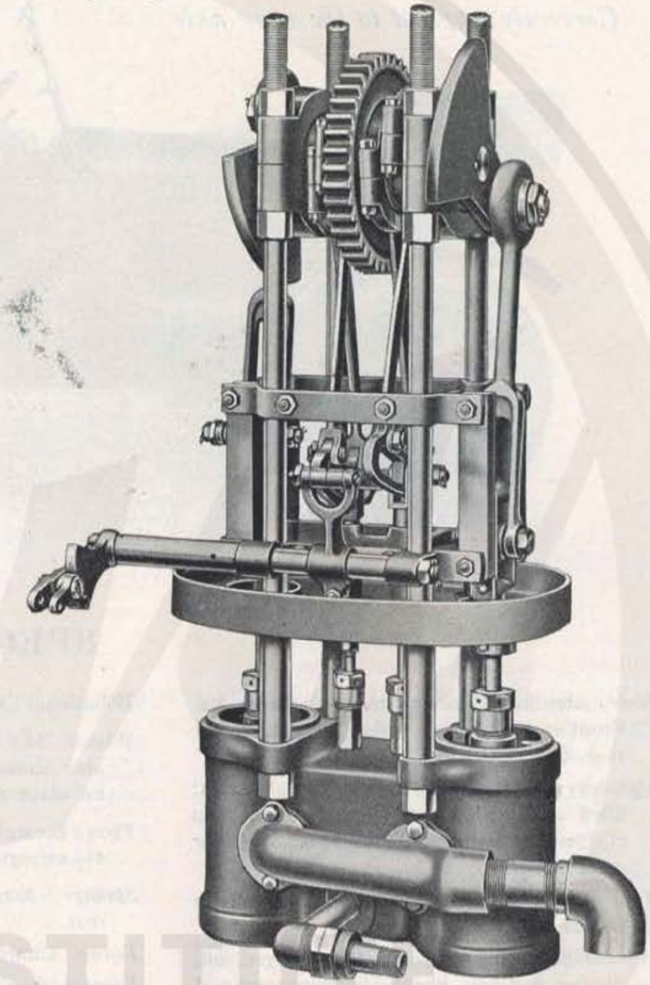


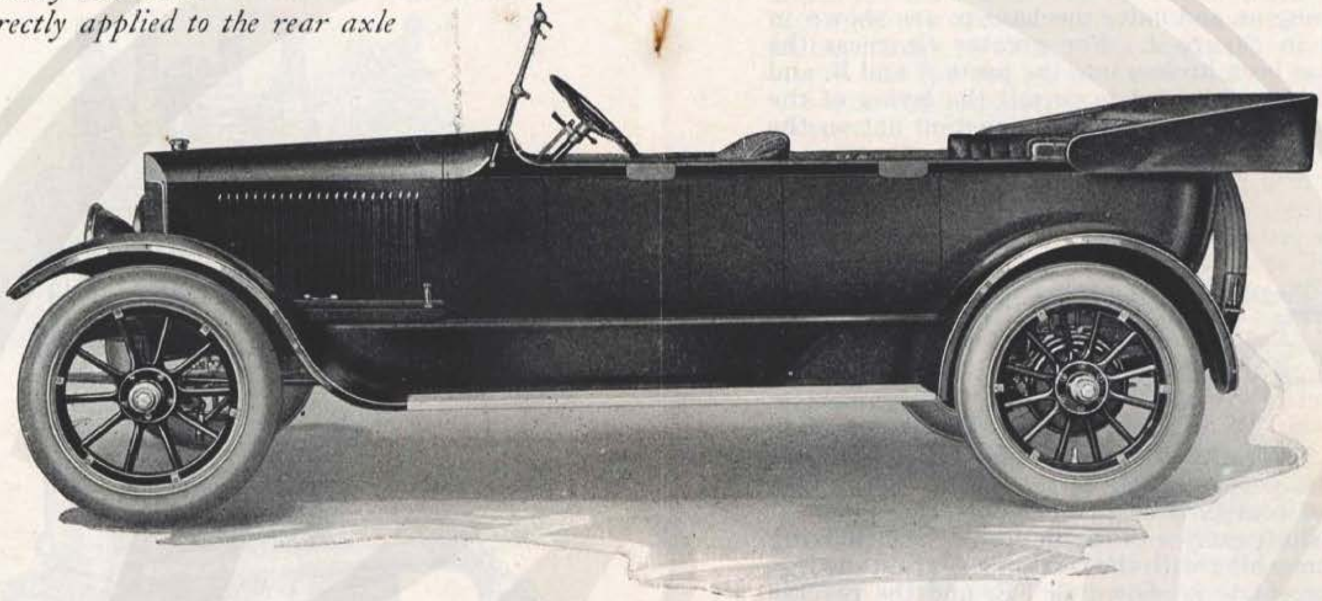
Figure I

rear axle is taken care of. This is done by a swivel union on the steam line, and a short hose connection where the exhaust enters the feed-water heater.

The engine shaft receives four impulses per revolution, the same as in an 8-cylinder gasoline engine. The action of the Stanley is much the smoother of the two, however, since it is actuated by the cushion-like expansive force of steam instead of by a succession of hammer-like explosions. Moreover, the impulses in the Stanley are derived from a common source, the boiler, and they are, therefore, perfectly uniform and steady, as contrasted with a gasoline engine, in which it is

Power—

Correctly generated
Correctly controlled
Correctly applied to the rear axle



SPECIFICATIONS

Body Aluminum; smooth-line, with flush sides. Front seat, 42 inches wide, 18 inches deep; rear, 48 inches wide, 20 inches deep.

Upholstery Soft genuine leather, straight grain; filled with curled horse-hair. Wide, deep cushions in both front and rear, tilted for comfort.

Top Improved one-man type, locking to windshield.

Windshield Slanting special Troy design, ventilating and rain vision; black enamel and nickel.

Color Royal green with running gear and fenders black. Valentine's colors and varnishes used exclusively.

Lights Electric throughout, with Willard battery and Apple Electric Generator; combined headlights and dimmers with separate bulbs and Controlite Lenses. Electric dash and tail lights.

Horn Klaxon electric, under hood; button under driver's left foot.

Steering Gear Warner, with 18-inch wheel; left side; worm and gear type.

Wheelbase 130-inch with standard 56-inch tread.

Wheels 34 x 4, with Firestone Light Demountable Rims. Wire wheels optional at $100 for black and $110 for white per set of five.

Tires Straight groove, black tread, cord. 35 x 4½ straight side.

Springs Semi-elliptical front; full-elliptical rear.

Frame Channel section pressed steel.

Front Axle Complete Timken installation.

Rear Axle New design Stanley with Timken inside bearings. S. K. F. outside bearings.

Brakes On rear wheels with 14-inch drum and 2-inch face. Hand emergency brake of expanding type and pedal service brake of contracting type.

Pumps Driven from rear axle at one-quarter engine speed.

Water Tank 24-gallon capacity, tank hung under frame, giving water mileage of 150 to 250 miles.

Radiator Standard Mayo, V-shaped, cellular type.

Fuel Tank Main fuel tank for kerosene at rear, 20-gallon capacity; pilot tank and cylinder oil tanks under front seat.

Boiler Standard Stanley fire-tube type, welded construction, 23-inch diameter.

Burner Drilled type; can burn kerosene or gasoline or any mixture of the two. Pilot burns gasoline from miniature tank of 4-gallon capacity.

Engine Two cylinders, 4 x 5, slide valve type; double acting; bolted to rear axle and geared direct into differential ring gear. The entire differential and engine assembly enclosed in a dust-proof, oil-tight housing and running in a bath of oil.

Instrument Board with steam gauge, duplex fuel gauge, oil sight feed, Warner speedometer and lighting switch.

Pilot Electrically heated from Willard Storage Battery.

Prices (Subject to change) f. o. b. Newton. War tax, $150.00.

Model 735, seven-passenger touring car	$3,450
Model 736, four-passenger touring car	3,425
Chassis only	2,950

impossible, even in the same cylinder, to get the same impulse twice in succession. As a matter of fact, the term "impulse" is a misnomer. They are not impulses, but a uniform, continuous flow of power.

The engine and valve mechanism are shown in outline in Figure J. For greater clearness the shaft has been broken into the parts A and B, and these parts separated to permit the laying of the main crank and the valve link-motion flat on the

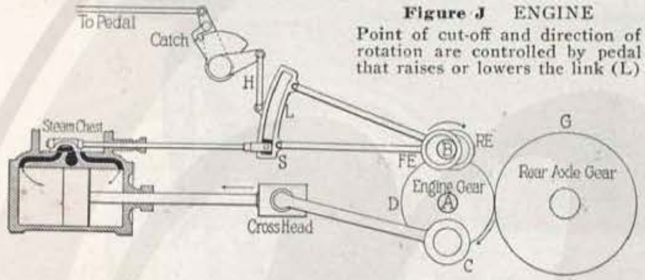


Figure J ENGINE
Point of cut-off and direction of rotation are controlled by pedal that raises or lowers the link (L)

paper; in reality the crank and link-motion are in planes perpendicular to the paper. The steam chest, of course, is common to both cylinders.

The shaft carries the main crank C, the driving gear D meshing with the rear axle gear G; the forward eccentric is shown as FE, and the reverse eccentric as RE. These eccentrics act the same as small cranks, and are so represented. The passages that lead from the steam chest to the ends of the cylinder are the steam ports; the large round opening in the center, directly below the valve, is the exhaust port.

In the position shown the right steam port is open a little; steam is entering the right end of the cylinder, moving the piston to the left, and thus driving the crank-shaft in the direction of the arrow and propelling the car forward. At the same time the exhaust steam is escaping from the left end of the cylinder through the left steam port and the exhaust port, which are now connected by the valve. At the given instant the valve is moving to the right, and a little later it will close the right port, this taking place when the piston has made about five-eighths of its stroke. For the rest of the stroke the steam in the cylinder works expansively.

As the piston completes its stroke the valve reaches a point well over to the right, uncovering the left port, and at the same time connecting the right port with the exhaust port; this admits steam to the left end of the cylinder while it permits the escape of the exhaust steam from the right end.

Thus it is seen that the steam pressure is applied first to one side of the piston and then to

the other; that is, the engine is double-acting, and this operation will continue as long as steam is supplied to the engine from the boiler.

It may be desired, however, to reverse the car, and it is here that one of the fundamental advantages of the steam engine for automobile use makes its appearance. The engine is simply reversed and the car moves backward.

Suppose the engine, as shown in Figure J, were stopped in the position shown. As it is, steam is entering the right end of the cylinder, pushing the piston to the left and imparting a clockwise motion to the crank-shaft A. It is obvious that to change this motion to counter-clockwise, and reverse the car, it is only necessary to have the pressure of the steam exerted on the other side of the piston, which will move the crank C to the right. Since the entrance and exhaust of the steam are controlled by the slide valve, all that is required is some means of connecting the valve and valve stem up with the reverse eccentric RE, instead of the forward one FE. This is exactly what is done by the link L. There is a little block S on the end of the valve stem which fits freely in the slot of the link; so when the link L is dropped down, as shown in Figure K, the block holds its position on the end of the valve stem and connects the upper eccentric rod with the valve stem. And as the upper eccentric rod is moved by the reverse eccentric RE, which is now on the back of the crank-shaft B, the valve is drawn back to the position shown in this figure (K). It will be observed that this has accomplished just what we wanted; the other port is opened and the steam is entering

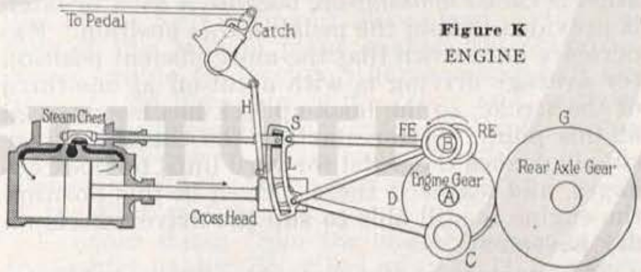


Figure K
ENGINE

the cylinder from the left and exhausting from the right. This gives the reverse motion to the engine. Of course, both ends of the link are in motion, as there is an eccentric on each end, but the valve is moved by the eccentric rod which is in line with the valve stem; the other end of the link simply idling back and forth without affecting the movement. Thus it is clear that raising and lowering the link brings either the forward or reverse eccentric into operation, so that if this link position can be controlled by the driver the engine can be reversed or driven forward at will.

This is done by suspending the link from a rod or swing arm H, known as the link-hanger. This is connected by a rod to a pedal in the driver's compartment. When the pedal is as far to the rear as it will go, the link is raised, as shown in Figure J, and when the pedal is pushed forward as far as it will go the link is lowered, as shown in Figure K. These positions are known respectively as full forward, and full reverse.

Hence, to reverse the car it is only necessary to push the pedal forward and open the throttle. If desired, the throttle can be left open and the car shuttled backward and forward solely by the pedal. So it is not necessary to wait until the car comes to a full stop before applying the reverse, but it is easier on the tires if this is done.

The engine has maximum power when in the full forward or full reverse positions, as it is in these positions that the valves receive the maximum movement that may be imparted to them by the eccentric arms. There are intermediate positions in the link, however, that reduce the travel of the valve and cut off the steam earlier in the stroke. Referring to Figure J again, it is evident that if the link is slightly lowered by pushing the pedal forward a little, the valve will be carried to the right of the position shown in the figure, as the block slides in the slanting link. Now, since the valve's own motion at the moment is also to the right, this additional movement to the right puts the valve further on its way and causes it to cover the right port *sooner;* that is, the steam is cut off at an earlier point in the stroke. This operation is called *hooking-up,* because a hook or latch is provided to hold the pedal in this position. Experience has shown that the most efficient position for average driving is with a cut-off at one-third of the stroke, so the hook-up lock has been placed at this point. After starting the car the driver simply pushes the pedal forward until the lock engages, and leaves it there. Even in this position the engine is still able to slip the drive wheels on dry pavement.

The bearings of the engine are lubricated by an oil bath. An oil-tight, dust-proof housing surrounds the working parts, so the oil is free to splash. One filling (six quarts) in this case is sufficient for several thousand miles of travel. Since the oil is not exposed to carbon, road dust, or unburned fuel, it retains its life longer, and shows less waste, than a gasoline engine supply possibly could.

The cylinders are lubricated by oil pumped into the steam line between the boiler and the engine.

The pump is one of the assembly of four, referred to in the paragraph on "Water System." The engine, therefore, receives a perfectly definite amount of oil per revolution. A sight-feed indicator is mounted on the instrument board.

The mileage obtained on kerosene is about the same as that obtained on gasoline, by a gasoline car of the same weight. The fuel consumption is proportional to speed, just as in a gasoline car, and ranges from ten to fourteen miles to the gallon, depending on conditions. Owing to the fact that kerosene is comparatively low in price, the car is particularly economical on fuel.

The Stanley power plant is rated at 20 horse-power. This may appear low for a car weighing 3,650 pounds, but with a steam power plant it is really ample. The average load on the engine in a car of this weight is not likely to be more than 10 horse-power, which is well within the rating. When more than the rated power is wanted the Stanley power plant can handle a load far in excess of this. In fact, it can carry an overload of two or three times its rating continuously, and can deliver to exceed 80 horse-power for a limited time.

The feature of energy storage must be considered in any discussion of the power rating. The Stanley power plant can develop power greatly exceeding its continuous maximum rating, provided the period of heavy load is followed by a period of moderate load during which time the steam pressure can return to its normal value. Thus, when the Stanley Car is driven down a hill, the throttle is closed, shutting off the *steam,* but not the *fuel.* And the combustion of fuel continues, storing energy in the boiler in anticipation of the next period of heavy load. This feature of the Stanley plant enables the 20-horse-power engine to develop 5 horse-power half the time and 35 horse-power the other half, without at any time exceeding the continuous boiler rating of 20 horse-power. This range of ability is possible only with the steam engine, and with a boiler of the Stanley type.

Exhaust steam from the engine passes to the feed-water heater, described on page 11, and then to the condenser. The latter operates, just as an ordinary radiator, except that it cools and condenses the steam instead of water. In fact, the Stanley condenser is a standard Mayo Radiator. The steam enters at the top, passes through the cellular passages with their large radiating surface, and leaves the bottom in the form of water, which returns to the water tank. A fan back of the radiator has not proven necessary, as is the case with gasoline cars, because the engine never runs unless the car is moving.

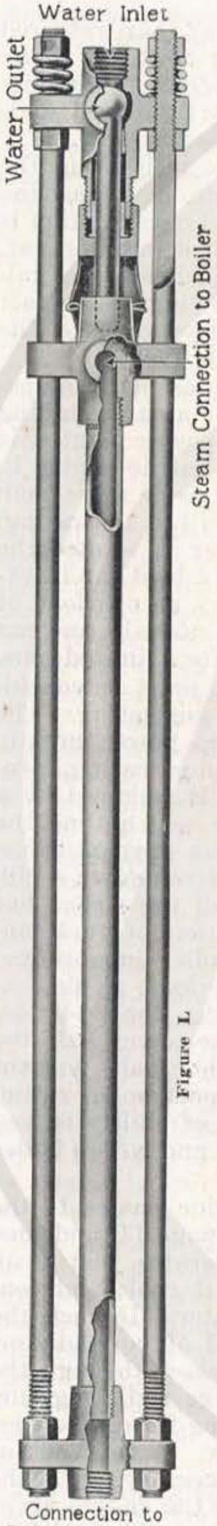


Figure L

AUTOMATIC CONTROL

The Stanley Car is fitted with three automatic regulators and two relief valves. The former are, the feed-water automatic by-pass, the low-water automatic shut-off, and the steam automatic. The latter are, the safety valve and the fuel automatic relief valve. These devices are all of simple design and sturdy construction.

AUTOMATIC BY-PASS

The feed-water automatic by-pass, Figure L, regulates the level of the water in the boiler. It is located on the side of the boiler. It consists of a tube held in the center of a frame made of two stout rods and two end pieces. The rear end of this tube is connected by a pipe to the upper part, or steam space, of the boiler. The other end is connected to the lower part or water space. The water, therefore, stands at the same level in this tube as in the boiler. If the water level is below the tube the latter is occupied by steam. The heat of the steam causes the tube to expand, and the lengthening of the tube closes the valve, shutting off the by-pass line and compelling the water coming from the pumps to enter the boiler. When the water-level in the boiler rises, the steam in the tube is replaced by water, which, becoming cooler than the steam, contracts the tube, allowing the water from the pumps to return through the by-pass to the tank, and thus stopping the flow to the boiler. This valve, alternately opening and closing, keeps the water-level within a range of about two inches, without any attention on the part of the driver. The

valve is exceedingly simple, having no delicate parts, and since it is worked by the almost irresistible force of expansion and contraction, its operation is positive and reliable.

LOW-WATER AUTOMATIC

The low-water automatic is a device provided for cutting off the supply of fuel to the burner in case the water-level in the boiler falls below normal. This might result from driving the car without water in the tank. The automatic is mounted at the side of the boiler. It is shown in detail in Figure M. The principle of this device is much the same as that of the feed-water automatic by-pass, just described. It consists of a vertical tube with the upper end closed and the lower end opening into the boiler at the minimum level it is desired to allow the water to reach. As long as the water-level is above the opening to the tube, the latter remains full of water. This water remains cool because the tube is dead-ended and the water is out of circulation. If for any reason the level falls enough to uncover the opening to the tube, the water in the tube drains out and is replaced by steam. The change in temperature causes an expansion of the tube which closes the valve and shuts off the fuel. The fuel remains cut off until the water-level has returned to the proper height, after which the tube fills with water again. The result is that the tube contracts, the valve opens, and the fuel is allowed to pass to the burner.

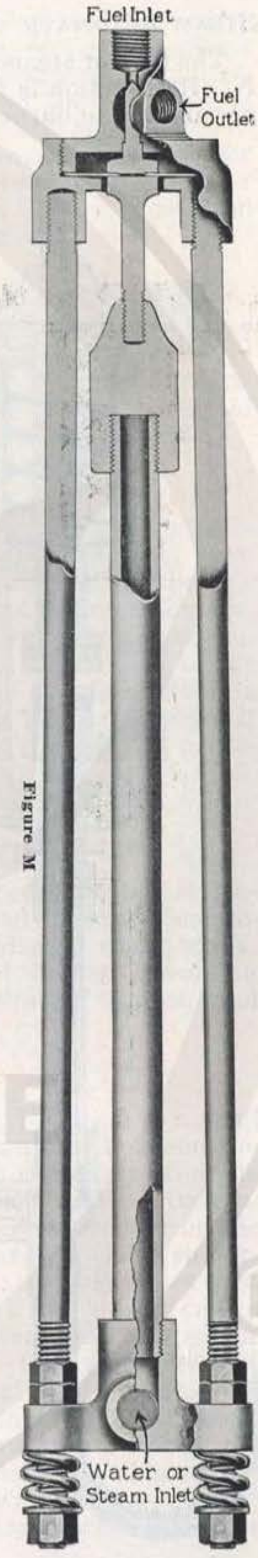


Figure M

Steam Automatic

The fuel, or steam, automatic is shown in Figure N. Its function is to regulate the amount of fuel passing to the burner so as to maintain a constant steam pressure. The rate at which steam is drawn from the boiler varies considerably with the speed of the car and the conditions under which it is traveling, and the steam automatic provides a proportional amount of fuel. The steam automatic consists of a flexible, metal diaphragm clamped between the upper and lower sections of a hollow casting. Steam pressure from the boiler is admitted to the upper side, and a coil spring is adjusted against the lower side of the diaphragm. The spring is set to balance the steam pressure, so at the normal boiler pressure the diaphragm takes a neutral position. The diaphragm, therefore, moves with every variation in the steam pressure in the boiler; and a very simple arrangement of a stem from the diaphragm to a valve in the fuel line gives a simple and dependable automatic control to the fuel supply. When the steam pressure in the boiler falls below the predetermined amount, the pressure on the upper side of the diaphragm is reduced and the spring lifts the diaphragm, which, through the stem attached to it, opens the valve in the fuel line and admits the fuel to the burner. More fuel means more rapid

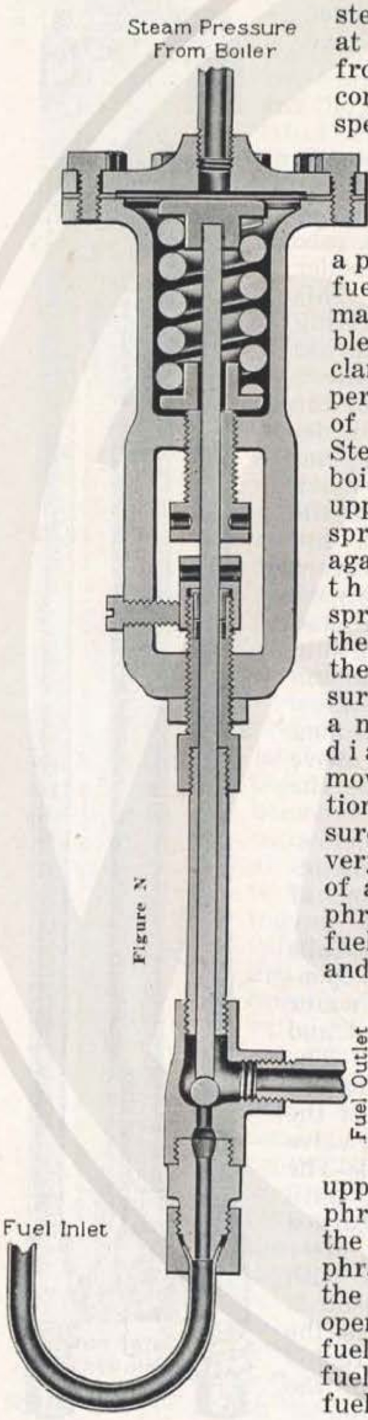


Figure N

steam generation in the boiler and the pressure climbs up; this pressure, of course, affects the diaphragm, forcing it down against the spring and moving the valve stem so the fuel line is closed again. The steam automatic is the connecting link between the steam pressure in the boiler and the intensity of the burner; so that the latter is controlled by the former and the driver relieved from any attention to the burner.

Safety Valve

The steam safety valve is of the ordinary spring loaded type, and is set to release at a pressure somewhat above the ordinary working pressure. It is simply an added precaution in the event of any possible accident to the steam automatic.

Automatic Relief Valve

This device, which resembles the steam automatic in general design, regulates the fuel pressure in the service tanks, so that when the line to the burner is shut off by the steam automatic, the output of the fuel pump, which runs continuously when the car is moving, can return to the supply tank. The relief valve simply controls a by-pass line from the pump to the tank, which it opens when the fuel pressure reaches the predetermined high point.

MANUAL CONTROL

Primary control of car, when running, is centered in the throttle valve and brakes. Supplementary manual control, used only occasionally, consists of the electric pilot heater, reversing pedal, and auxiliary hand shut-off valves, and pumps.

Throttle Valve

The throttle valve, shown by Figure O, is a small cone-seated valve, in the steam line between the boiler and the engine, which is raised from its seat by a stem extending through the valve-casing. The stem is actuated by a small lever on the end of a shaft which passes through the dash parallel with the steering-post, and terminates just below the steering-wheel. At this upper end, a control lever is attached, conveniently located for manipulation by the driver. One finger suffices to control the lever so as to give any desired admission of steam to the engine, or shut the steam off entirely. The whole construction is sturdy and not subjected to high strains or heat. The superheating of the steam takes place after it passes the throttle, the throttle valve being placed in the line between the boiler and the superheater. The arrangement of the valve is such as to give properly graduated steam-admission, so as to avoid shock and give easy control when first opening the valve, and to shut itself in case its control were broken.

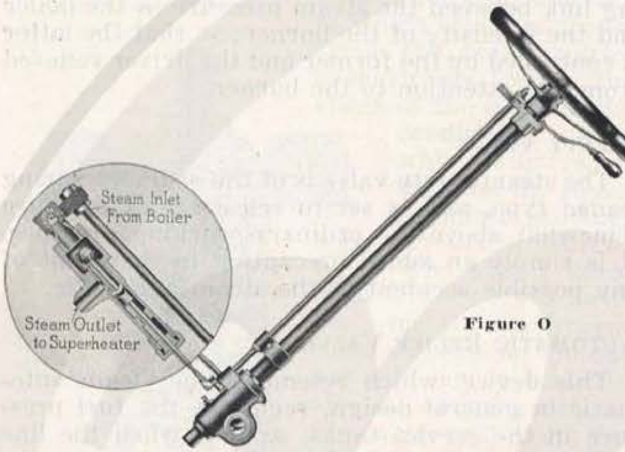


Figure O

The simple throttle valve of the Stanley is much more than the full equivalent of the gear-changing mechanism on gasoline cars. It is as if the car had a silent gear box with not a gear in it, but giving an infinite number of speeds, and as if the gears changed themselves, instantly and noiselessly, without the driver's attention, and without even his knowledge, without jerks or interruptions of the propelling force, and in such a way as always to provide the gear ratio most advantageous to the work at hand.

On account of this feature of the throttle control, no gear-shifting mechanism is necessary or even desirable on the Stanley Car. Confirmation of this statement may be found in the fact that the Stanley engine can start from rest, with the cranks in the least favorable position, with a turning force at the crank-shaft some nine times as great as the best that can be developed, at any speed, by an 8-cylinder gasoline engine capable of developing 70 horse-power. If the cranks are in the most favorable position for starting, the comparison becomes 13 to 1.

Steering Gear

The steering gear is of standard construction, the Warner Gear being used. The rake and camber given the knuckles are such as to give maximum ease of control and minimum strains on the gear.

Brakes

The brakes are of standard construction, the service brake, operated by pedal, being outside contracting, and the emergency brake, operated by lever, being inside expanding.

Electric Pilot Heater

The electric pilot heater, which heats the pilot, is briefly described on page 7. The switch and timing thermostatic automatic release are enclosed in a neat case from which the push-button projects. It is necessary to use this switch only after a considerable period of idleness of the car, and then only after the pilot has been turned off.

Reverse

The reversing pedal is under the driver's left foot, next to the brake pedal. Pressing it forward reverses the engine. No other action is necessary, and no care is needed as to whether the engine is stopped before reversing. This is a point of great consequence in critical moments of danger.

There is an intermediate position of the pedal which "hooks up" the engine valve gear (described on pages 19 and 20) to give maximum steam and fuel economy. This is the normal running position.

Hand Pumps

This auxiliary hand pump is beneath the floor of the driver's compartment, and is operated by a light lever passing through a slot in the board. As it is seldom used, the lever is made removable, so as to be out of the way. The pump is of twin

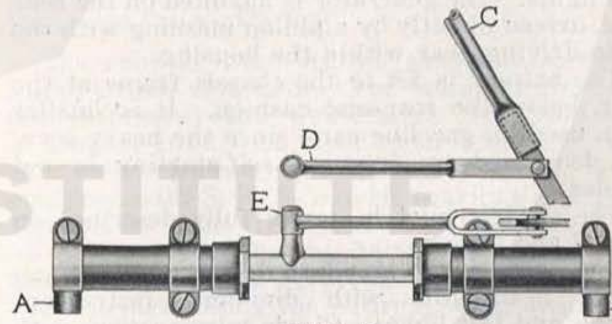


Figure P

HAND PUMP ASSEMBLY

a—Fuel inlet and outlet. *b*—Water inlet and outlet. *c*—Detachable hand lever. *d*—Fork connecting rod. *e*—Plunger rod connection.

construction with opposed cylinders and a double-ended plunger. One side is for pumping water into the boiler, and the other side is for pumping fuel into the small pressure service tanks normally supplied by the power fuel pump. This latter has to be done only after the fuel system has been completely drained.

Valves

The steam car has often been regarded as bristling with valves requiring expert manipulation. This is not the case. There are a few valves, but they are not used at all when running the car. They are simply added precautions, like removing the lock-key, closing the gasoline-cock, and switching off the ignition system or lights on a gasoline car when leaving it standing.

There is a hand shut-off valve on the main fuel supply, controllable from the instrument board, and a similar valve on the fuel supply to the pilot. Under the instrument board there is a shut-off valve in the water line to the automatic by-pass, which is used for filling the boiler above the normal level. This may be a convenience when the car is to stand for a considerable time. There are two small valves at the foot of the dash, only used when pumping the initial air into the fuel service tanks.

On the boiler there is a blow-off valve for cleaning it out, used every thousand miles or so. In the piping system valves are placed at appropriate points to facilitate disconnecting one part or another without draining the entire system, or to facilitate testing.

It will be noticed that none of these valves are used when running the car.

Electric System

This consists of generator, battery, pilot heater, and lights. The generator is mounted on the rear axle, driven directly by a pinion meshing with the main driving gear within the housing.

The battery is set in the chassis frame at the rear, below the rear-seat cushion. It is smaller than used on gasoline cars, since the heavy service demanded by frequent self-starting is not needed.

The electric pilot heater is fully described on page 7 and page 8.

The lights are of standard design and arrangement: head-lights with dimmers, instrument lights, and tail lights. Single wire system, with grounded return is used.

Instruments

Indicating instruments, showing all conditions of the power plant, are within easy vision of the driver. The steam pressure gage, fuel pressure gage, lubricating-oil indicator, battery-charging indicator, and speedometer are mounted on the instrument board. The indicator, showing water-level in the boiler, is set lower on the dash, and the

indicator, showing water-level in the water tank, is set in the floor board. Both the pilot fuel tanks

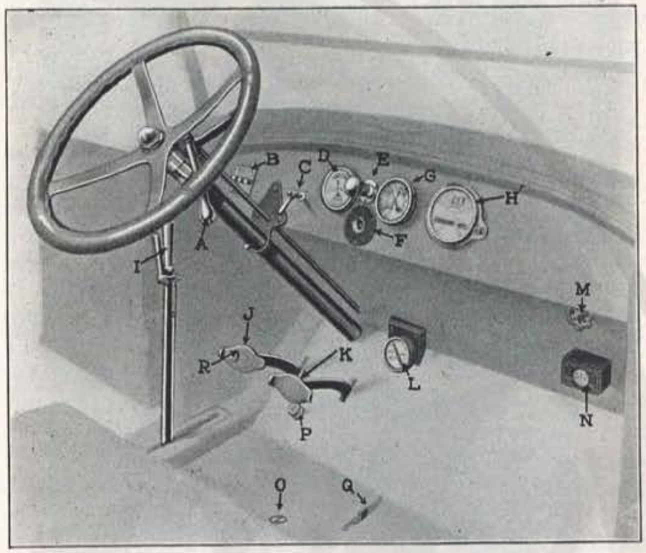


Figure Q

INSTRUMENT BOARD AND CONTROL DEVICES

a—Throttle. *b*—Lighting switches. *c*—Main burner control. *d*—Steam gage. *e*—Dash light. *f*—Oil sight feed. *g*—Fuel pressure gage. *h*—Speedometer. *i*—Emergency brake. *j*—Reverse pedal. *k*—Foot brake. *l*—Water level indicator. *m*—Hand by-pass valve. *n*—Light electric indicator. *o*—Water tank gage. *q*—Hand pump lever stub. *r*—Hook-up button.

and the main fuel supply tank have level indicators in convenient view.

Running Gear and Body

The running gear follows generally accepted highest class standards. The frame is of ample section pressed steel, well braced. The front axle is Timken fitted with taper roller bearings. The rear axle is made by the Stanley Company. It is equipped with S. K. F. outside bearings and Timken inside. The driving effort is transmitted by all four springs, thereby having advantage over the Hotchkiss type of drive, for instead of the rear springs taking the entire driving strain the load is distributed through both front and rear springs by the rods, which connect both front and rear axles.

Starting

This may be either from dead cold, or it may be a resumption of service after the car has been standing for either long or short period with the pilot burning. In the latter case, the pilot maintains the full steam pressure for several hours, so that the car can be driven off at once, and the

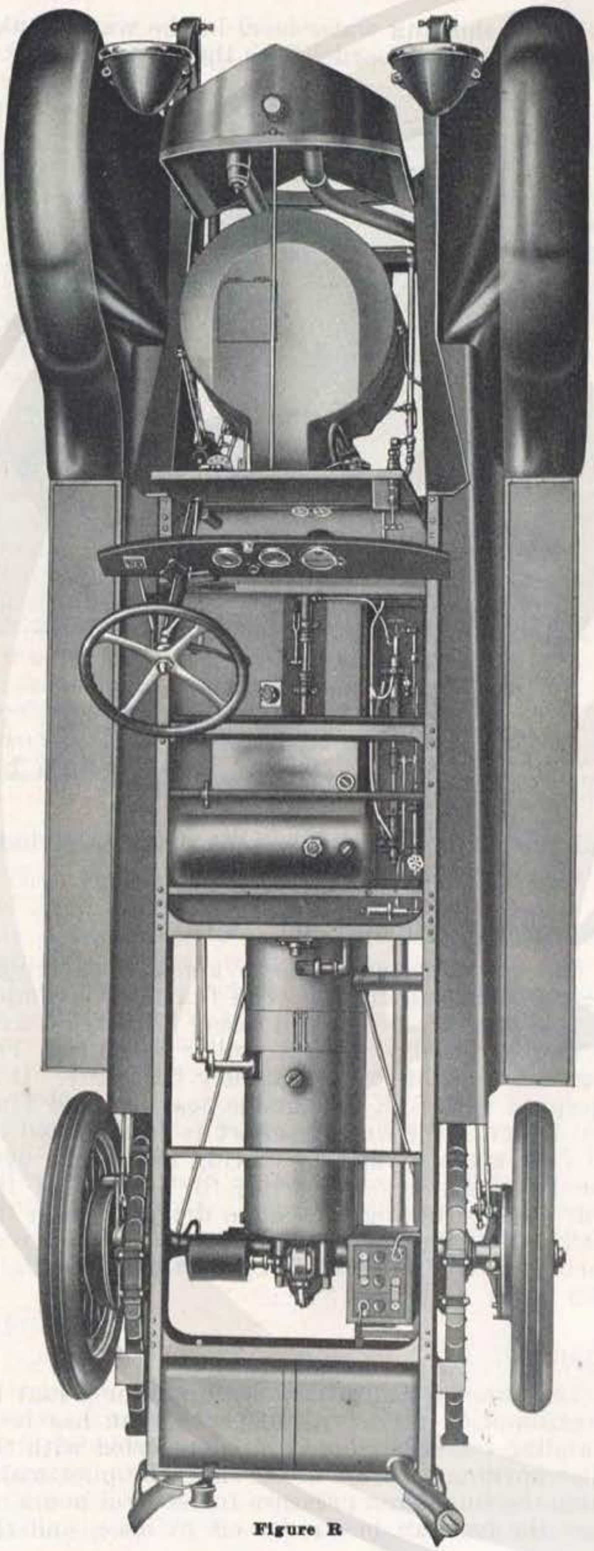


Figure R

main burner started at leisure. If the stop has been for a longer period, say overnight, there will still be sufficient steam pressure for starting, but it may be somewhat low, and in this case the main burner should be turned on a few moments before starting, so as to build up a good reserve of pressure.

When starting from dead cold, the pilot is first set in operation by opening the pilot fuel valve and pressing the electric push-button, as described on pages 7 and 8.

Fuel is then turned on to the main burner, and is vaporized and ignited by the pilot. No further attention is needed, in a few minutes a good steam pressure is available and the car is ready to run. Thereafter the steam pressure is automatically maintained.

WINTER CONDITIONS

The growing custom of operating automobiles during the winter, in the most adverse weather, merits allusion to these conditions, for another inestimable benefit of the steam power plant is here concerned. Not only are the essential parts of the power plant heavily clothed with non-conducting composition, retaining their heat, but the heat storage and distribution in boiler, water tank, and other parts is very large. This keeps the entire mechanism warm. The car can stand in the street for hours in below-zero temperature without trouble from freezing, and is then ready for an instant start. Even when standing for longer periods in unheated garages the pilot keeps the boiler, not only warm, but with steam up. If it is desired to leave the car indefinitely in freezing temperature, with the pilot extinguished, all parts of the water system are readily drained.

An important point is that the radiator contains no water at any time, therefore there is no opportunity for freezing in this particularly exposed part.

It will be apparent from the foregoing description that the Stanley Car affords its owner an ideal ride — an enjoyable, exhilarating ride — and above all a sense of safety and security for himself and his family. The car is always on its feet. The driver can do anything he likes with the power, which is always at his service. No sudden emergency can ever surprise him out of his control of the car. On a railway crossing he can go as slow as a careful man should, and if need arise, he can make the car leap (that is the right word) out of danger, and he can do this even in the event of his fuel supply being exhausted. In crowded traffic he can take instant advantage of every opening. On grades, he may realize the pleasurable sensation arising from the rhythm of uniformly sustained speed — sustained without evidence of exertion or distress on the part of the car — without even consciousness that there is any such exertion. He experiences the exhilaration of the athlete who, while putting forth magnificent effort, knows that his limit is still undemonstrated, and that if occasion arises, his reserve power is equal to any emergency.

The gasoline engine will never be the equal in performance of the steam engine until it is provided with a gearbox having an infinite number of speeds; until the gears in this box change themselves without attention on the part of the driver and, in fact, without his knowledge, and in such a way as always to give the ratio best suited to the work at hand; until the changes of gear are made without noise and without interruption of the tractive effort; until the engine secures overload capacity and starting torque; until it ceases to have the "stagger point"; until it has some reserve of power, in some degree at least, resembling the tremendous storage of energy provided by the hot water in the steam car's boiler; until it runs with the mathematical steadiness and consistency of the steam engine. This list might be extended to cover many other points, but it seems unnecessary. Faults may be found with the steam car, but absolutely not with the characteristic of the steam engine, which approaches the ideal for automobile work.

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