THE
WHITE STEAM
CAR

SERVICE MANUAL
EFFICIENCY REPORT
MISCELLANEOUS

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NOTE

This complete service manual is a true copy of The White Steamer handbook written in 1910 by A. T. Edmonson, Chicago, Illinois.
K. Ziesemer of 3211 N. 5th St., Milwaukee, Wisconsin, steam car owner, enthusiast, and mechanic recognized the scarcity of manuals on steam cars and the dire need for such.
It was for this reason that this copy was made, which covers every possible trouble that the White Steam Car could be subject to.

February, 1951

This service manual was transcribed in digital format by J.Arnoud Carp of Heuvellaan 5, 1217 JL Hilversum, The Netherlands, Steam car owner and enthusiast.

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CHAPTER I

THE WHITE CAR

All the forces controlled by man for industrial purposes are derived from three main sources. The first of these is the muscular force of man and animals; the second is the attraction of the earth which we know as gravity; and the third, being chemical combinations. The latter is by far the most important, as it is in this way we obtain heat and electricity, the two greatest forces in use at the present time. Electricity must be placed second to heat, for in most cases it is obtained by a primary use of a heat motive power. Even waterpower owes its energy originally to the heat of the sun, which drew the water into the air and gave it its potential energy of altitude. Windmills come in the same class, as the winds are caused by the unequal distribution of the sun's heat. The steam engine is a heat motor, and the most extensively used of any for industrial purposes. The steam itself does not perform the work, but the heat contained in the steam. Water vapor is the best known medium for conveying heat from its source to the place where it is converted into useful work--namely, the engine cylinders.

History shows that the ancients knew something of steam. Two hundred years ago steam pumps of a crude design were in use in England for lifting water out of the mines. About 1775 James Watt invented the steam engine in the form it is most commonly known today. Watt was a genius, for the principles he laid down at that time are still followed. The majority of improvements since have been mainly along the lines of detail, material and construction. The same can be said in regard to the advance made in the art of manufacturing devices for generating steam. The same principle has been adhered to, namely, of having a large volume of water exposed to more or less heating surface and a receptacle at the top from which to remove the steam without entraining the water. The earliest boilers carried a steam pressure of 2 lb. to the square inch. From 2 lb. pressure there has been a steady increase up to the high pressures used in modern marine and locomotive boilers. As fast as the advance in strength of materials and improved construction permitted the amount of pressure was raised, yet there is little difference between the first and last in principle.

About 1899 R. H. White of Cleveland, Ohio brought out the White Steam Generator, which embodied many new principles. This departure from the old ideas was the greatest stride in the science of steam generation since the time of Watt, and should be noted as a distinct invention, not an improvement. To appreciate it one should compare it with an old type boiler. Placed together, the two appear as a pygmy and a giant, although their power capacity is exactly the same. A man of ordinary strength can easily lift the present 40 HP generator. To conclude this line of thought the performances of this new type of steam generator have created a sensation in the engineering world. Much credit is due the inventor for breaking away from the old ideas and giving to the industrial world of the present something so new and efficient.

As often described in the literature issued by the White Co. this generator consists of a series of coils of seamless steel tubing, placed one above another, and the whole surrounded by a light annular casing. The greatest point of difference from the old type of boiler is that the water enters at the top and the steam is drawn off at the bottom. The water is being continually forced downward by the feed pumps to replace that which passes out as steam. The small amount of water contained insures against explosion. A boiler explosion, as commonly known, is caused by the quick liberation of a great quantity of water, which is under high temperature and pressure. The liberation suddenly reduces the pressure and the whole mass of water flashes into steam almost instantaneously. Such a thing is absolutely impossible with the White generator. The nearest thing to it would be a rupture of a tube through which the small amount of steam would escape with less noise than would occur when the safety valve "pops off."

There are 2 principal points to observe in the care of the generator. Avoid overheating and keep the water tank clean. If the coils are allowed to run at a red heat the metal becomes soft and the pressure is apt to expand them enough to cause rupture. (2) Mineral scales, which are the enemies of ordinary boilers, have no effect on the coils. The circulation is too rapid. However, if the oil in the water tank is permitted to accumulate and is pumped into the generator by allowing water to run low, much harm will result. The oil spreads itself over the inner surface, and unless removed while still soft, will carbonize from the heat, in the course of a few days. Once carbonized, it necessitates taking the generator apart in order to remove.

The White engine is a cross compound of the marine type. The earlier models had both valves of the D slide type. In 1907 and 1908 they had a high pressure piston valve and a low pressure slide valve, and at the present time both the high and low pressure have piston valves. The piston valve has the advantage of being almost perfectly balanced, and consequently wears very little. The Joy valve gear is being used at present, taking the place of the

Stephenson gear, which was formerly used. Summing everything up, it is just an ordinary steam engine, with the exception of being very compactly built of excellent material.

The splendid results achieved are due to the generator and the high degree of superheat given to the steam. Usually a small steam plant is very extravagant of fuel and steam, sometimes using as high as 100 lb. of steam per HP per hour. As a rule, the larger the plant the more economical. However, the figures of ll.95 lb. of steam per developed HP per hour, which is the result of Prof. Carpenter's tests, are superior in many cases to those shown by large compound condensing engines and even triple expansion ones. Aside from the generator and engine the rest of the White Car is similar to any other of standard make, with the possible exception of there being no transmission gear box.

CHAPTER II

HINTS ON ECONOMY

Webster says, "Economy avoids all waste and extravagance." The popular definition of being the opposite of expense. Such is not exactly so. It is, however, the direct opposite of needless expense. Applied to the case of the automobile, economy means the avoiding of all the expense of up-keep which is unnecessary and which ought not exist. A group of the necessary expense items is composed principally of the following, namely, that of tires, depreciation and fuel.

Much has been printed on the subject of the care of tires. A tire of standard make is usually good for several thousand miles. A great deal of tire trouble could be avoided by giving heed to a few main points in regard to their care. One of the most important of these is that of inflation. To run a tire without its containing the proper air pressure will greatly shorten its life. A table of proper pressures for different sizes of tires can be obtained of any first-class manufacturer for the asking. A rough but efficient method is to inflate the tire until its walls cease to bulge and are straight. This when only the weight of the empty car is being sustained.

Avoid unnecessary use of the brakes. The strain all comes on the fabric of the tires. For the same reason do not turn corners at high speed. Avoid letting grease or oil come in contact with the tires. Oils and greases are natural enemies of rubber. Too much emphasis cannot be put on the fact that many blowouts are the result of overloading the car. A car is usually equipped with tires to carry the load for which it is designed. Any more than this, results in overstrains on the tire fabric. Owing to the elasticity of its power, a steam car is very easy on tires in comparison with a car of the same weight propelled by an explosive motor, and there should be no reason why a steam car owner with a little care, should not get exceptional mileage out of his tires.

Depreciation can be divided into two classes: Theoretical and actual. Suppose a car is bought and driven five hundred miles; at the same time receiving the best of care. In reality it is a better car than it was the day it left the factory, for all the bearings are broken in and everything is just beginning to work "sweetly". The theoretical depreciation amounts to something like twenty five per cent, as the car is now a "used car" and that is its status on the market. However, it is with the actual depreciation, and how to avoid as much of it as possible, that we wish to deal.

For practical purses, a used car is just as valuable to the happy owner, regardless of its age, as a new one, provided he gets the service out of it. To obtain this kind of service it is necessary to eliminate all sources of depreciation, aside from natural wear.

Enumerated in the order of their importance, the following seven items are the source of the greatest wear and tear on a car. Namely, lack of lubrication, abuse of the throttle, abuse of the brakes, fast driving on rough roads, overloading, turning corners at high speeds and a lack of cleanliness. Lubrication heads the list, but as it has been discussed in the chapter devoted to that subject, it is unnecessary to repeat.

Owing to its great amount of reserve power the steam car can be abused by an improper handling of the throttle. If the latter is opened quickly, the amount of power, which is applied in accelerating the speed rapidly, is enormous. It results in a great overload on engine, drive shaft and rear axle. No car, whether steam or gasoline will stand this treatment and continue to run as well as it would if it were handled in a sane manner. The proper way to manipulate the throttle is to open it gradually. Allow the car to get into motion before turning on any great amount of power. It is also a good point to remember to close the throttle before applying brakes. Regarding the latter, the abuse of the brakes is just as needless and just as injurious as that of the throttle. The steam car is particularly capable of being driven by throttle control alone and violent application of the brakes should be reserved only for emergencies. The habit should be acquired of shutting off the power and coasting up to the desired stopping place. How often we see a car brought up abruptly, with all brakes squealing a protest. No sane person would think of stopping a good horse in that manner. When on country roads and approaching a rough bridge or a corner, coast up to it when possible, cross easily, and gradually opening the throttle, pick up the former speed. A few little habits like these will save many a dollar in the course of a year.

There is little excuse at any time for fast driving, and none at all for fast driving over poor roads. Nothing will rack a car to pieces sooner. When a car weighs from 2,500 to 4,000 pounds, and is driven at a high speed, where the road is rough, the strains and stresses produced are exceedingly great. It is marvelous that some machines stand as much as they do. Furthermore, the danger of accident from breakage’s and from losing control is no small item and should not be overlooked.

The man who persists in overloading his car shows up his total ignorance of the laws of mechanics. When an engineer designs a bridge he makes it a certain number of times stronger than is necessary to carry the greatest load it will ever be expected to accommodate. This excess strength is termed the factor of safety. Also, when he designs an automobile to carry, let us say, five passengers, a certain factor of safety is allowed. The bridge is safe from harm for the reason that the normal conditions are such that it cannot be overloaded, but there is nothing to prevent an owner from overloading his car if he wills to do so. The surest preventive of this, however, is a strong application of good common sense.

Another money saver in regard to a car is cleanliness. An accumulation of mud, sand, dust and grease works harm in many ways. The grit works into many places, causing wear. Into the body joints, the frame joints, the brakes, the drive shaft, the engine and in fact all over the car. It prevents the discovery of loose bolts and nuts, which, if found in time, might save a broken part or possibly life or limb. Sometimes an owner even finds that he is losing that respect for his car without which he does not give it the care it deserves. All this because he has allowed it to become run down and disreputable looking.

Summing up briefly, if an owner wishes to keep his car out of the repair shop, he should comply with the following rules:

1. Lubricate plentifully and systematically.
2. Use judgment in handling the throttle.
3. Use the throttle much and brakes little.
4. Shun making time on rough roads.
5. Carry the cars, quota of passengers and no more.
6. Spend a little time each day in cleaning.

A still shorter summary would read like this:

"KNOW YOUR CAR".

A Few suggestions for obtaining good water- and fuel performances on the road might not be amiss. Drive at a uniform speed, as nearly 18 to 20 miles per hour as possible. Take hills easily. It requires great excess power to climb grades at high speed. Keep "old style" engines hooked up as much as they will stand without vibrating. The new engines do this automatically.

Be sure brakes do net drag. To show how much power is lost by dragging brakes, let us suppose a case.

The diameter of the Model "K" wheels is 36 inches. The diameter of the brake drum is 14 inches. Suppose the brake is dragging, so that it takes thirty-pound pull at the outer circle of the tire to slowly move the wheel when car is jacked up. This amount has been determined by experiment and is not an unusual occurrence. Sometimes it is even more. By the law of levers, the radius of the wheel times the pull equals the radius of the brake drum times the resistance in the opposite direction (which is of course the drag of the brake). Then

18 times 30 equals 7x where x represents the drag.
540 equals 7x.
x equals 77.1 pounds.

Therefore, it would take 77.1 pounds pull at the rim of the brake drum to start wheel to moving, or putting it another way, the brake offers resistance of 77.1 pounds at a distance of 7 inches from the center of revolution. Then the horsepower absorbed can be expressed.

Horsepower equals circumference of brake drum in feet times number of revolutions per minute times resistance in pounds divided by 33,000.

Circumference of a 14-inch circle equals 3.1416 times 14, equals 43.98 inches.
43.98 inches divided by 12 equals 3.66 feet.
To get the number of revolutions in a mile divide 5280 by the circumference of the wheel which latter is 9.42 feet. The result is 560. Thus, if we are going sixty miles per hour, the wheels will be making 560 revolutions per minute. At thirty miles per hour, one half of which is 280 revolutions per minute, end at twenty miles per hour, one-third of which equals l86.6 revolutions per minute. Substituting these values in our horsepower formula and using 186.6 revolutions per minute for twenty miles per hour, we have

Horsepower equals 3.66 times 188.6 times 77.1 divided by 33,000 equals 1.6 HP

As this is the power absorbed by one brake, the total by both 2x1.6=3.2 HP Assuming that the friction remains the some at all speeds (which is not exactly true) the power at thirty miles per hour equals 4.8 HP, and at sixty miles per hour equals three times that of twenty miles per hour, which gives the great figures of 9.6 HP wasted.

If the car uses l½ pounds of fuel per HP hour, then in 10 hours running, at 20 miles per hour, we have used 48 pounds of fuel to overcome the drag of the two brakes. As gasoline runs about six pounds to the gallon, therefore, 48 pounds = eight gallons gasoline wasted at 20 miles per hour.

These calculations are roughly made and do not strictly conform to the laws of friction, but the results are near enough to answer the purpose, namely, to show how surprisingly large is the amount of fuel wasted in many cases. As the ratio of the brake drum diameter to the wheel diameter is approximately the same on all models, the same results can be applied to al1.

Bear in mind the first sentence of this chapter:

"ECONOMY AVOIDS ALL WASTE AND EXTRAVAGANCE".

CHAPTER III

LUBRICATION

Lubrication is the process of introducing some substance between two moving contact surfaces in order to preserve them from wear. If the surface of a bearing, no matter how finely finished could be viewed through a microscope, it would have a very rough and ragged appearance. When two such surfaces are moving in different directions, while in contact, these "tiny mountain ranges" will begin breaking each other loose from their respective surfaces, meanwhile continually creating new ones. This process is commonly known as cutting or scoring. If we can introduce some substance between these surfaces, which will fill all the little crevices, and hold them apart, we have a lubricant. The use of grease and oil accomplished this end, and under proper conditions gives satisfactory results.

An article by Prof. Thos. P. Stillman, says: The generally accepted conditions of a good lubricant are as follows:

1. Body enough to prevent the surfaces to which it is applied from coming in contact with each other. (Viscosity).
2. Freedom from corrosive acid, either of mineral or animal origin.
3. As fluid as possible consistent with "body"
4. A minimum coefficient of Friction.
5. High flash and burning points.
6. Freedom from all materials liable to produce oxidation or gumming.

A lack of proper lubrication is one of the greatest sources of damage and depreciation with which the automobile has to contend. Even under the best conditions, the dust and mud of the road are apt to increase the chances for wear by working in between the bearing surfaces. The least harm, which can result from improper lubrication, is a very rapid increase in the rate of wear. From this degree it may range on up to the point where an entire unit of mechanism may be cut to pieces and ruined in the space of a few minutes. One cannot be too careful about the lubrication, for it is the very life of the machine.

The benefits derived from proper lubrication are numerous. Chief of these is long life due to lack of wear. Easy running results in economy of fuel and tires. The man who spends from 20 minutes to half an hour oiling and inspecting his car before starting out is the one who never leaves his driving seat while one the road, except for accidental breaks or tire trouble. One does not necessarily have to be an engineer or mechanic in order to run an automobile successfully. A liberal use of common sense and oil will accomplish wonders along this line.

The points to be lubricated on the White car, enumerated in the order of their importance, are as follows: First, the cylinders: Applied energy is obtained from a steam engine by means of the steam pushing a piston up and down in a closed cylinder. This piston must fit close enough to be steam tight and at the same time be free to move up and down. From this fact it can readily be seen that the power and economy of the engine depends upon a steam tight joint between the moving piston and the cylinder walls. Proper cylinder lubrication helps to preserve this steam tight fit and helps to prevent leakage past the piston by forming a film on the cylinder surface.

The conditions within the cylinders are such as to demand a constant supply of oil of a high flash test. The supply must be regular, as the flow of steam is continually carrying it away through the exhaust. If the oil ceases to feed even for a short time, the pistons and valves become dry almost immediately and are apt to start cutting. The steam used in the White engine is very hot, much more so than is commonly used in other steam plants, consequently it is necessary to use an oil which has a high test and a good body under high temperatures. It is advisable to select an oil which is well recommended and known to be all right. Then use that oil to the exclusion of all others, for it does not pay to experiment with oils, when the result may be a pair of badly damaged cylinders. The oil enters the cylinders by way of the steam chest, where it lubricates the valves before reaching the pistons. The feed is made positive by means of a little plunger pump, which is located in the oil box on the dash. The pipe from this pump to the cylinders should be inspected occasionally to see that it has no leaks. Any leak would rob the cylinders of their full amount of lubrication and should be stopped at once. The later model cars have a handle on the oiler box, which operates the force feed by hand. The proper time to use this is when the engine is laboring up a hill or through sand, etc., at slow speed. When the engine is running under light load, to oil by hand is entirely unnecessary, and merely results in wasting oil. The automatic oiler supplies a sufficient amount for all but the most extreme conditions. It probably does even then, but many prefer to be on the safe side by using the hand oiler.

When first startling a cold engine it is advisable to give the hand oil pump a few strokes. The feed pipe may have become partly empty, and as the automatic pump feeds very slowly, the engine would run some time before the oil reached the cylinders.

On the scale of importance, the second place for lubrication is given to the engine crankcase. A quantity of oil is contained therein, lubricating the revolving parts of the crankshaft by means of the splash principle. The importance attached to the lubrication crankshaft bearings is due to 2 things. First, the amount of power transmitted from the cylinders to the propeller shaft. Second, the small space within which the mechanism is enclosed. Work produces friction and the more compact the machinery doing the work is the greater becomes one importance of good lubrication. A good crank case oil should not be too thin, but should have body enough to lubricate well under a heavy load and still flow through the ball races. It should have good wearing qualities and not change to a thick jelly-like form under the beating due to the revolving parts. It is very important that it be free from acid. Corrosive action due to the latter is very injurious to ball bearings, as it pits the balls and ball races.

The crank case oil should be changed before it is "worn out". The periods of changing, of course, depend upon the amount of use of the car and the severity of the work it is doing. At least once a month the crankcase should be drenched out with kerosene, which can be accomplished by putting in 2 quarts after draining out oil and running the engine a few moments. This loosens and washes out all sediment and dirt, which may have accumulated, leaving everything clean for the fresh oil. When the car is in use 2 extra quarts of oil each week poured directly into the crankcase will insure against a deficit. The automatic oiler on the dash has one lead to the crankcase, which is constantly renewing the supply, but the extra amount will prove beneficial. Better too much than not enough.

On the later models, where the crankcase is made almost absolutely oil tight, the amount of renewal can be less, but the oil should be entirely changed more often. On these models, where the pumps are enclosed in the crankcase, it is well to guard against water getting into the oil, by keeping the packing glands tight. Water intensifies the action of any acid, which might be contained in the oil. If one quart of pure lard oil is mixed with 3 quarts of the crank case oil and this mixture is used, the lard oil will help protect the bearings from any corrosive effect of water and acid by forming a film, which coats the balls and ball races. This hold good for all models, as there is a possibility of water in the oil on the older models. On these it can work in through the crossheads, after having escaped through the stuffing boxes in the form of steam, hence it is advisable to keep the piston and valve stem stuffing boxes tight.

The next item on the lubrication list is the rear axle. Not only does the rear axle transmit the power developed by the engine, but it must also carry its share of the load. Furthermore it must stand the shocks and strains produced by the inequalities of the road. For these reasons it stands in importance as to lubrication very close to the cylinders and crankcase.

As the pressure on the lubricant between gear teeth is very great, we need an oil which has plenty of body. Usually the same kind of oil used in the cylinders is found to give good results. Some advocate the use of light grease or non-fluid oil. This may serve very well, when the climate is warm, but better results will be obtained in cold weather by using the cylinder oil. A spoonful or two of flake graphite, sprinkled in the oil, will be of benefit. Do not get much more than this amount, as the excess may choke the bearings and prevent the oil from getting into the ball races.

The oil should be changed about every 1,000 to 1,500 miles, depending upon the work of the car. Drain out and drench with kerosene. When refilling do not get the level above the level plug on side of gear casing, as an excess amount will cause oil to overflow at axle ends, where centrifugal force will throw it on the brake drums and wheels. The two outer bearings on the rear axle receive no lubrication from the oil in the gear case, but depend upon grease, which is supplied through grease cups. These cups will be found just inside of the brake drums. They should be kept well filled and should be screwed up a turn or two each day. Once a week an entire cupful should be forced into the bearing. Any first-class hard oil will do for use in all grease cups. Graphite greases give excellent results.

The drive shaft is the connecting link between the engine and rear axle. It must transmit all the power and do this at different angles, caused by the up and down motion of the body on the springs. To compensate for this motion, a sliding joint and universal joints are provided. The work performed by these is very severe, and they should receive careful attention as to lubrication.

The lubricant should be hard oil or graphite grease. The later models have grease cups provided on both slip joints and universals. On the others the grease must be forced into the pins with a grease gun, which is provided with the car. On cars having slip joint square in. the engine flywheel, the plate, (held by four screws), must be removed to apply the grease. If a smooth running car is desired, all drive shaft bearings must be kept well greased.

The work done by the front wheel bearings is usually underestimated. They receive all the shocks of the road surface and the side strains caused by changing the direction of the car. By the leverage of the wheel from hub to tire, this latter is sometimes very great, especially in turning corners at high speed or turning out of ruts. The front hubs are packed with hard oil, the bearings being ball bearings. This will provide lubrication for long periods. However, it is not wise to trust the grease for too great a length of time, as it may become dry hard from excessive wear. At least every five thousand miles of fairly continuous use the old grease should be cleaned out and replaced with a fresh supply. Graphite grease is especially good for front wheel bearings.

At all times when car is running, the safety of the passengers depends upon the steering gear. A steering gear, which binds or is loose from wear, is a constant menace. Both can be prevented almost entirely by plenty of lubrication. Without it all the pin joints wear rapidly, owing to the vibration of the front wheels.

Hard oil is used throughout. The majority of the joints are covered with leather "boots". These should be unlaced to allow cleaning of joint and renewing of grease. Pay especial care to the steering knuckles, as the load upon them is heavy. The grease cups on these should be screwed up every day. The steering gear housing is packed with grease, within which works the worm and segment. A grease cup is provided for this.

A mixture of light oil and kerosene is excellent for dry springs. Pour it over the springs at night and wipe off surplus in the morning. By lifting body of car with jacks and removing load from springs, the mixture will penetrate better between the leaves.

The spring and shackle pins, as well as radius rod pins, are important points to lubricate. The weight of the entire body and passenger load, as well as power plant, is suspended on these. As they are in constant motion, it is easily seen that unless well lubricated, they will wear rapidly. The pins have a hole in their centers through which grease can be forced with a grease gun.

The brake levers, especially the ones on the rear axle, are very much exposed to mud, water and dust. The oiling of these is often neglected, and the result is they rust and seize. In the latter case the brakes will not release after they have been applied. On brake bands lined with camel's hair belting or fiber, a little light oil applied will improve their holding qualities.

Do not neglect to oil all the small pin joints. These do not need it as often as some of the other points, but they need it at times just as much. The reverse lever and rod, the gear shifting lever and rod, brake lever, pedals, simpling valve connections, all need oil at regular periods.

The last item does not exactly pertain to lubrication, but to a part of the oil system. This is the steam gauge and water regulator. The pressure, which operates the water regulator, is obtained through a pipe connected to the main steam pipe just before it reaches the throttle. A continuation of this pipe runs to the dash and terminates in the steam gauge. Thus the water regulator and steam gauge obtain their pressure from the same source. To protect the gauge and water regulator diaphragms and to avoid a pressure fluctuation, this line is filled with cylinder oil. By opening the valve under the footboards and directly below the oiler, the path of the oil is changed from the cylinders to this pressure pipe. Giving the hand pump on the oiler 20 to 30 strokes is sufficient to fill this line with oil. A positive way is to break union where pipe connects at steam line and pump till oil drips out. Be certain that the valve is closed before starting the engine. If steam gauge pointer vibrates it is a fair indication that the pressure pipe needs oil.

CHAPTER IV

INSTRUCTIONS FOR ADJUSTING TEMPERATURE ON OLD REGULATION

Before any attempt is made to regulate the temperature on a White car there are several things that it is positively necessary to do before any satisfactory results can be obtained by changing the adjustment of the thermostat. It is necessary to be positive that all of the other automatic parts of the car are working properly. Make it a fixed rule on both the old and new regulation never to touch the thermostat, unless you are absolutely sure that this is true. See that the water lines are clean, namely, the screen in the water tank and the hose connecting the tank to the pumps. Be certain that the pumps are pumping their full amount of water. This can be verified by an examination of the checks and feeling the effect of the pumps with the hand pump plunger. Be sure that the water regulator pin valve has a good seat and does not leak. See that the gasoline line is clear from the tank to the burner, that the wicking in the strainer is not choked; that the vaporizer is clean, also the vaporizer nozzle.

When all these things are done, and not before, it is time to make the final adjustment on the thermostat. The engine is allowed to run at a speed of approximately 400 to 450 RPM. The thermometer is inserted in the thermometer well in the steam line. To be working correctly, the thermostat should open and close turning on and shutting off the fuel quickly and cleanly. It is important that it shuts off the gasoline entirely, otherwise the slowly drifting gases may cause backfiring. Allow the engine to run for half an hour. Read the thermometer every 3 minutes, or at least often enough to see if there is any change in the temperature. After running a while the thermometer will register a maximum temperature and stand there. After being positive that this point has been reached, take out the thermostat needle valve and screw lock nuts up or down, according to whether the temperature is to be raised or lowered. Turning the nut one turn downward towards point of needle valve raises the temperature sixty degrees, and vice versa. The thermometer should stand at 390^{o} when the thermostat is set correctly. This will probably give a temperature of 400^{o} when the car is running on the road. A centigrade C thermometer is customarily used. If not possible to obtain a centigrade thermometer and a Fahrenheit is used, 735^{o} is the correct reading. After adjusting the thermostat while the car is standing, engine running idle on the floor, take it out on the road and test it for power. If the pumps are working properly, and everything else is all right, including the temperature, there will be enough power to satisfy anyone.

NEW REGULATION

In regulating the temperature on the new system, the same procedure is followed as mentioned above for the old. Be positive about the condition of the pumps, the water regulator, the flow motor, the fuel line and the vaporizer. Also that the thermostat needle valve does not leak water when closed. Latter is very important on account of the fact that the regulation of the new system depends upon the water and fuel fed to the generator and burner respectively in a certain ratio. In case the thermostat valve leaks, the ratio would be upset, as there is too much water for the amount of fuel. As mentioned above, the adjustment of the thermostat should be the very last step when regulating the temperature. The operation, however, is a little different in that the nuts on the needle valve are turned down to lower the temperature instead of up. It is not good policy to try to get a temperature reading with the engine running idle. The proper way to proceed is to run the engine idle with the thermometer in the steam line and check up the reading of the pyrometer. After this is done it is easy to take the car out on the road and make the adjustments for temperature at a speed of about 20 MPH. Be sure to run the car long enough to give temperature time to become fixed. It is apt to vary when first starting out. If at any time the temperature should change suddenly while on the road do not change the thermostat adjustment. The chances are that the vaporizer tip has a little dirt in it or that the thermostat valve is not closing properly. Either one of these will cause an over supply of water for the amount of fuel.

DIRECTIONS FOR VALVE SETTING ON THE OLD TYPE ENGINES

1. Fix the reverse lever in a rigid position at full valve stroke "go ahead", namely, in the same position as it would be with the reverse lever in the first notch.
2. Screw the valve stem into the valve stem guide to as nearly the proper position as possible by guess.
3. Turn the engine in the direction it runs when the car is running ahead.
4. In setting low pressure valve, turn the engine until the center punch mark on the high pressure counter-weight is on a level with the edge of the crank case. In this position the low-pressure piston is at one end of its stroke. Now, look at the valve and note how much it is open. The amount of opening in this position is known as the "lead of the valve".
5. Turn the engine in the same direction until the mark on the counter-weight comes opposite the crank on the other side. This throws the low-pressure piston at the other end of its stroke. Note how much the valve is

open. If it is open the same amount as it was on the other end of the stroke, the valve is set correctly. The valve should be opened the same amount on each end when the piston is at the respective ends of its stroke. The lead is now divided equally.

6. Tighten the lock nut on the valve stem and the process of setting the low-pressure valve is complete. To set the high pressure, the same method is followed, using the low-pressure counter-weight to find the dead center for the high-pressure piston. Usually the lead is between one thirty-second and one sixteenth of an inch. This method is an approximate one, used by road repairmen, but is sufficiently accurate for all practical purposes.

DIRECTIONS FOR VALVE SETTING ON THE NEW TYPE ENGINES

1. Have the valve stem screwed down as nearly the proper position as possible. The valve on the new type of engine is an inside admission valve. The steam edge of the valve is on the inside and not at the end, as on the older type engines. Therefore, the valve setting will be done by inside edges. The position of the valves can be seen through holes in which the cylinder cocks are placed. These latter must be removed. Begin turning the crankshaft slowly in a forward direction, at the same time rocking the reverse rocker arm on the engine back and forth. At some point of the revolution of the crankshaft the valve stem will cease to move up and down, while the reverse rocker arm is being moved back and forth. At this point the piston is at the end of its stroke, and valve should be opened the amount of the lead. The same method of dividing the lead equally is followed as in the older style engine. The principal differences are the method of finding the dead center of the engine and the fact that the steam edges of the valve are on the inside. It is worth the trouble after having tightened the lock nuts on the valve stem, to repeat the whole operation, and check the work done. Occasionally in tightening the lock nut the valve stem is turned a little, causing the valve setting to be slightly inaccurate.

DIRECTIONS FOR SETTING PISTON

In setting the pistons back in the cylinders, after having removed them, a certain position is necessary. The figures given below represent the distance from the machined upper face of the cylinder to the piston head, the crosshead being at the upper extremity of its stroke. This distance is termed by White mechanics "the piston clearance," a term which is not exactly correct, however, as the true clearance would be between the piston head and the cylinder head. The "Clearance" on the Models C and D is as follows: High-pressure, one-half inch; low-pressure, seven-sixteenths. On Models E, F, H, and L, high-pressure, seven-sixteenths; low-pressure, three-eighths, On Models G and K, high-pressure, eleven-sixteenths; low-pressure, five-eighths. On Model M and MM, high-pressure, seven-eighths; low-pressure, seven-eighths. On Models O and OO, high-pressure, thirteen-sixteenths; low-pressure, thirteen-sixteenths. After screwing the piston down to the proper Position, be sure that the lock nut is tightened snugly and that the lock washer is turned up around the nut. If this nut loosens up there is enough motion in the threads to cause a pound when the engine is pulling.

DIRECTIONS FOR PACKING STUFFING BOXES

A leaky stuffing box is a good indication of a careless and inefficient driver. When stuffing boxes are packed properly, the packing should be cut in lengths to make a closed ring around the piston rod. This was the method of earlier days. Packing can now be procured put up in rings ready to go into the stuffing box. It is a good point to lubricate the packing with oil and graphite when putting it in. Push as many pieces of the packing into the stuffing box as can be gotten in with the fingers, taking care that the joint in one ring is on the opposite side of piston rod from the joint in the ring which is just above it. When the box is filled, the packing nut should be screwed up as far as possible. Then remove same and insert more packing, each time screwing up the nut and compressing the packing already in place. A common mistake is in having the last ring of packing loose enough at the end to catch under the gland. In this case the gland appears to be tight, but does not compress the packing, and a steam leak is sure to follow, no matter how tightly the nut is screwed up. The causes for leaking stuffing boxes will be taken up under the proper head in connection with the charts.

TO DRAIN THE CAR FOR STORAGE OR SHIPPING

In order to properly drain the water from the car when getting it ready for storage or for shipment in cold weather, it should be done while the car is hot.

1. Run the engine long enough to get the car heated fairly up to its maximum temperature, approximately half an hour, with condenser drain cock open.

2. When car is thoroughly warmed up, shut off the fire a moment and let the pumps force a little extra water into the generator. Stop engine.
3. Disconnect union on suction hose, which connects the tank with the pumps, and allow water to run from water tank. Disconnect union on the main water line at the hand water pump.
4. Remove plug from bottom of flow motor or in the later models, where there is no plug, disconnect line to the thermostat by loosening union where it enters side of flow motor. Run engine a moment to give the pumps a chance to force all water out of water line.
5. With engine running slowly, turn on independent fuel valve, allowing steam pressure to rise almost to the blowing-off point.
6. With fuel valve still open, and while engine is running slowly, open blow-off valve on the left side of the car (commonly known as the water end blow-off). Just previous to opening this valve, partly open the steam blow-off valve.
7. While the steam pressure is dropping, and the engine is dying for lack of pressure, pump oil into the cylinder rapidly (a pint will not be too much). The internal heat cylinders will vaporize the oil, causing it to penetrate all nooks and corners, spreading a film over all the parts and insuring against rust. Open valve under footboard and pump the water regulator lines full of oil until it drips from the steam blow-off. Give the hand pump two or three strokes to force water from the line, between hand pump and water blow-off. On cars having water heater, loosen unions at inlet and outlet, allowing any water contained therein to run out. Loosen all check caps and see that check balls trap no water. On later models, where the water regulator is in a position with the discharge pipe opening upward, the regulator should be removed and water allowed to run out.

If these instructions are followed, the heat retained in the generator, the piping and the cylinders will evaporate any small amount of water left, leaving the car perfectly dry and absolutely free from danger occasioned by low temperature.

These instructions also hold good for cars with the old regulation, by leaving out any mention of the flow motor or the feed water heater. If the car is to be laid up for some months and the packing in the pumps has seen long service, it would be advisable to remove same to prevent corrosion of the pump plungers. If the proper amount of oil has been pumped into the engine, there is little danger of any corrosion of the valve stems and piston rods, but it would do no harm to remove packing from their stuffing boxes. Some owners, of careful engineering experience, believe in removing cylinder heads and steam chest cover and smearing all surfaces with a liberal coating of Vaseline.

Be certain that no water is allowed to remain in the crankcase. To clean same thoroughly, drain out old oil before steam is blown off. Put in half a gallon of kerosene and run engine a few minutes. Drain this thoroughly and put in fresh oil. Then proceed as in item No. 2. This fresh oil can be allowed to remain. The same thing can be followed out on the rear axle gear case.

CHAPTER V

MISCELLANEOUS SUGGESTIONS

Avoid racing engine when steaming up car. The steam pressure rises no faster by so doing.

Run engine slowly, with simpling pedal pressed down, until all water is out of cylinders. This will save many connecting rods and cylinder heads.

To loosen stubborn steam line unions hold a heavy hammer squarely against one face and tap the opposite side with a light hammer. Repeat this for all faces. Apply kerosene frequently. The worst cases can be loosened this way until they will turn with an ordinary wrench.

A good prevention for tight steam line unions is an application of a mixture of graphite and oil. Apply same when putting union together. Do not leave flakes of graphite on the ground faces as they may cause the joint to leak.

To locate a leak in the air system, make a thick soap suds and apply with a brush. Any leak will create a mass of bubbles.

If vaporizer screws loosen easily, but refuse to come out, do not attempt to force them. Saturate with kerosene and twist back and forth a few times. Presently they will remove easily. The accumulation of carbon on the end threads inside causes them to bind. The kerosene loosens this and permits the screw to turn outward.

Keep engine simpled when maneuvering in close quarters. It handles better. Also remember to close throttle an instant before applying brakes.

Make it a habit to steer with the left hand and handle the throttle with the right. Practice opening and closing the latter with a wrist movement. Much closer results can be obtained than by pulling on the wheel.

If gears bind and refuse to shift after stopping car, it is caused by steam trapped in the steam chest. Throw reverse lever to reverse, and then to center position. This relieves the twisting strain on the driving shaft and gears will slip out of mesh easily. There is no occasion for applying force to gear lever.

Open steam blow-off valve before turning on fuel when steaming up a cold car. The pressure rises very rapidly with a generator full of cold water and may rise excessively before the valve can be opened. The latter is especially true in case the valve sticks and refuses to open readily.

In steaming up be sure vaporizer is sufficiently heated before turning on fuel, and avoid a backfire. Usually when vaporizer outlet pipe is hot to the touch just outside the generator casing, the vaporizer proper is heated enough to turn on the fuel. Open and close the feed valve at intervals of three to five seconds until dry gas is coming from vaporizer nozzle.

To loosen brass union nuts, apply a wrench and jar same with the hand. They loosen much easier this way than by a steady pull. In putting same together, there is no necessity for great tightness as all joints are ground to a fit.

Avoid putting strains on piping and unions without holding in the opposite direction with an extra wrench.

Soap is a good emergency packing for gasoline joints.

Change any rubber hose as soon as it becomes soft and flabby. Pay no attention to water, as to whether it is hard or soft, but allow no water containing sand or mud to be used. Sand will pit the pump checks and cut the walls of the flow motor cylinder.

Keep brakes in good condition. The time comes to every one, sooner or later, when they will need a good set of brakes badly.

Form the habit of filling the water tank each morning, even though it takes only a gallon or so.

Blow off generator twice a week from left side. By closing valve before the steam has quite all escaped, the generator will refill itself with water. This is due to the fact that as the enclosed steam is condensed it forms a vacuum. The pressure of the atmosphere forces water from the tank to fill the space formerly occupied by the steam.

If car refuses to start when throttle is opened slightly, do not open it farther. Close it immediately and investigate. It will probably be found that the simpling pedal is not pushed entirely down, the emergency brake is on, or the reverse lever is in the center notch. Observance of this point may save a set of cylinder heads,

If the water regulator screen clogs frequently with lint, it is evidence that the water pump packing is old and rotten, or that a rough spot on the pump plunger is tearing grooves in the same.

Do not allow the steam line from the generator to the engine to become bare and exposed to the air. It allows considerable heat from the steam to escape and consequently is a source of fuel waste.

After replacing a bolt and nut, immediately put in the cotter key and spread it. Serious accidents might result from a missing cotter key.

If a loose bolt is discovered, tighten it at once. Loose parts wear rapidly.

On the "new style" engines do not tighten valve stem stuffing boxes any tighter than necessary to hold the steam. There is little pressure on them, and any extra tightness simply places an additional load on the valve gear.

Know that your lighting plant is in good condition. You may be far from home when overtaken by night and darkness. It is unpleasant to drive without being able to see the road.

If a heavy wind is blowing, if possible, leave the car standing facing the wind. Sometimes a gust of wind may whip in from the back and extinguish the pilot light. For the same reason carry the pilot turned higher on a windy day.

If the pilot light goes out while running, close fuel valve and run a short distance before relighting. This gives time for all unconsumed gas to escape. Have match lighted and in place before flushing a hot pilot light. This avoids an accumulation of gas.

In applying emergency brake, do not allow brake dog to slip into each notch as lever moves forward. Grasp the lever, lift the dog, and move forward as far as it will go and release. Sliding the dog over the notches soon wears it until it will not hold.

A little kerosene poured into water tank while the water is hot greatly assists in flushing off the oil.

After car has been standing at curb for some time, turn on fuel slowly at first. The same condition exists as when firing up. When leaving car at curb, throw gear lever in neutral position, close fuel valve and apply brake.

Know for certain that the pilot light is extinguished before refilling with fuel. This applies more strongly to gasoline. Kerosene is not so easily ignited.

Never clamp a flow motor or pump in a vise. The pressure will distort the barrel of the former and check seats in the latter.

Do not put a wrench on any fuel line unions with pilot light burning, unless positive that all feed valves are closed.

Be courteous to those you meet on the road. It costs you nothing, and occasions arise when its results might prove invaluable. Beware of loose sand, soft gravel and wet pavements. Once experienced, the sensation of losing control of the car is never forgotten.

Eighty per cent of the recorded accidents are the result of carelessness and taking chances. Slow down and look both ways at a railroad crossing. The death notices in the daily papers emphasize this point.

Do not shoot over the tip of a hill at full speed. Some one else may be doing the same thing in the opposite direction. The same applies to curves where you cannot see the road ahead.

If your car is running well do not tinker, "tinkeritis" is a disease, the only cure for which is a few good-sized repair bills.

CHAPTER VI

CHART # 1

NEW REGULATION WITH FLOWMOTOR CONTROL

OVERHEATING		Adjustment too high		
	Thermostat	Element		Bent Binding in stuffing box
	Flow motor	Worn lap fit on fuel valve stem Fuel stem not screwed into piston rod sufficiently Packing glands too tight Piston binding Weak, short or broken spring Vaporizer nozzle too large		
	Water Regulator	Dirty screen Insufficient lift of pin valve		
	Checks	Flow motor check leaking Hand pump checks leaking		
	Water Cushion	Sprig broken - Piston Binding		
WET STEAM	Thermostat	Adjustment too low		
		Water valve		Weak spring Short spring Tight stuffing box Seat leaking Seat out of alignment
	Flowmotor	Piston binding Water passing piston.		
	Fuel ratio	Nozzle tip clogged Carbonized vaporizer		Dirty strainer Valves not open enough Vaporizer nozzle too small
		Choked supply		
		20 HP fuel valve on 30 HP car		
NO POWER	Dry Steam	Water leak on feed line Leaking flowmotor bypass valve		Rough pin or seat Pin wedging Screen wedging
		Leaking water regulator		
		Clogged Generator		
		Suction line		Porous hose Flabby hose Dirty strainer
		Cracked diaphragm		
		Insufficient throttle opening		
		Pumps	Leaky stuffing boxes	(Pitted balls (Flat balls (Loose seals (Too much lift
			Faulty checks	
VARYING HEAT	Speed constant	Thermo valve		Weak spring Tight packing Needle binding on seat
		Boiler check leaking		
		Thermo element		Slightly bent Tight stuffing box
	Speed varying	Flow motor adjustment Leaky thermo valve. Thermo valve loose (lock nut) Dirty generator		

CHART # 1 (continued)

BACKFIRING	When fire comes on	Crack in burner grate Turning on fuel too fast when cold Pilot too low. Dirty pilot No lagging on burner Too much air in mixing tube	
	either: split vaporizer slow gas leak	Red hot coils (overheating) Fire on continuously (wet steam) Vaporizer nozzle out of center	
	When fire Shuts of	Insufficient air	
		Foreign object lying on burner grate	Dirt Asbestos Vaporizer out of hole
		Dragging fire	Vaporizer nozzle large Shutter closed Nozzle in too far
HOWLING	Constant	Pilot light low or dirty Flaw in vaporizer Vaporizer nozzle not central Vaporizer nozzle too large Mud in mixing tube Insufficient air Carbon in vaporizer nozzle tip Vaporizer nozzle tip not screwed tight	
	Intermittent	Thermostat	Element bent - Needle valve tight Element binding - Spring weak
FIRE REFUSES to CLOSE OFF	Water regulator	Screen clogged Insufficient valve lift Pin wedging-screen binding	
	Flowmotor	Fuel stem packing too tight Fuel stem bent or broken Broken spring Fuel seat leaking. Hand valve leaking	
NO FIRE without RACING ENGINE	Dry steam	Pumps faulty	
		Water regulator Flowmotor bypass	Valve not closing Dirt on seat Leaking seat
	Wet Steam	Thermostat not closing Thermostat set too low Thermostat leaking at seat	

Items on CHART #1

OVERHEATING

Overheating is any condition by which the temperature of the steam, as it goes to the engine, is above normal; normal being 400^{o} Centigrade. An extreme case is when the coils of the generator are heated to a red heat. There are a number of causes for too high a temperature, many of which are due to the carelessness of the man operating the car.

THERMOSTAT

The function of the thermostat in the new regulation is to govern the ration of fuel and water by admitting an extra supply of water to the generator through a line, which passes around the flow motor. If the thermostat does not bypass sufficient water, then the fuel is fed in excess, and the temperature will run too high. If the thermostat is opening at too high a temperature, the result will be just as bad as from any other source of overheating. The opening and closing of the water valve depends upon the expansive action of the element in the thermostat, due to the heat of the steam. If this element becomes bent, it naturally shortens in length. This forces it to expand farther before opening the water valve, causing a higher temperature. If the stuffing box through which the element works is too tight, there is the possibility that it will cause the element to bind. The latter is the most common of thermostat trouble. Always see that the thermostat stuffing box is not so tight but that the element can work freely. It is better to have a slow steam leak than to have it work tight.

FLOW MOTOR

Bear in mind that the correct regulation of temperature and pressure, by the new system, is based on the fact that the flow motor feeds the fuel and water always in a fixed proportion. Anything that tends to upset this proportion will upset the regulation. If this idea is kept in view it will greatly simplify the reason for some of the following items causing an upset in the balance of fuel and water:

1. If the lap fit on the fuel stem becomes worn, it will give the fuel a chance to flow to the burner before the water can get to the generator. This will cause over-heating, especially at slow speed. The fuel valve is made to fit very closely for a certain distance, in the hole through which it works. This lap fit is close enough to prevent any flow of fuel. The stem is supposed to move this distance before the graduated part slips through the hole and the fuel starts, which gives the water a chance to lead the fuel. It follows that it is not the proper thing to grind a seat on this valve. The grinding material soon spoils the lap fit, and overheating will result. At high speeds a worn fuel valve is not so noticeable as the stem moves farther down on the stroke, the ratio again becomes correct.

In replacing fuel valve on the flow motor, if the fuel stem is not screwed into the piston rod sufficiently, we have exactly the same effect as if the fuel valve were worn, namely, the fuel starts ahead of the water, or at least the ratio changes. The stem should be screwed into the piston rod until the tension of the spring is felt. Then give it five more full turns, which gives an adjustment correct enough for practical purposes.

If the stuffing boxes are too tight, the piston, while moving down, as it should be, drags in closing off. This possibly might feed some fuel after the water regulator has bypassed the water from the generator. Stuffing boxes on the flow motor should be no tighter than can be tightened with the fingers.

Piston binding in the flow motor barrel would cause a change in ratio. One or two cases have been met with where this was caused by sand in the water. Most often it is caused by placing flow motor barrel in a vise. If the piston binds sufficiently, the flow motor will refuse to close, leaving the fuel turned on.

If the spring within the flow motor is weak, broken or too short, it takes a less amount of water to push the piston down, consequently the fuel would overbalance the water. This is a very rare occurrence, however.

If the vaporizer nozzle is too large it would have a tendency to give the fuel the advantage over the water, causing a high temperature, The standard vaporizer nozzle advocated by the company should always be used. Otherwise the fuel and water ratio will be changed.

WATER REGULATOR

If the water regulator pin valve has insufficient lift, it will cause a back pressure through the water line. This back pressure will transmit a pulsation of the pumps to the flow motor piston, causing it to move up and down rapidly and feeding a slow amount of fuel without water, or at least hindering the flow motor from closing properly. This also has a tendency to wear out the lap fit on the fuel valve. The correct lift of water regulator pin is one sixteenth to five sixty-fourths an inch.

If the water regulator screen becomes clogged with dirt or lint from the pump packing, it will give exactly the same effect as insufficient lift to the water regulator pin.

CHECKS

The flow motor check is the one the water passes through just after leaving the flow motor, and it protects the flow motor from any backpressure. If this check is leaking, the water backs up after passing through, giving us a condition for overheating. On models, which have the plug in the bottom of the flow motor, and where the flow motor check serves also as a boiler check, leakage can be detected by removing the plug and listening to the steam escaping back into the flow motor. Also if the flow motor stem jerks back and forth when well down in open position, instead of remaining stationary, it is evidence that the checks are leaking back.

If hand pump checks are leaking, the water passes through flow motor as usual, at the same time feeding its full proportion of fuel. Instead, however, of going to the generator it slips across through these checks back to the water tank. It is easy to see that this would cause overheating. If these checks are leaking badly the pressure drops very rapidly when the car is standing.

WATER CUSHION

A broken water cushion spring gives the same effect as having too small a lift on the water regulator pin. Removing this cushion and inserting a plug will give this same effect.

WET STEAM--THERMOSTAT

If the thermostat is adjusted to open at too low a temperature, the result will be wet steam. If the water valve does not close at the proper time, too much water will be pumped to the generator. If the spring which pushes the needle valve to its seat is too weak, or if the stuffing box, through which the needle valve works, is too tight, the valve will not close at the proper moment. If, for any reason, this valve does not shut when the element contracts away from the bell hanger, such as binding in the seat or a particle of dirt under the seat, or an imperfect seat, the result will be wet steam. The most common cause, however, is having the stuffing box too tight. This stuffing box should be no tighter than can be tightened with the fingers.

FLOW MOTOR

If by any means the water can pass the piston in the flow motor without pushing it down the result will be that the water overbalances the fuel.

If the piston in the flow motor is binding it might cause wet steam, depending upon the point at which the piston binds and whether it is opened or closed.

FUEL RATIO

If for any cause the normal supply of fuel cannot flow at the proper time, the result will be wet steam. A chokage of fuel supply can be caused by sediment in the strainer or the vaporizer nozzle tip being too small. The most common occurrence causing a choked supply is that one of the holes in the vaporizer tip becomes clogged with small particles of carbon. If the gasoline valves on the tank and the hand valve at the footboard are open, only a small amount, it will give the same result. Many instances have been noted where owners have been guilty of the latter in order to economize fuel, but contrary to their expectations, this resulted in using almost twice as much as would have been the case if the valves were opened full. The reason for this is obvious. If the valves are not opened wide and the water overbalances the fuel, the fire cannot catch up enough to superheat the steam, consequently is burning all the time. Economy in a White car depends upon the steam being superheated. Other mistakes giving the same result have been occasioned by putting on a twenty HP fuel valve on a thirty HP car, or by putting a small twenty HP nozzle on a thirty HP car. The twenty HP nozzles are hexagonal, the thirty and forty HP nozzles are square.

A dirty vaporizer gives the same result as a choked supply. It can be detected on the vaporizer gauge on the dash. If the gauge flies around in excess of the pressure in the tank when the fire is on and shuts off very slowly after the flow motor closes, it is a good indication that the vaporizer is clogging, either in the passages or at the tip.

LACK OF POWER BUT DRY STEAM

This implies that the system does not make much steam, but what steam there is, is of good quality. Usually the steam pressure never reaches the bypass point, nor does the fire burn very much at any time without racing the engine.

Any water leak on the feed line from the pumps to the flow motor will rob the flow motor, consequently it will not open sufficiently, and we have neither fire nor water for the generator.

A leaking flowmotor bypass valve can be caused by an imperfect seat, collection of dirt or the valve not seating centrally. The effect when this valve is leaking is to rob the generator of both fuel and water, as the water is returned to the water tank without feeding any fuel. A quick and easy way to detect any such leakage is to break the little union at the upper end of the flowmotor. Having the engine running and the steam pressure below the bypass point. If the valve leaks, the escaping water can easily be seen. No water should flow unless the flow motor piston is at the lower end of its stroke. Under normal circumstances it is merely returning the excess water back to the water tank, when the piston has traveled one inch.

LEAKING WATER REGULATOR

This is another point at which the water may escape without altering the ratio between fuel and water. It might be caused by an imperfect seat on the water regulator pin valve, the pin may stick while off the seat or the screen might wedge and refuse to close the valve. Sometimes a particle of dirt can give the same effect. Water regulator leakage may be quickly detected by breaking the union on the line, which returns the bypassed water to the tank. If your steam pressure is below the bypass point and water comes from this union, then the valve is leaking. No water should flow unless the pressure is above the bypass point. The pin and the screen should both work back and forth freely. If the seat is imperfect it can be ground in with a little pumice stone and oil, or powdered glass and water.

SUCTION LINE TO THE PUMPS

If the hose from the tank to the pumps is so soft that it collapses when the pumps make the suction stroke, or is porous enough to admit air, the pumps will not give their full amount of water. The same thing will happen if screen in the bottom of the water tank becomes clogged with dirt.

CLOGGED GENERATOR OR STEAM LINE

If there is a clogged or choked place in the generator tubing or in the steam line to the engine, the steam cannot flow to the engine fast enough to keep up the power of the car. This subject will be dealt with later.

PUMPS

Any defect or disarrangement of the pumps will lessen the supply of water to the flow motor. If the stuffing boxes on the pumps are leaking it will greatly cut down the normal amount of water supplied by the pumps. The stuffing boxes should be kept well packed and tight enough not to leak, especially on the new type engine, where any leakage runs into the crankcase.

The checks are the most common source of trouble in regard to the pumps. If the latter refuse to force their full amount of water and it is certain that the water can reach the pumps, examine the checks; look at the balls and see that they are not pitted and that they do not have flat spots or rings on their surface. A very rare occurrence, which chokes the supply furnished by the pumps, is that the seats may become loose in the casting. The check balls should have a lift of one thirty-second of an inch for the pump checks for the line checks, which have five-eighths inch balls, the lift should be three sixty-fourths of an inch.

CRACKED DIAPHRAGM

This is an item, which has been entirely eliminated by the use of more than one diaphragm. In the Naught Six car only one was used. At the present time each water regulator has four. If the diaphragm should crack, the steam escaping through would force the water supply back from the pumps causing them, of course, to cease supplying the generator.

INSUFFICIENT THROTTLE OPENING

If the throttle is so set that it cannot be opened far enough, the car, of course, will appear to have an insufficient amount of power. To get this effect, however, the short lever on the throttle would stand at a right angle to the frame of the car, and such a condition would easily be detected.

VARYING HEAT--WITH SPEED CONSTANT

If the temperature varies as much as seventy-five degrees above and below four hundred degrees while the car is running at a practically constant speed, it is probable that this is due to an irregular action of the thermostat. Should the thermostat spring which seats the needle valve be weak or the packing in the water valve stuffing box be tight, either of which may prevent the valve closing at the proper time, the generator will receive too much water. Then it may happen that when the valve does close it is too late. The temperature has begun to fall.

If the element should be slightly bent it may spring sideways while expanding, instead of pushing through the stuffing box. When the tension is sufficient to start motion through the stuffing box, the valve is suddenly opened too wide, and too much water will be pumped to the generator before it again closes, causing the temperature to drop. Sometimes this may happen running at a steady rate of speed and with apparently no cause. Another thing which may cause the temperature to vary (rising, however) is that the "Boiler checks" being imperfect or having a loose seat, might allow the water to flow back into the tank. Of course, after this happens there would be a rise in the temperature owing to the lack of water in the generator. The water must move downward through the coils (when generator is being refilled) pretty well towards the bottom of the generator before the temperature of the steam changes enough to affect the thermostat, which although it closes will do so too late to prevent a drop in temperature.

VARYING SPEED

If the temperature drops when the car is speeded up it may be due to one of three causes.

First. If the flow motor fuel stem is not screwed into the piston far enough or is worn, the temperature at a slow speed is a false one, and upon speeding the car up the natural thermostat temperature is regained. Under this condition, if the temperature is set for slow speed or with the engine running idle, the chances are that when the car is driven at any higher speed it will be too low.

Second. If the generator is dirty, a quick call for rapid production of steam will result in drop of temperature. Should the coils have a thick deposit of oil on their inside surface, the heat will not pass through the walls of the pipes and the above mentioned deposit as rapidly as it should. It will probably pass through fast enough to keep up the temperature of superheated steam if the steam is not being used too fast. But when the demand of steam increases and the flow becomes very rapid, the heat cannot pass through the walls fast enough to maintain a superheat, and the steam temperature drops.

Third. Under the average running conditions, the thermostat needle valve remains more or less off the seat; when the speed of the car is suddenly increased and the flow of the steam increases correspondingly, its temperature drops a small amount quickly, causing the thermostat valve to close. This in turn will cause the flow motor to feed the full amount of fuel, which would tend to raise the temperature enough in a short time to cause the thermostat valve to begin opening again. But if the valve is leaking and the extra amount of water continues to pass through to the generator, the temperature will continue to drop instead of regaining the balance.

BACK-FIRING

Backfiring is a term used to denote the ignition of the gas as it leaves the vaporizer nozzle instead of above the burner grate. There is no danger connected with it, although it makes a roaring noise. The proper thing to do is to close the gasoline valve and let the car continue to run until the gas already in the vaporizer is burned out. Then turn on the fuel again and proceed as before. We have divided the subject of "Backfiring" into two general classes**.** It may happen when the fire is just coming on, or it may happen when the fire is shutting off, or as under the heads of B and C on the chart, it may happen either way.

WHEN FIRE IS COMING ON

Any cracks in the burner grate are pretty sure to cause backfire. A backfire is apt to occur accompanied by slight explosions as the gas ignites back to the nozzle. If there is a suspicion that the burner is cracked, It is best to take it down and examine it carefully. The crack can be plastered over with fire clay, allowing it to dry, or it can be dried quickly by the flame of a blowtorch. In case the burner is taken down it is a good thing to see that it is perfectly clean and that there is no mud or loose dirt contained in the base of the burner.

Sometimes a backfire will occur in firing up, if the raw fuel is turned on too rapidly. When first admitting fuel to the burner, care should be exercised that the vaporizer is hot enough to vaporize the fuel properly. For the first thirty seconds the fuel should be turned on and off at intervals of about two seconds, preventing too great a rush through the comparatively cold vaporizer. It is characteristic of the Bunsen system that the richer the mixture the lower the flame lies upon the burner. If the fuel is too "raw", the mixture is so rich that the flame lies directly on the burner slots, giving a good chance for the ignition to occur below the grate, thus causing a backfire.

If the pilot light is turned too low, the vaporizer may not be kept sufficiently hot to vaporize properly, giving the effect of turning on the raw fuel too fast. Again the gas may accumulate around the back side of the burner before the low pilot light flame reaches it, and when it ignites it may puff back through the burner grate and catch on the vaporizer nozzle.

If there is any leaking around the edge of the burner, especially on some of the older model cars, the flame from the inside may shoot out and ignite the gas at the vaporizer tip.

If too much air is being admitted through the mixing tube, giving a high fluffy fire, the mixture may be so thin that it will not ignite rapidly and accumulate enough, so that when ignition does occur it may puff back and cause the gas to catch at the vaporizer tip.

A split vaporizer may cause a backfire, either coming on or shutting off. To cause this the split would probably be on the lower side of the vaporizer. The jet of flame, by striking the burner slots, might force through enough to ignite the gas below. A split vaporizer is usually caused by being overheated or partly clogged and overheated at the same time. The new style vaporizers issued by the White Co. in the fall of 1908 have almost entirely eliminated any troubles from clogging or splitting. These vaporizers are very light, are perfectly smooth inside, and heat very quickly.

A slow gas leak through the flow motor fuel valve or the hand valve may accumulate the gas at the back side of the burner, which may cause a backfire when the fire comes on and the flame may catch back when shutting off, owing to the lack of velocity of the gas which is leaking through. A slow leak should never be tolerated. It causes the car to smell of vaporized fuel, besides causing back-firing.

WHEN FIRE SHUTS OFF

Red-hot coils may radiate enough heat downward to cause the gas to ignite below the burner grate owing to the radiation overheating the top of the burner.

If the fire is on continuously (caused, for instance, by wet steam), the burner grate may become overheated to such an extent as to cause the gas to ignite below.

If the vaporizer nozzle is not central to the mixing tube, one part of the burner may receive too much gas and also too rich a quality thereby causing a hot spot on the burner grate, which would cause ignition below. Aside from the fact that it causes backfiring, a crooked vaporizer nozzle may very greatly decrease the economy of the car on fuel. A good way to line up the vaporizer nozzle properly is to watch the jets of gas when first turning on the fuel in steaming up. The points where the different jets strike the side of the mixing tube may be located exactly and the nozzle can be set accordingly to a very accurate degree. This subject of having the vaporizer nozzle central is much more important than the average operator thinks.

If the burner is not getting enough air it will act the same as though it were getting too much raw fuel, as mentioned above. Causes for lack of air are, nozzle being too large (sometimes drilled out in order to get more power), mixing tube shutter being closed too much, or the nozzle projecting into the mixing tube too far. If the gas is too rich or does not have air, the flame is very low on the burner grate, causing the grate to become hot enough to ignite the gas below.

Any substance lying on the burner grate will accumulate the heat at that one spot sufficiently to cause ignition below. A niece of mud or asbestos would be sufficient to cause backfiring. One of the most frequent causes is that in putting the vaporizer in its place, care is not taken that the point end of the vaporizer is in its support. This allows the vaporizer to lie on the grate, which will be almost certain to cause backfiring.

Dragging fire is a term used to denote the regulation, which does net close off the supply of fuel quickly and cleanly after the water regulator bypasses. It has much the same effect as slow gas leak mentioned above. It is sometimes brought about by an accumulation of dirt in the water regulator screen and inoperative water cushion or not enough lift on the water regulator pin.

HOWLING

"Howling" or "whistling" is the name given the noise made by the gas on entering the mixing tube. A car in normal condition should never howl. We have also divided howling into two classes**.** Class A: constant howling, and Class B: intermittent howling. As a rule, howling and backfiring go hand in hand. Glancing at the chart it can be seen that a great many of the causes for howling will cause backfiring, and vice versa.

By term "constant howling" is meant to infer that the car howls every time the fire comes on full force. By intermittent, we mean that the howling happens occasionally, possible at regular intervals.

If the pilot light is low or is dirty, the vaporizer is not hot enough to vaporize the fuel sufficiently, causing the mixture to be too rich.

Once in a great while a vaporizer casting has been discovered that has proved to be faulty, owing to poor foundry work. A sand flaw would allow the gasoline to make a short circuit and emerge at the vaporizer nozzle without having been sufficiently vaporized. As mentioned above, the new steel vaporizer eliminates all such imperfections as this.

If the vaporizer nozzle is crooked, namely, not lined up centrally with the mixing tube, it will almost invariably cause howling. Also if the nozzle is too large for the burner, the result will be the same.

Any mud, dirt or foreign substance lying in the mixing tube or in the base of the burner is very apt to cause howling and backfiring. Not enough air, by having the shutter closed too much, will give the same result. In the summer time, when the atmosphere is hot and consequently light or in high altitude the shutter should be open wide. In extreme cases it may be necessary to remove the shutter. When the atmosphere is heavy, due to cold weather, the shutter should be adjusted by partially closing. This will be taken up more fully under the subject of fire. If a particle of carbon or some foreign substance lodges in the tip of the vaporizer, it will cause howling, The chances are it will lie across the diameter of one of the holes, and this is very apt to deflect the stream of gas emerging from the same. It is a good idea to have a regular inspection of the vaporizer tip. An expert operator can tell within 30 seconds after one of the vaporizer holes has become clogged.

Intermittent howling is caused by an erratic action of the regulation, probably due to the thermostat. If the thermostat element is binding or the water needle valve is sticking in the stuffing box, there will be periods when the car is running with little, if any, fire. If this continues for too great a length of time, the vaporizer and its outlet pipe may become somewhat cooled, and when the thermostat suddenly closes the valve the flow of fuel is turned on suddenly by the action of the flow motor. This will probably cause the car to howl until the temperature is regained and it is working normally again.

FIRE DOES NOT SHUT OFF

This general head is used merely to help pick out the different items for closer analysis. If the fire will not shut off after the water regulator bypasses the water back to the tank, it is caused either by the water regulator or flow motor. It is obvious that if the water regulator is not bypassing properly on account of a dirty screen or insufficient lift on the water regulator pin, the back pressure will keep the flow motor from closing properly, causing the fire to burn slowly to a more or less degree. On the other hand, if the packing in the flow motor stuffing boxes on the fuel stem piston rod is too tight, the flow motor may in extreme cases refuse to close and the fuel will continue to feed, regardless of the action of the water regulator. In connection with this it is worth mentioning that the fuel stem being bent or broken, or a broken spring inside the flow motor (very rare) would give exactly the same result. Occasions have occurred when the hand fuel valve was leaking slightly and the fault was laid to the flow motor. A good way to detect leakage when it is too slight to cause a flame above the burner is to apply a match to the vaporizer tip. Immediately after stopping the flow of fue1 there is always enough gas to support the flame for a short time, but if the hand valve and the flow motor valve are seating perfectly, this flame should burn out for lack of gas. If it continues to burn, and blows occasionally, either the hand fuel valve or the flow motor valve is leaking, If the valve operated from the seat is closed, and the flame goes out, the chances are two to one that it is a flow motor gas valve leaking. Never try to grind this valve for leaking. Grinding material will spoil the lap fit. An easy way to stop this valve from leaking is to form a seat by tapping the head of the valve by means of a small hammer and punch, care being taken not to tap too hard and to turn the valve stem around at short intervals.

FIRE WILL NOT COME ON WITHOUT RACING ENGINE.

We have divided this condition in two features. Take notice if the car has wet steam or dry steam. If the steam is dry, It shows a deficiency in the water supply to the generator. In this case it is best to first be assured that the water can get to the pumps. This can be brought about by inspecting the water tank to see if it contains water, the strainer in the bottom of the tank to see that it is not clogged, or the hose leading from the tank to the pumps, that it is not soft or clogged. All these conditions have been described under the head of lack of power, but dry steam. Under this heading of dry steam there are but two places where the water can go if the pumps are pumping normally, through the water regulator bypass and the flow motor bypass. This can be quickly determined by breaking the unions respectively on same.

On the other hand, if the steam is wet and the fire does not come on, the chances are greatly in favor of the fact that the water is passing through the thermostat when it should not be doing so, thus causing the water to overbalance the fire. If the thermostat is set too low it will give this same effect after the car has been running a few minutes. In case the fire refuses to come on, the first thing to do is to look at the flow motor. If the flow motor is not opening, then the above mentioned circumstances hold good. If it is open and there is no fire, look for a dry gasoline tank, a clogged vaporizer or a choked gasoline supply somewhere. There maw be the possibility that the hand fuel valve has not been opened, as is often the case with a "green hand" operating the car.

CHAPTER VII.

CHART # 2

GENERAL SYMPTOMS

Excessive water Consumption	Wet steam (see Chart #l) Any water leak Engine stuffing boxes leaking Condensing system Engine valves scored Broken piston rings	Pump suction hose choked Faulty condenser pump Fan not running Mud on condenser tubes Condenser fouled inside Overflow valve spring weak Overflow valve loose
Excessive Fuel Consumption	Fouled vaporizer Vaporizer nozzle too small Vaporizer nozzle not central Air pressure high or low	Strainer clogged Tank valve not open wide Hand valve not open wide 20 HP fuel valve on 30 HP car
	Chokage of fuel flow	
	Wet steam Dirty generator Dragging brakes Too much air Fuel too light	
Excessive pressure when Throttle is closed	Water overbalances fire	Pressure rises rapidly if throttle is closed while fire is on caused by residual gas in vaporizer after the flowmotor shuts off.
	Clogged generator Clogged steam line	Pressure drops when throttle is opened. Springs back when throttle is closed.
Generator symptoms	Pressure drops suddenly Speed of car constant	Hand pump checks leaking water in generator back into water tank
	Rising pressure after stopping a few minutes	Coils too hot Coils fouled of dirty Slow gas leak in flow motor Slow gas leak independent valve
	Excessive loss of pressure after standing a few minutes	Temperature too low Hand pump checks leaking Boiler check leaking Safety valve leaking Throttle leaking Any steam leak
	Fire burning too long in order to raise steam pressure above bypass	Lack of water in generator when starting Dirty generator coils Wet steam Clogged vaporizer
Sluggish car	Brakes dragging Wet steam Dirty generator or steam line Lack of water in generator (No reserve) Throttle set wrong. Will not open wide enough.	

Items on CHART #2 GENERAL SYMPTOMS

The items enumerated in Chart Two are partially a reiteration of some of the items on Chart One. They are mostly general terms used for the purpose of identifying the symptoms developed by the car. The most of the items are treated more specifically under the same heading on some of the other charts.

EXCESSIVE WATER CONSUMPTION

WET STEAM

Wet steam is one of the most common causes for a car using more than the normal amount of water. The steam not being superheated sufficiently, lacks the expansive qualities that it should have, consequently it takes a great deal more volume to furnish the power to drive the car. A greater volume means that the condenser must do a greater amount of work and where this amount is more than it can do satisfactorily, the result is that the steam overflows. Any such overflow means a waste of water. If on an average road a car is running at a moderate speed and the condenser overflows the steam, either the temperature is too low or the condensing system is at fault (barring items five and six on Chart Two.)

WATER LEAK

Occasionally very little attention is paid to one or more seemingly slight water leaks. However, when you stop to think that the water tank capacity is only seventeen gallons, and that a slight leak may waste from one to four gallons in the course of half a day's running, it is plain to be seen that a water leak may have something to do with the total water consumption. Always stop a water leak no matter how slight.

LEAKY STUFFING BOXES

Leaking engine stuffing boxes will waste, during the course of a day's run, an amount of water which is surprisingly large, as mentioned before. Leaky stuffing boxes indicate a careless operator. Always keep them tight. (See Engine Chart Four.)

CONDENSING SYSTEM

If the car persistently uses too much water when the temperature seems to be correct and at the same time no water leaks can be seen, the chances are that the condensing system is in some way to blame. The condenser pump is a very important part of a condensing system. In order to have a good condensation and saving of water, the pump must keep the condenser empty of water and partially of steam. The condenser should run with a partial vacuum. On all the cars (with the exception of G, K, O, and M) having the suction hose from the condenser to the condenser pump, there is a possibility that this hose may become rotten and flabby, thus obstructing the suction of the pump. In looking over the condensing system, it is well to examine this hose occasionally. See that the stuffing boxes on the condenser pump do not leak air or water. The checks should be examined also to see that there is no dirt or that they are not worn out of true.

The condenser fan is for the purpose of pulling a greater quantity of air trough the condenser over the radiating surface than will pass through with a natural draft produced by the speed of the car. If this fan does not run the air will not carry away as much heat, thus impairing the efficiency of the condenser.

Too often very little thought is given to keeping the condenser tubes clean. If these tubes are covered with mud, the radiation qualities are greatly hindered. Any mud in the condenser should be washed out with a hose and a bristle brush.

An imperfect seat or a weak spring on the overflow valve may be the cause for poor condensation by admitting air to the condenser and preventing the pumps from producing a partial vacuum; also the overflow valve might become loose where it is screwed into the condenser.

Sometimes a poor grade of oil used in the cylinders, or the steam being at an excessive temperature will cause the oil in the exhaust steam to deposit in the condenser tubes. This condition spoils the condenser efficiency to quite a marked amount. The condenser can be cleaned by first pouring kerosene through and flushing with a plentiful supply of water.

ENGINE VALVES CUT

Scored engine valves are very wasteful of steam, as it is passing through the engine constantly. This condition overloads the condenser, causing it to overflow and waste the water.

BROKEN PISTON RINGS

Broken piston rings are similar to cut engine valves, in that they are wasteful of steam. The rings are supposed to be steam-tight, and of course if they are broken the steam will blow through constantly, whether the piston is moving up or down. This excessive amount of steam will overload the condenser in a manner similar to a cut valve.

EXCESSIVE FUEL CONSUMPTION

Too much fuel consumption and the using of too much water in the majority of cases go hand in hand, The cause for one will be the cause for the other. It is well to remember this fact as mentioned hereinbefore, about the water and fuel being supplied in a certain ratio. Emphasis is put upon this fact for the reason that if it is kept in mind it will greatly simplify the process of locating many of the troubles.

DIRTY VAPORIZER

By diminishing the full flow of fuel, a dirty vaporizer will cause wet steam. As mentioned before, a much greater quantity of steam is used, owing to its lack of elasticity and expansive properties; likewise, the generator must furnish a greater quantity. This will keep the fire burning a greater part of the time, even under ordinary running conditions. Continuous burning of the fire is the direct source of excessive fuel consumption. A dirty vaporizer can be detected by watching the vaporizer gauge on the dash. If this gauge drops back very slowly and hangs for quite a length of time at ten to fifteen pounds, it is worth while to have a look at the vaporizer, or at least at the nozzle tip, which some times clogs from small particles of carbon.

VAPORIZER NOZZLE TOO SMALL

As was mentioned in Chart One on regulation, the standard nozzle recommended by the White Co. should always be used. The twenty horsepower nozzles are hexagonal; the Naught Seven model H nozzle has four number fifty-six holes, the Naught Eight Model L nozzle has three number fifty-four holes, as also has the Naught Nine Model O. These numbers are stamped on the side of the nozzle. The nozzles for the larger cars are made square. The Naught Seven Model G nozzle has four number fifty-four holes, and the Model K and Model M have three number fifty-one holes. In the Nineteen Ten models, two sets of nozzles are furnished with each car, one for gasoline and the other for kerosene. These are each designated by being stamped on the side. It is very important that they should be used as specified.

VAPORIZER NOZZLE

The fuel economy of the car depends a great deal upon the adjustment of the vaporizer nozzle. For instance, an extreme case which came to notice was where a nozzle was so much out of alignment that two of the jets of gas were missing the mixing tube entirely. If the nozzle points directly into the center of the mixing tube, the mixture of gas and air is distributed equally over the surface of the burner, and also
Is mixed to the most perfect degree, giving perfect combustion. This condition distributes the heat of the flame evenly under all the coils, and consequently attains the highest economy.

AIR PRESSURE TOO LOW

The flow motor is designed for feeding the proper amount of fuel when the fuel is being forced through by a pressure of fifty to fifty-five pounds. Therefore, any pressure below fifty pounds gives the water a chance to overbalance the fuel.

ANY CHOKAGE OF FUEL FLOW

This will give the same result as a dirty vaporizer. By the term chokage is meant any obstruction in the feed pipes or anything that prevents the fuel from flowing fast enough to take care of the water that is passing through the flow motor. A common mistake is an insufficient opening of the hand valve at the seat or the shut-off valve at the gasoline tank. These should be opened at least four turns.

WET STEAM

As mentioned above, anything that will cause excessive water consumption will usually cause the same thing for fuel. (See Wet Steam).

DIRTY GENERATOR

If the coils have a deposit of carbon on their inside surface, it will take a greater amount of fuel to supply the same heat to the steam inside the coil, owing to the fact that the coil will not absorb the heat so readily. The carbon inside being a non-conductor of heat, consequently a portion of the heat is being wasted. Expressing it in another way, the generator is being constantly "forced" to keep up a superheat.

BRAKES DRAGGING

This is one of the most common causes for a car using too much fuel. If the brakes drag it may not mean much of a loss for one revolution of the rear wheel, or even a dozen revolutions, but in the course of a run of one hundred and fifty miles an enormous amount of power will be wasted in pushing the dragging brakes. The rear wheels should always spin fairly free.(See Chapter III).

FUEL TOO LIGHT A GRADE

If the fuel is too light it will give a very light, high fire and will not give as much heat as heavy fuel. In extreme cases the flame of the fire may be above the lower coil. It will be found that the cheaper gasoline will give much better results than the more expensive. The heavier the fuel, as a rule, the more heat units it contains per pound. For that reason a great deal more mileage can be obtained from kerosene than gasoline.

ITEMS CONCERNING THE GENERATOR

These items are to express the general symptoms in order to get a line on something which may be referred to the chart on regulation.

EXCESSIVE PRESSURE AFTER CLOSING THROTTLE

By this term is meant that the steam pressure rises above the bypass point to an excessive amount after the throttle is closed, this amount varying from two hundred to five hundred pounds. There are two general causes for this condition.

If the water is overbalancing the fire, the generator is carrying more water than it would under normal condition. When the throttle is closed while the fire is on full, the residual gases in the vaporizer boost the steam pressure very rapidly. (For remedy, see Wet Steam, Chart One.)

If the steam seems to be dry and hot, and the pressure drops back anywhere from one hundred pounds to three hundred pounds when the throttle is opened suddenly, and then on closing the throttle the pressure springs back anywhere to a thousand pounds, either the generator or the steam line has a clogged place which obstructs the flow of steam to the engine. The steam pressure for the gauge is taken from the steam line near the throttle. If there is a choked place in the line back of this the steam is taken thru the throttle faster than it can come thru the obstructed place, consequently there is a drop in pressure at the throttle, which drop is registered by the steam gauge. When the throttle is closed, the steam passing thru the clogged place balances up the pressure at the throttle or on the forward side of the clogged place. This accounts for the steam gauge registering so high when the throttle is closed. It may be seen that under this condition the steam gauge does not register the true boiler pressure with the throttle open any amount. However, only when the throttle is closed is the true boiler pressure indicated. As the water regulator also receives its pressure from the same source as the steam gauge, it may also be seen that the same is working under a false pressure, and the pumps may be pumping against a much higher generator pressure than is indicated by the steam gauge. A Car containing a generator in this condition does not possess very much reserve power.

PRESSURE DROPS QUICKLY WHEN CAR SPEED IS CONSTANT.

This is a very rare occurrence. Should it happen accompanied by a peculiar moaning sound, the chances are that the checks in the hand pump are allowing the water in the generator to escape back to the water tank. In case this should happen while running on the road, the proper thing to do is to immediately shut off the fuel and let the pumps renew the supply in the generator. After this has been done, turn on the fire and conditions will be normal again. Unless this is done, the lower generator coils would become overheated before the water could be pumped in.

EXCESSIVE PRESSURE AFTER STOPPING A FEW MINUTES.

If the coils are too hot, the reserve heat contained by them will cause the steam pressure to rise gradually after the flow of steam stops. If the coils have a deposit of carbon on their inside surface, their temperature is greater on the outside than that of the steam contained within (see Dirty Generator under Excessive Fuel Consumption), especially if the car has been running at a good speed. After stopping a few minutes, this heat will soak through to the steam inside, thus raising the pressure.

A SLOW GAS LEAK

A slow gas leak sufficient to keep a simmering fire under the coils will cause the steam pressure to rise steadily if the throttle is closed. Always close hand valve at seat when stopping.

EXCESSIVE LOSS OF PRESSURE AFTER STANDING A FEW MINUTES

If the running temperature is low there is not much reserve heat in the generator, consequently the pressure will drop very rapidly after stopping.

HAND PUMP OR BOILER CHECK LEAKING

This is the same condition as is given under number two.

SAFETY VALVE LEAKING OR ANY STEAM LEAK

The volume of the steam in the generator being so small, a leaking safety valve or any leak will cause the pressure to drop in a short time while standing. All conditions being correct and everything tight, the car should stand twenty-five minutes to an hour and still contain pressure enough to move itself, the time, of course, depending upon the temperature of the atmosphere.

FIRE BURNS TOO LONG IN ORDER TO MAKE STEAM PRESSURE REACH BYPASS POINT

If, when starting out with a cold car, the fire is on full and the pressure is not rising, the fire should be shut off for a moment or two, until the pumps can have a chance to force an additional supply of water into the generator. After a few moments the fire can be turned on, on condition that the pressure starts to rise immediately. Owing to the fact that the thermostat controls the temperature by means of its feeding an auxiliary supply of water, it can have no effect on the lower coils until a certain amount of water has entered the generator. This precaution holds good either for starting up the car when the engine is running idle, or when the car is pulling out on the street. On the other hand, if after the car has been running idle and under an additional load, such as climbing a grade, the fire burns steadily without boosting the steam pressure, the chances are that the generator is dirty. Before coming to any conclusion like this, however, it should be known that there is a full flow of fuel to the burner. Also that the temperature of the steam is correct.

SLUGGISH CAR

If the car does not seem to have the proper amount of reserve power, if it does not move out at once when the throttle is open, the possibilities are that the trouble can be traced to one of the five items mentioned on Chart Two under this head. For more specific details these may be looked up elsewhere.

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CHAPTER VIII.

CHART # 3

MINOR ITEMS

Vaporizer	Clogged	Graphite on screws Rough casting (porous) Pilot too high Flow motor Slow gas leak independent valve
	Split	Pilot high. Vaporizer red hot Clogged while red hot Excessive air pressure
Pilot light	Goes Out	Water in gasoline Gas mixture too light Pilot turned too low Pilot dirty Too much oil in engine crankcase
	Burns red	Hole in nozzle too large (old style) Dirty spreader cone Leaky flush valve Loose screws Not hot enough to vaporize
Car steers hard	Front wheels not parallel Steering gear joints dry Front tires soft Worm and segment binding	
Springs Squeak	Dry or rusty Shackle pins dry	
Rear Axle	Grinds	Gears dry Broken balls Rough bearings
	Vibrates	See engine vibration Loose torsion bar spring Wheels loose. Radius rods loose
	Thumps	Broken balls Broken gear teeth
	Too much oil causes a leak into brake drums	
Fire	High off burner Light blue Proportion of air too great	Light grade of fuel Mixing tube open too wide Nozzle too small or choked Nozzle too far away from shutter Air leaks around burner Air pressure too low
	Low on burner Red Proportion of gas too great	Shutter closed too much Nozzle too large Nozzle too far into mixing tube Air pressure high Vaporizer not over pilot Pilot low
Car smells of gas	Stuffing box leaking on pilot adjusting valve Flow motor fuel valve leaking Independent valve leaking Mixture light Pilot light extinguished	

Items on CHART #3 MINOR ITEMS

VAPORIZER

When using any liquid fuel it must first be changed to a gaseous form in order to get the best results from the combustion. In this form it is most easily mixed with the air.

The vaporizer in the White Car serves the purpose of changing the fuel from a liquid to a gaseous form. It enters the vaporizer and is changed by the heat therein to a gas. The earlier vaporizers were in the form of a casting having several through passages which were connected in series. The fuel travels back and forth at least six times before emerging as a hot gas. As has been mentioned before, the later vaporizers are of steel and very light compared to the old ones. The latest ones for kerosene contain steel rods running through the passages. About the only trouble that can happen to the vaporizer is having these passages become coated or filled with carbon. Gasoline and kerosene are known as hydro-carbon fuels and are composed principally of hydrogen and carbon. If this carbon is deposited in the passages it will eventually check the flow of gas or fuel. This condition, however, has been almost entirely eliminated in the later types of vaporizers.

A very common cause for choking is putting too much graphite on the vaporizer screws after cleaning. When the fuel first passes through some of the graphite which is on the inside is carried with it and lodges at the nozzle tip. After cleaning the vaporizer it should also be blown out with air pressure with the nozzle tip off.

A slow gas leak is the most common cause for vaporizer trouble. The fuel passing through the slow leak drifts through the vaporizer without any velocity. Owing to its lack of velocity it has time to become hot enough to cause the carbon to drop or deposit. A good way to detect a leak after the car has been standing a few moments, is to apply a match to the vaporizer nozzle. If there is a flame at the nozzle it shows a slow gas leak. Be sure to wait a few moments, for after stopping there is usually a slight amount of gas left in the vaporizer. If the flame continues to burn and will not die out, it shows a leak.

If the pilot light flame is turned too high, especially if the car is standing, it will overheat the vaporizer. When the first fuel passes into the vaporizer upon starting the heat is so intense that the carbon will be deposited. When the vaporizer tip begins clogging regularly with particles of carbon it is a wise thing to remove the vaporizer and clean. It shows that a carbon deposit has already started inside.

The cause of a split vaporizer is the result of overheating from a high pilot light, or it may result from clogging and overheating at the same time. A split vaporizer is easily detected by a smoky fire. Loose vaporizer screws may give the same result. Sometimes a red flame can be seen within the fire box by looking through the vaporizer door.

PILOT LIGHT

Neither the pilot light nor the vaporizer should be a source of much trouble, providing certain precautions are taken. If the pilot light persists in going out, it is probably either dirty or turned too low. The pilot light should be turned high enough so that the noise of the flame is just noticeable from the outside. When burning kerosene it should be carried with a flame much higher. The pilot light should burn with a blue flame and the little flame-spreading cone should be at a bright, cherry red. A light gas mixture in the mixing tube may blow the pilot light out by accumulating before ignition, and igniting with a puff. Water in the gasoline tank will extinguish the pilot light flame. However, the tank must contain quite a bit of water before giving any pilot light trouble. If the pilot light cannot be turned high enough to make a slight roaring sound or will not burn with a blue flame, the probabilities are that it needs cleaning. This can be done by removing the small screws and cleaning out the passages with a drill provided for the purpose. Care should be taken in replacing the screws that there is a small copper gasket under each one, and that too great pressure is not applied in tightening, as the threads are very fine and easily stripped. In lighting the later style pilot lights, where there is no flush valve, be sure that the drip cup is full of gasoline before applying match. Do not open regulating valve too much at first, as a sudden rush of fuel may chill the pilot light vaporizer and cause it to burn with a red flame.

PILOT LIGHT BURNS RED

If the pilot light will not burn with a blue flame it might be caused by some of the screws leaking or the flush valve might not be closed tightly enough. On the old style pilot lights the little hole in the nozzle may become too large. This can be remedied by peening it over with a light hammer. This will not happen, however, to the later pilot lights, owing to the difference of having a graded valve. The older model pilot lights will be turned on full with one half turn of the regulating valve. With the later ones from Naught Seven it may be necessary to open the regulating valve from one to four turns in order to have a sufficient flame. A corroded flame spreader might cause a red flame. The pilot light should be removed and this brushed off occasionally. A very common cause for a pilot light burning with a red flame is not having it heated enough to vaporize properly. Pilot lights have been condemned as worthless when all that was wrong with them was that they were not heated enough in starting.

PRECAUTIONS

When flushing the pilot light, feed just enough to fill drip cup inside of the shell. If an excessive amount of fuel is turned into the drip cup upon becoming hot it changes to gas faster than it can pass up through the shell, consequently the flame flares outside. During the time of flaring outside it is not heating the pilot light vaporizer inside. The pilot light should be heated and made to burn blue without any flame outside the shell. Much quicker results can thus be obtained. Always leave regulating valve open when putting up car for the night. Contraction of the metals while cooling is apt to spoil the needle valve seat. On older models it may enlarge the hole in the nozzle. In later models, the graded needle on the end of the valve stem may be seized by the walls of the nozzle orifice and the result will be that it will twist off when the valve is opened.

CAR STEERS HARD

If the front wheels are not parallel the tires have a tendency to run at an angle and hence slip some if the wheel is running in a straight line. This condition makes it difficult to steer a car and also wears the front tires very rapidly. In order to check up the steering gear to see if the front wheels are parallel the distance should be measured from felloe to felloe on the front side of the wheel at the centerline. Then measure the distance at the backside diametrically opposite. Supposing the distance in the front is one fourth of an inch less than the rear measurement. This shows that the wheels are turned in, in front. The remedy is to lengthen the tie rod between the steering knuckles.

It seems to be a very common thing to neglect the lubrication of all the steering gear joints, consequently the wear is greater than it should be and a sum of the resistance of all these joints is enough to make a car steer very hard. If front tires are soft it makes a car steer hard. (For the proper pressure on tires see table issued by some reputable tire company.)

IF THE REAR AXLE GRATES OR GRINDS

A broken ball or a rough cup or cone will cause a grinding sound in the rear axle. In a case of this kind an examination should be made before the bearing cuts itself to, pieces. A good way to test for this condition is to jack up the car and spin the wheels by hand. The chances are that any roughness in the bearings can be detected in this way. Care should be taken that the rear wheels are not allowed to become loose. This is caused by the nut on the end of the axle shaft not being sufficiently tight or by the omission of a cotter pin. CAUTION: In replacing the rear axle wheels be sure that the lugs on the axle cone are in place in the slots in the rear wheel hub. If this is not done the cone may screw inward on the axle shaft and lock the axle.

VIBRATION

(See Engine Vibration)

A great many cases of engine vibration are laid to the rear axle, owing to the fact that it appears to be there. One should be very sure before taking any steps either way whether it is the engine or the axle.

On the Naught Five and Naught Six cars the torsion bar spring sometimes allowed to become loose or weak. This permits too much motion of the bar making a bumping noise in the rear system, with each stroke of the engine, more particularly on slow heavy pulling.

If the wheels or radius rods have too much motion due to wear it may cause vibration at certain speeds and again it may not. However, they should not be allowed to remain loose, as this condition increases the rapidity of the wear.

By the rear axle thumping is meant a dull knock at regular intervals. Such a knock might be caused by broken balls and broken gear teeth or a nut of the differential bolts striking the casing. If there is one thump for each revolution of the rear wheel it may be that a gear tooth is broken on the main driving gear. At least it proves that the knock is caused by some part of the axle, which turns at the same rate as the rear wheels. If the noise occurs at intervals faster than the revolution of the rear wheels it is probable that it is caused by a broken tooth on the pinion driving gear.

FIRE

A great deal could be written about this subject, but for the purpose of operating the White Car a few facts are sufficient.

In order to obtain the greatest mileage from a given amount of fuel we should have the best combustion possible. Combustion is the chemical union of the oxygen in the atmosphere with the materials used for fuel. To obtain the best combustion there should be just the right amount of gas mixed with the correct amount of air and this mixture will produce the greatest amount of heat. However, unlike the internal combustion motor, there is a much wider range through which the mixture can vary without affecting the final results to any appreciable amount, but there are certain wide limits within which we must keep to get the best results. These limits we have designated under the heads of portion of air too great and portion of gas too great.

If the proportion of air is too great the resulting flame has a very light blue color and leaps high off the burner. Sometimes high enough to be above the lower coil. Naturally, this condition would not be such as to give the greatest amount of heat to the coils. A great deal of the heat is wasted by the fact that the combustion takes place at such a high point in the coils. This condition is apt to cause the front seats of the car to become heated. As has been mentioned, the cheaper grades of fuel commonly known as stove gasoline will give better results than the more expensive ones. Most of the items given on the chart are due to either making changes or incorrect adjustments.

Too great a proportion of gas for the size of the mixing tube or for the air that can flow into the mixing tube gives a very red flame, which hangs low on the burner. The amount of air depends somewhat upon climatic conditions and altitude. The colder the atmosphere the greater the amount of oxygen drawn into the mixing tube, the inlet remaining the same, and vice versa when the atmosphere is warm or the altitude is high. The correct color of the flame is a purplish blue slightly tinged with red. The flame should not lift over one half of an inch above the burner slots. The following rule will hold good under most conditions. The lighter the mixture the higher and bluer the flame. The richer the mixture the lower and redder the flame. Keep the shutter closed as much as possible without causing howling or back firing. This condition seems to give the best results.

CAR SMELLS OF GAS

This is a disagreeable condition and is entirely unnecessary. The packing in the pilot light adjusting valve stuffing box may leak. The gas escaping through rises outside the pilot light without igniting and sometimes can be smelled from the seats of the car. To test for leakage, apply a lighted match while the pilot light is burning. Also should the flow motor fuel valve or the warming up valve be leaking the smell of gas may result. The leakage being so slight the gas draws upward from the nozzle of the vaporizer instead of entering the mixing tube.

CHAPTER IX

CHART # 4

ENGINE

<table>
<tr><td rowspan="14">ENGINE</td><td rowspan="5">Vibration</td><td rowspan="2">Compound</td><td>Leaky simpling valves
Flaw in cylinders</td><td>Passover valve
HP poppet valve</td></tr>
<tr><td colspan="2">Wet Steam
Piston or slide valves cut
Broken piston rings</td></tr>
<tr><td rowspan="3">Either simple or Compound</td><td>Engine loose on frame
Loose flywheel</td><td rowspan="3">Crankcase
Cylinders
Flywheel square</td></tr>
<tr><td>Lack of lubrication</td></tr>
<tr><td>Loose rear wheels
Valves set incorrectly
Reverse rod short
Broken balls. Rough bearings</td></tr>
<tr><td colspan="2">Pounds</td><td colspan="2">Worn main bearings
Loose connecting rod
Piston head loose on rod
Piston rod loose in crosshead
Main bearing cap loose
Pumps loose on bracket
Bent condenser pump rocker-arm (G-K)
Condenser pump loose in crank case
Frame bolts loose
Broken crankshaft</td></tr>
<tr><td colspan="3">Kicks when throttle is closed</td><td>Throttle seat leaks</td></tr>
<tr><td colspan="2">Jerks when changing from simple to comp.</td><td colspan="2">Tight stuffing boxes on simpling valves
Simpling spring weak</td></tr>
<tr><td colspan="2" rowspan="3">Refuses to start</td><td>Valves set wrong</td><td rowspan="3">Simpling pedal not pressed down
Passover valve not leaving seat
Low pressure poppet valve not seating</td></tr>
<tr><td>Simpling valves</td></tr>
<tr><td>Reverse on center</td></tr>
<tr><td colspan="2" rowspan="3">Causes for leaky Stuffing boxes</td><td colspan="2">Steam too hot
Poor cylinder lubrication
Piston rods and valve stems rough
Packing caught under gland</td></tr>
<tr><td>Leaking throttle</td><td rowspan="2">Rapidly
Without simpling
Reverse on center</td></tr>
<tr><td>Operating throttle</td></tr>
</table>

Items on CHART #4 ENGINE

There is no difference in the fundamental principles upon which the old and new style engines are designed. The greatest difference is in the mechanical construction. Two very important items in connection with the care and operation of any steam engine are, first, starting when cold; second, lubrication. In starting any steam engine when it is cold the first steam admitted to the cylinders is condensed by the cold cylinder walls. Care must be taken not to allow the engine to attain too much speed until the cylinder temperature is high enough to prevent condensation. This water from the condensed steam must be given time to escape from the cylinders otherwise it may damage some of the moving parts owing to the fact that it is incompressible and cannot escape quickly enough. This matter has been taken care of in the new engines by the means of cylinder cocks, which should be opened when the engine is started cold and allowed to remain open until the engine is turning freely. On the older types the usual procedure is to open the throttle before the steam pressure rises too high. The engine should be kept simpled and the reverse lever changed back and forth from reverse position to go ahead. By keeping the engine simpled double the amount of ports for water to escape are provided than would be if the engine were starting compound. When the piston reaches the end of the stroke and there is water in the end of the cylinders it will be released into exhaust if the reverse lever is thrown to the opposite position. It is a good rule to allow the engine to run simple until steam emerges from the over flow pipe on the condenser. This assures that all the water is out of the cylinders, and that steam is coming from exhaust.

STEAM VIBRATION

Vibration is the effect of anything which may cause the turning moment or torque of the engine to be perceptible from the seat of the car. Instead of pulling smoothly, as a steam engine should it shakes the car. Vibration has been divided into two heads in order to be able to diagnose and locate the trouble by elimination.

ENGINE VIBRATES WHEN COMPOUND

A compound engine is one in which the steam does part of its expansion in one cylinder, then passes on to another where this expansion is completed. The exhaust from the high pressure Is used to feed the low pressure. If by any means the steam can escape without doing full work in the low pressure cylinder or it can get to the low pressure cylinder without doing its full amount of work in the high pressure cylinder it will have a tendency to cause one cylinder to do more work than the other. This will unbalance the engine causing it to pull in a jerky manner. If the engine vibrates when running compound, but does not when running simpled the chances are that the steam is by some means getting to the low pressure cylinder without having done its work in the high pressure cylinder.

There are three valves on the top of the engine, which are designated on the chart as simpling valves. Two of these are known as poppet valves, the other one the pass-over valve (old style engine.) When the engine is simpled the pass-over valve is opened allowing the steam direct from the generator to pass through to the low-pressure steam chest; the high-pressure poppet valve opens allowing the exhaust from the high-pressure cylinder to escape directly to the condenser. The low-pressure poppet valve should seat closing the passage between the high-pressure exhaust and the low-pressure steam chest. Under this condition we have two cylinders working independent of each other. Each receives its steam from the generator and each exhausts into the condenser. When the simpling pedal is allowed to rise the engine changes from simple to compound. The pass-over valve closes, the high pressure poppet valve also closes and cuts off the high pressure exhaust from the condenser, causing it to pass through the low pressure poppet valve (which is now open) into the low pressure steam chest. This rather lengthy statement is for the purpose of conveying the idea of where the steam should go when engine is simpled and where it should go when engine is compounded. Thus, we see in running compound if the pass-over valve is leaking or binding, so that it does not seat, the engine is trying to run partly compounded and partly simpled at the same time. The steam which leaks through the pass-over valve may cause back pressure on the low pressure piston and also it will cause the low pressure cylinder to do more than its share of the work, thus destroying the balance between the two.

If the high-pressure poppet valve leaks or does not seat the exhaust from the high-pressure cylinder will escape into the condenser instead of finishing its work through the low-pressure cylinder. This will rob the low-pressure cylinder of its full share of the steam and destroy the balance. A good way to test the high-pressure poppet valve to see if it is seated is to turn this stem with a pair of pliers if the simpling mechanism is in compound position. If it is not seated it will turn easily, but if it is seated properly it will not turn, without applying considerable force.

A sand flaw in the cylinders might allow the steam to short circuit over-loading the low-pressure cylinder. This is a condition of which but two cases have come to our knowledge. It is mentioned merely as a last extremity. All the cylinders are thoroughly inspected and tested before leaving the factory. However, a very slow leak or flaw, which might not be perceptible when new could in the course of time be enlarged by the passage of steam and later become more noticeable.

Occasionally, the engine will not pull smoothly for a few minutes after starting until the steam has attained its superheat. This condition is commonly known as when the car is "warming up". The steam not having the elasticity that it should, will not do as much work in the low pressure cylinder as it does in the high pressure, thereby destroying the balance between the two cylinders.

By the expression "piston or slide valves cut" is meant a condition where the steam tight surface has become rough or grooved, owing to the two metals cutting each other. This condition is brought about by poor lubricating oil a lack of oil or running with the temperature of the car too high. Should a high-pressure valve be cut it allows too much steam to go through to the low pressure, giving the same condition as leaky simpling valve.

Broken piston rings will also allow too much steam to pass to the low-pressure cylinder, providing the rings, which are broken, are in the high-pressure. If the low-pressure rings are broken the steam will escape to the condenser without doing the full amount of work. Either condition destroys the engine balance. Broken rings are usually caused from a lack of proper lubrication or starting the engine too fast with water in the cylinders.

ENGINE VIBRATES EITHER SIMPLED OR COMPOUND

The items enumerated under this head are causes of vibration under running conditions either simpled or compound. If the bolts, which hold the engine to the frame, should become loose the engine will bump up and down on the frame at each stroke of the engine, especially when pulling slowly. Vibration may not be perceptible after the car has attained speed.

In Models E, F, H, and L which have the engine fly wheel should the bolts holding this fly wheel become loose it will cause the vibration especially when pulling. The slip joint on the drive shaft fits into the square socket in the flywheel. As this joint must slip each revolution it is obvious that if the flywheel is loose it will move on its retaining bolts as it flies around. This same condition can be brought about if the radius rods are so short that the drive shaft projects into the flywheel socket far enough to bump against the bottom of the socket. This is also especially noticeable when the engine is pulling hard or accelerating the car on rough roads. The driveshaft square should be sunk in the fly wheel socket three-eighths of an inch measured on a horizontal center line through the drive shaft.

Lack of lubrication has been treated under Chapter II. The important points as mentioned there especially for smooth running are the engine, cylinders, and the drive shaft bearings.

Loose rear wheels on the axle may cause vibration to set up at certain speeds. If in looking for the cause of vibration it is discovered that the rear wheels are loose they should be tightened at once.

If the valves have been taken out and not replaced properly the admission of steam will not take place at the proper part of the piston stroke. This is enough to cause the engine to pull in a jerky manner, thereby causing it to shake the car. (See instructions for valve setting.) In extreme cases the engine may refuse to start.

Sometimes in changing the engine or having had it out of the car the rod which runs from the reverse lever to the reverse arm on the engine frame may be too short. In this case when the reverse lever is in full stroke notch the valves are running on cut-off. No steam engine will pull smoothly at slow speeds if running on cut-off, especially if the valve gear gives an increased lead with the shorter cut-off. In cases where the reverse rod is short the engine may vibrate until the car picks up speed and then runs as smoothly as could be desired. To test this move the reverse lever beyond the reverse notch of the quadrant while the engine is running. It should not move past this notch, the width of the latter, before the lever begins to kick. The best way is to adjust so the lever will kick just back of the full stroke notch on the go ahead and will cease when dropped into the notch. This insures that the valves have full travel at slow speeds and if it is then desired to work the valves on cut-off at high speeds the valve gear may be hooked up.

A broken ball in the crankshaft bearings or rough bearings caused from lack of lubrication may cause the engine to vibrate. There is no way of telling this fact without proper examination.

ENGINE POUNDS

An engine pound is a decided knock or thump usually caused by a loose or worn part. Do not confuse the terms "vibration" and "pound." An engine can pound and still pull smoothly, or an engine can vibrate when all its moving parts are properly adjusted and well lubricated.

A loose or worn main bearing pound is usually a heavy thump and the best way to determine which bearing it is to make an examination. Sometimes if it is the low-pressure main bearing the pound is heavier when engine is pulling simple. Often times it can be remedied by inserting over-sized balls. The bolts, which hold he main bearing caps, may become loose allowing the whole main bearing to move up and down. When looking for a main bearing pound these bolts should all be tested.

A loose connecting rod is one where the bolts have become loose or the bearing surface has become worn. A connecting rod pound is a double pound most noticeable when the pulling is slow and heavy. Running along at a steady rate of speed, it is usually decreased or sometimes eliminated by hooking up the reverse lever.

If a piston head is loose on the piston rod the result is a heavy double pound. If the piston rod is loose where it screws into the crosshead the pound will be much lighter and sharper. It is a double pound and is heaviest at slow speed. The later condition may be easily determined by trying piston rod lock nuts with a wrench. A double pound is one, which thumps at each end of the piston stroke.

If the lock nuts, which hold the pumps on the bracket, are not tightened sufficiently or should become loose the result will be a pound which should be looked after immediately. If allowed to continue the motion of the pumps may strip the threads necessitating the replacement of a casting. To diagnose this pound notice that it occurs only when the pressure is below the bypass point and when the pumps are pumping against the pressure of the generator. Above by-pass point it ceases. An easy way is to raise the hood and take a look at the pumps. Any movement up and down can easily be seen,

In the Models G and K it happens sometimes that in starting the engine too quickly the condenser pump rocker arm is bent. This is due to the fact that the condenser is overloaded, with water from cylinder condensation, and the pump is doing full work. As the air pump plunger is a part of the condenser pump plunger any shifting upward of the rocker arm will raise the air pump plunger enough to cause it to strike the top of the air pump cylinder. This pound is a single pound and is very dull and heavy. Sometimes it can be felt by placing the fingers on top of the air pump. Also it may decrease or be eliminated when the air pump is pumping air to the tank, as also might a low pressure main bearing pound. If the arm is not bent too much it can be remedied by putting a gasket under the air pump head of such a thickness as to raise it enough that the plunger will not strike it.

In the Models E, F, H, and L the condenser pump may become loose in the crankcase. Any movement of the condenser pump can be detected by the eye. It might be well to test the pin to see if it is tight in the crosshead.

If the engine frame bolts are loose enough the result might cause the engine to pound, as it lifts up and down on the frame. While this was mentioned under vibration an extreme case might be classed as an engine pound. Sometimes this can be detected by watching the joints where the engine arm seats on the frame when the engine is running idle, or by feeling it with the end of the finger.

BROKEN CRANK SHAFT

This condition is more apt to happen on the engines, which have the foot brake on the flywheel. It is usually brought about by applying the brake too fiercely, or without closing the throttle. It can be detected sometimes by the fact that the flywheel wobbles and does not run true. The surest way is to remove the crankcase and test by holding the flywheel and moving the crank.

ENGINE KICKS UPON CLOSING THROTTLE

Should the engine jerk the drive shaft for a few revolutions after closing the throttle and car is coasting it is caused by the throttle seat leaking steam and thereby not completely shutting it off. This steam is not sufficient to keep the engine running faster than the car. First the car over-takes the engine and then the engine over-takes the car alternately, taking up the slack on the drive shaft and loosening it again. Remove the throttle and grind seat with pumice stone or powdered glass. To test for leaky throttle allow engine to remain stationary a few moments, then press down simpling pedal. If engine starts to move the throttle is leaking. Should the simpling pedal refuse to move be very careful about pressing it suddenly, as the engine will probably race. The best way to release the steam, which is imprisoned in the steam chest, is to give the pedal a few sharp kicks thus releasing the steam a little at a time.

ENGINE JERKS WHEN CHANGING FROM SIMPLE TO COMPOUND

When starting the car on the street the simpling pedal should be held down until the engine has caused the car to pick up some momentum. When releasing the pedal allow it to come back to compound position with a snap. If the pedal is allowed to come back slowly there will be a short interval of time when the engine is neither compound nor simple and working against itself. This will cause it to jerk the drive shaft violently. If the stuffing boxes on the simpling valve stems are too tight they offer enough resistance to the simpling spring to cause the change from compound to simple to take place too slowly. All these packing boxes should be kept well oiled, so that the spring can work the parts freely. If the simpling spring is weak it may give this same condition.

ENGINE REFUSES TO START

If at any time when the throttle is open the engine does not start promptly do not turn on more steam, but close the throttle and ascertain the reason. Should the engine have just been reassembled there would be the possibility of the valves not being set correctly. Examine the little pass-over valve rocker arm an see that it is adjusted to give a movement of at least one thirty-second of an inch to the pass-over valve stem. If this valve does not open and the high-pressure cylinder happens to be on dead center the low pressure cylinder will receive no steam and the engine will refuse to start. This can be detected by raising the hood and working the simpling pedal. Also notice if the low-pressure poppet valve is adjusted so that it seats. In case it does not the steam which passes through the pass-over valve passes directly through into the condenser without starting the engine. To detect this condition simple the engine and try turning the valve stem with a pair of pliers. In case it is not seating it will turn very easily. It is very common for the driver to forget to press down upon the simpling pedal when starting. Make it a habit always to do this. Sometimes the reverse lever is thrown in the center notch.

In this last case the valves are covering all the admission ports to the cylinders and the steam will not be admitted.

STUFFING BOXES WILL NOT REMAIN TIGHT

Contrary to the experience of some the stuffing boxes on the engine should need little, if any, attention. This assertion, is made, however, on condition that the stuffing boxes have been broken in properly. In starting a new engine or an engine that has just been packed throughout care should be exercised during the first two weeks in regard to the stuffing boxes. The packing is new, consequently it is very soft and is not formed to the shape of the piston rod. The stuffing boxes should be tightened up daily, without being allowed to leak, for the first two weeks, then an additional ring of packing should be inserted in each box. After the packing has once become seated, provided it has not been allowed to leak enough to start a steam groove, the stuffing boxes should then with the proper handling of the throttle last the rest of the season. We know of one instance where a thirty horse power car has finished its second season and still has the same packing which was put in it at the factory. At the beginning of the second season a little additional packing was put in each stuffing box.

If the steam is hot and the proper lubrication is lacking the packing may become hard and dry enough to score the piston rod. Once this has happened the packing cannot be made to seat tightly, and the engine should be repacked throughout after refinishing the rods.

Any scoring, rough spots or nicked places on either the valve stems or piston rods will become a source of constant annoyance by causing leaks. This little rough place in moving up and down through the packing cuts exactly like a saw tooth and will continue to cut a groove through which the steam will escape as long as it is allowed to remain on the rod. Such a rough spot is sometimes caused by allowing the stuffing box wrench or tool to slip and strike the rod causing a slight abrasion of the surface. If there is any suspicion that the rods have rough places they should be removed and smoothed down by draw filing or better still by refinishing in a lathe.

For item "D" packing caught under edge of gland, see directions for packing stuffing boxes, Chapter Four.

If the throttle leaks while the car is standing, pressure of steam will accumulate in the steam chest. This may force its way through the valve stem stuffing boxes, thus starting a steam groove in the packing. Under running conditions the actual pressure in the steam chest is a great deal less than that in the generator. Only when the throttle is opened rapidly or when climbing a hill does the pressure within the steam chest even approach that of the generator. On the new model engine the valve stem stuffing boxes are subject only to the exhaust pressure of their respective cylinders.

Probably enough has been said about the proper handling of the throttle on a Steam Car. The explosive engine attains its working speed before the car is started to move, but the steam motor must start the car while it is starting itself. In this fact lies the difference between the two in regard to the damage which may be done by applying the power too rapidly. At any rate, the more recklessly the throttle is used the sooner the stuffing boxes will start to leak. This is true in regard to opening the throttle without pressing down the simpling pedal or with the reverse on center. Hence our caution mentioned above--"If the engine refuses to start promptly close the throttle and find out why it does not."

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CHAPTER X

CHART #5

"OLD REGULATION"

From the time of building the first cars up to year of Naught Seven the regulation remained exactly the same in principle. This principle was entirely different from the one in use at the present time. The thermostat regulated the amount of fuel fed to the burner by closing off the supply when the temperature reached a predetermined degree. The water regulator controlled the amount of water fed to the generator by opening and closing at a predetermined pressure. Suppose a case, where the fuel is turned on to the burner and the fire is burning. There is enough excess fuel to cause the temperature in the generator to rise. When the temperature reaches three hundred and ninety degrees the thermostat closes shutting off the supply of fuel. Without any fire below the coils in the generator the steam pressure immediately begins to drop back, As soon as it drops to the point where the water regulator closes the water starts to the generator, causing that already contained therein to begin to move downward through the coils, being forced to do so by the action of the pumps. This movement of the water causes the temperature of the steam to drop a slight amount, just enough, however, to cause the element in the thermostat to contract sufficiently to turn on the fuel again.

CHART # 5

OLD REGULATION

<table>
<tr><td rowspan="13">Lack of power
Dry steam</td><td rowspan="2">Overheating</td><td colspan="2">Thermostat set too high</td></tr>
<tr><td>Thermostat refuses to close</td><td>Bad seat
Needle binds
Dirt on seat
Bellcrank sticks</td></tr>
<tr><td>Wet steam</td><td colspan="2">Dirty vaporizer
Thermostat low
Clogged fuel line
Valves not open wide</td></tr>
<tr><td>Faulty pumps</td><td colspan="2">Checks
Porous or flabby suction hose
Dirty tank strainer
Leaky stuffing boxes</td></tr>
<tr><td colspan="2">Leaks between pumps and generator</td><td>Unions
Water cushion</td></tr>
<tr><td>Water regulator</td><td colspan="2">Cracked diaphragm
Bad pin valve seat
Pin or screen wedging</td></tr>
<tr><td>Backfiring</td><td colspan="2">See Chart One</td></tr>
<tr><td>Howling</td><td colspan="2">See Chart One</td></tr>
<tr><td colspan="2">Fire on continuously</td><td>Wet steam
Thermo will not close</td></tr>
<tr><td colspan="3">Fire not on enough, see lack of power</td></tr>
<tr><td colspan="2">Excessive variation of steam pressure</td><td>Clogged water regulator screen
Thermostat bellcrank sticking
Steam leaking into thermostat
Slow leak through thermostat
Dirty generator
Water overbalancing fire</td></tr>
<tr><td>Excessive water consumption</td><td colspan="2">Wet steam
Leaks
Condensing system (Chart # 1)
Stuffing boxes</td></tr>
<tr><td>Excessive fuel consumption</td><td colspan="2">Wet steam
Dirty generator</td></tr>
</table>

The steam pressure almost immediately rises above the bypass point, the water regulator bypasses the water supply, and the temperature rises again causing the thermostat to close the fuel valve. This is a full cycle and these cycles follow each other in routine at regular intervals when the car is working. This regulation maintains a constant temperature, but not a constant pressure. For instance, if the generator is entirely empty of water the temperature will rise to a point where the thermostat will close, cutting off the fuel, and still there will not be a pound of steam pressure. In the other hand if the generator should be entirely full of water we will get an excessive amount of pressure before the temperature is high enough to shut off the fire. These are the two extremities, but when running on the road the pressure should not vary more than one hundred pounds at the most, unless the running speed is suddenly changed.

OVERHEATING

On the "Old Regulation" the thermostat is usually directly responsible for any overheating. For setting thermostat see directions, Chapter Four. Any condition, which would prevent the needle valve from closing at the proper time, would probably cause over-heating. If the seat on the needle valve is poor causing leaks it will cause the temperature to continue to rise. Be sure that the needle can work freely in the guide, as it depends upon its own weight to cause it to seat. A particle or dirt lodging on the seat would give the same result. By inserting the finger into the opening when the cap is removed one can ascertain whether the bell crank is binding. This should move perfectly free and fall with its own weight.

WET STEAM

The causes enumerated here are all discussed under the same head "New Regulation." The symptoms of a dirty vaporizer are as follows: The fire sounds weak; and seldom shuts off. It burns a considerable time after closing hand valve. With a clean vaporizer and full flow of fuel the fire should have a deep powerful sound. Usually with a dirty vaporizer the sound possesses more of a hissing quality and the color of the flame is of very light blue. To find a clogged place in the fuel line, always begin at the vaporizer and work towards the gasoline tank. In the large section of the fuel line where the pilot light line branches off from the main line is placed a strainer composed of candle wicking. This should be cleaned occasionally. Care should be taken in replacing it that the ends of the wicking are away from the direction of flow, otherwise it might bunch together and cause a chokage.

LACK OF POWER, BUT DRY STEAM

All these items have been discussed under the "New Regulation." A quick way to prove whether the generator is getting enough water is to give a few strokes of the hand pump while running. If the pressure begins to pick up immediately it is almost conclusive proof that the water supply is at fault. Usually in a case of this kind the fire keeps shutting off without raising the steam above the bypass point, and the steam pressure is at all times subnormal. For other items see "New Regulation".

CHART #6

LUBRICATION

Engine	Cylinders	Pistons Valves Stuffing boxes	Constant supply of "Standard Steam motor oil" "White special steam oi1" "600W vacuum compounded"
	Fan and fan shaft	-----	Turn up grease cups daily
	Water pump block	-----	Oil daily
	Oiler driving mechanism	-----	Oil daily
	Crankcase	Crossheads Connecting rods Crank shaft Valve gear	Change bi-weekly Cylinder oil, 3 quarts Pure lard oil, 1 quart
Rear axle	Gears		Cylinder oil up to level plug Change every 1000 to 1500 miles
	Outer bearings		Grease cups daily
Drive shaft	Universal joints Slip joints		Grease weekly
Front wheels			Change grease every 5000 miles Force grease into tube weekly
Springs	Leaves Shackle pins		Kerosene and a light oil Grease weekly
Steering gear	Joints Knuckles		Grease bi-weekly Grease daily
Small pin joints	Brake levers Reverse levers and rod Simpling valve gear Pedals Throttle rod		Oil weekly
Water regulator and steam gage			Cylinder oil when gage vibrates

NOTE:
The three kinds of cylinder oil are mentioned in the order of their merit. If one cannot be obtained use the next one on the list.

N. B. Conditions are assumed that car is used daily.

(EFFICIENCY REPORT)
STEAM PLANT OF THE WHITE MOTOR CAR
By R. C. Carpenter, of Ithaca, N. Y.
Member of the Society

1 The steam plant of the White Motor Car is an example of what can be accomplished on a small scale in the use of steam of high pressure and with a high degree of superheat in the steam engine and is consequently of interest to the mechanical engineer irrespective of its special application for the propulsion of motor cars. I take pleasure in presenting a description of this plant and also the results of a series of tests which I believe will prove of considerable interest to all engineers who are studying the question of the use of steam at high temperatures and pressures.

2 The White steam system was designed by R. H. White and has been successfully applied by the White Sewing Machine Company, during the last six years to several thousand motor cars; its essential and novel features are found principally in connection with the steam generator or boiler which is adapted to produce steam of high pressure and high temperature. The system is also of interest in the details of construction of its engine and in one means for automatically controlling the quantity, temperature, and pressure of the steam produced.

3 It is a well recognized fact that the efficiency of a steam plant is increased by the use of steam at high temperatures and pressures and there are numerous tests on record which bear testimony to this fact. The development of the art of producing and using steam of high pressure and of a high superheat has been slow although probably continuous. So far as I can learn from correspondence, no boilers or engines exceeding 100 HP in capacity which are adapted to produce and use steam exceeding 300 lb., pressure and 300 degrees superheat are built in this country at the present time. (Presented at the New York Meeting (December 1906) of The American Society of Mechanical Engineers, and to form part of Volume 28 of the Transactions. Pages 255-285.)

THE BOILER

5 The steam generator or boiler of the White system is a series of horizontal coils connected so as to form a continuous tube through which all the water fed to the boiler and all the steam discharged from the boiler must pass. It is not provided with any reservoir either for water or steam. A perspective view of the boiler as used in the 1906 car is shown in Fig. 1 with the external casing removed. Its essential distinctive feature from every other boiler is due to the fact that the water is dept at the top and the steam at the bottom; it differs from al types of stationary boilers by the absence of a reservoir for steam. The construction of the boiler for the 18 brake horsepower engine which was used in the 1906 cars is essentially as follows, and is typical of all sizes: Eleven helical coils of drawn steel tubing are joined in series and connected as shown in the diagram, Fig. 2, so as to produce a system of circulation of such a character that the water or steam, in order to pass from one coil to that next below must rise to a level above the top coil before it can pass down again. Fig. 1 shows the external view of the connections referred to, which pass from the external circumference of the coil upward to a point above the level of the top coil and thence downward in the central space, where it joins the coil of a lower level. Tubing having a nominal internal diameter of 3/8 inch was used in the boilers of l9O4-O5 and 1906 and of 1/2 inch in the new boiler recently built for the 1907 car.[1] The joints connecting the various coils are, it is noted, located in an accessible position. This construction makes it possible to maintain water in the upper portion of the boiler and steam in the lower. It prevents the water from descending by gravity and renders the circulation through the generator dependent upon the action of the pumps, which supply the boiler with water. The general direction of circulation of the water and steam is the reverse of that of the products of combustion.

6 The White boiler has frequently been classified as a flash or semi-flash boiler; whether this classification is correct or not depends upon the definition of the term "flash boiler". In the flash boiler, as I understand the term, water is suddenly converted into steam by contact with a very hot metal surface. And in the operation of such a boiler the metallic surface with which the steam is brought in contact is maintained at a much higher temperature than that of the steam. The White boiler, as noted from the description, always contains a considerable amount of water which is forced downward and over the heating surfaces at a rate proportional to the demand for steam, and under its normal mode of operation it is doubtful if the metallic surfaces have much or any higher temperature than that of the steam which they contain. The name Continuous Flow or Single Tube Boiler would, It seems to me, better describe the class to which the White boiler belongs than the term "flash".

[1] The actual dimensions of tubing used in the White boiler are as follows: E and F boiler (1905-06), internal diameter 0.372 inch, outside diameter 0.535 inch; G boiler (1907), internal diameter 0.540 inch, outside diameter 0.72 inch.

STRENGTH

7. The construction of the boiler has been shown and described, from which it is seen that the diameter of each pressure element is small and consequently of great strength and not likely to be strained to any high percentage of its ultimate strength by any pressure which could be produced under ordinary conditions.[2] The high working pressure gives great power to the engine and explains the great success of the car in climbing high hills and in passing over unusually bad roads. A safety valve, not shown in the drawing, is attached which may be set at any desired pressure but is usually set to blow off at from 1000 to 1200 lb. per square inch. Because of the small quantity of water and steam present in the boiler no serious damage is probable to person or property, even should boiler tube be accidentally split or ruptured, as the effect would be simply that of allowing the steam gradually without producing any disastrous results, and even this accident has been extremely rare. Considering the fact that thousands of these steam generators are in use, in the charge of men who have had practically no experience in the operation of steam plants, the results as to freedom from accident are remarkable and indicate that the apparatus is, from the standpoint of safety, not open to criticism.

8 I have tried to get data respecting the amount of deposit of scale in the tube of the White boiler due to its continued use, but without any very great degree of success. Investigation indicates that there has been very little practical difficulty due to this deposit and the makers report only a few instances, which have come to their knowledge of any trouble due to this cause. The velocity of discharge of steam through the single tube or the boiler is great and it is believed has been sufficient to remove the deposits in nearly every case. In the boiler of which the results of the test are given later, as much as 488 lb. of steam were produced per hour by the ½ inch tube. Without taking into account the extra volume produced by superheat, the calculated velocity approximates 1/3 more.

9 For the actual operation of the White boiler on the motor car, water is taken from a reservoir which is supplied in great part with water condensed in an air surface condenser. The condenser is located at the front of the car and receives the exhaust from the engine, which contains an appreciable amount of cylinder oil. A large proportion of this oil remains in the water tank and is discharged when convenient, but at times quite a considerable amount is forced through the boiler. So far as the makers have been able to ascertain no injurious effects have been caused by this practice and as a consequence they have made no attempts to introduce a separator for removing this oil.

THE CONDENSER

18 The steam system is provided with an air condenser which in its application to a motor car is placed at the front of the vehicle. It consists of a series or corrugated copper pipes with suitable header connections at top and bottom and is arranged to receive the exhaust steam into the upper header.[3] The condensed water falls by gravity to the lower header and is removed by a pump. The tubes are surrounded by air, which is circulated by the motion of the vehicle supplemented by the use of a fan located between the engine and the condensing surface. The condenser is furnished with a relief valve, which opens to exhaust steam into the air in case the backpressure becomes of sensible amount. The condenser as previously applied to motor cars was not adapted to produce a sensible vacuum, its purpose being to conserve the water supply. Recent improvements in the pumping system give a substantial vacuum from which a considerable increase in economy due to the vacuum is anticipated in the future. The motor car of 1907, it is expected, will maintain a vacuum of over ten inches at a speed of 20 miles per hour.

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[2] The strength of the fittings at the point of leakage for the tubing I found to vary from 7000 to 18,000 lb. per square inch.

[3] The condenser dimensions are as follows: For E and F cars (1905-6) 74 tubes, 24.5 inches long, with a total surface of 118 sq. Ft. For car (1907) of 65 tubes 27 inches long with a total surface of 136 sq. Ft.

TESTS OF THE WHITE STEAM PLANT

Prof. C. H. Benjamin, of the Case School of Applied Science, Cleveland, Ohio, made a very careful brake test of the steam plant of the White system of 1903 which used a 10 HP engine and found that when the engine was fully loaded it used only 12.6 lb. of steam per brake HP hour and 1.16 lb. of gasoline per H. P. hour. These results are unprecedented for small steam plants of any size and are nearly equal to the best results obtained with large triple expansion condensing engines. Some details and results of this test are given as an Appendix.

22 I conducted a test of the boiler and engine for the 1907 car from July 9 to 17, 1906, being assisted by Mr, Walter Grothe, M. E., engineer for the White Sewing Machine Co., Prof. W. N. Barnard, M. E., of Conell University, Mr. Wm. Scaife, and Mr. George Carpenter, M. E.

23 The engine and boiler tested have essentially the same features of design as those previously used, but are somewhat larger and have increased power. The engine used in the White steam cars of 1905 and 1906 had cylinders 3 and 5 inches in diameter by 3½ inches stroke, and was rated at 18 H. P. The one tested had cylinders 3 and 6 inches diameter by 4½ inches stroke, and is rated by the company at 30 H. P.

24 Dimensions of Engine for 1907 car:
Diameter of cylinders, 3" high pressure, 6" low pressure.
Diameter of piston rods, 9/l6" low.
Clearance of engine, 17.9" high, 9/16" low.
Weight of cylinder castings with guides, 98.5 lb.
Weight of valves and fittings, 28.0 lb.
Total weight, engine complete, 328 lb.

23 Boiler: The boiler consists of nine coils of drawn tubing with a nominal internal diameter of ½ inch, actual internal diameter of 0.53 inch, actual external diameter 0.72 inch, The external diameter of the boiler is 22 inches; its height, 11 inches. The boiler contains 243 feet in length of ½ inch tubing, and has a heating surface, which is calculated, as amounting to about 45.8 sq.

26 The weight of the boiler without fittings is 150 lb. The weight of casing, bolts, and all the fittings is 125 lb. additional, the total weight of the boiler complete as 275 lb. The weight of the burner is 40 lb. From this it is noted that the total weight of the power system is about 643 lb. The maximum brake horse power as shown on the test, is a bout 45, hence the weight is about 14.3 lb. per D. H. P.

THE FUEL

51 The fuel used in the test was gasoline supplied by the Standard 0il Company. Its specific gravity, as measured by a Beaune hydrometer, reduced to a temperature of 60^0 F. was 68.5, which corresponds to a specific gravity of 0.705 at 60^0 F. Its specific gravity as measured at a temperature of 75^0 was 0.6945, Water being 1. From this measurement a gallon of gasoline at a temperature of 60^0 should weigh 5.877 lb.

52 The heating value of this oil as determined by Prof. H. Diedrichs, as the average of three determinations, with the Junker calorimeter, is 19,606 B. T. U. per pound for the higher value uncorrected for water vapor. The chemical analysis of the oil, as made by Prof. B. S. Cushman of Cornell University, showed 84.76 per cent C, 15.24 per cent H, from which the heating value per pound, by calculation, is 20,400 B. T. U. The lower calorimetric value is about 10% below the theoretical calculated value, a discrepancy which I am not prepared to explain at the present time, but which I judge from consultation of a few authorities has occurred a number of times before, I consider the lower calorimetric value as more nearly representing the value of the fuel in practice than the other.

THE BOILER TEST

53 The average pressure of steam at the boiler during the various runs was 595 lb. The average degree of superheat at the boiler was 298^0. The mean temperature of feed water was 78^0. The average evaporation was l0.34 lb. of water for 1 lb. of gasoline. From this data, by consulting Buel's steam tables, we find

B.T.U. per lb. of steam above	212^0	=	1051
B.T.U. per 1b. for raising feed to	212^0	=	l44

By producing lines in Fig. 12, the
specific heat is found to be 0.69.

Heat required to superheat 298^0	=	298x69 =	206
		Total.	140l

Equivalent evaporation from and at 212^0 per sq. ft. of heating surface per hour, was 13 lb. for highest result.

54 In the above calculation the heat required for superheating is extremely approximate as the pressures in my test were about three times as high as those in the Sibley College test for specific heat of steam. In this last calculation I have obtained the specific heat as 0.69 by extending the lines in Fig. 12. This quantity gives the value of the heat in one lb. of steam above 212^0 as 1257 B.T.U., which averages about 29 B.T.U. per lb. higher than that which I calculated as supplied to the engine, and is I believe too high since the loss of heat between the points where the two observations were made was small and in my opinion must have been less than 1% or about 14 B.T.U. in this case. If the heat required for superheating were calculated by using 0.48 for the specific heat the above results would have been 1339 B.T.U. per lb. which is 62 B.T.U. or 4.4% less than the above.

55 The heat absorbed by the steam for one lb. of gasoline burned would be, in accordance with the above calculation, 14,486 B.T.U., corresponding to an equivalent evaporation from and at 212^0 F. of 14.9 lb. per lb. of gasoline, and made on the supposition that the specific heat of steam is constant and equal to 0.48, it would be equal to 13,845 B.T.U. corresponding to an equivalent evaporation from and at 212^0 of 14.3 lb. of water per lb. of gasoline.

56 If the heating value of the gasoline be 18,482 B.T.U. per lb., the respective boiler efficiencies of these 2 cases would be 78.4% and 75.0%. If the heating value be assumed at 20,400 B,T.U. per lb, the respective efficiencies become 71.2 and 67.3%.

THE EFFICIENCY OF THE ENTIRE PLANT

57 The engine developed a horse power on the brake at its highest load during the various tests with a consumption of 11.96 lb. of feed water per hour. The evaporation under actual running conditions with the feed water heater in operation was 11.5 lb. of water for one of gasoline. This would show that l.04 lb. of gasoline would be used under best conditions per developed HP

58 If the engine friction be considered as 1.6 HP, the water per IHP per hour would be as calculated under best conditions, 11.54 lb. and the gasoline per IHP per hour, l.004, which is practically one lb. of gasoline per IHP per hour.

59 If the gasoline has a heating value of 18,482 B.T.U. per lb., we find a heat efficiency for the whole plant on the basis of total heat supplied, compared with that converted into useful work on the brake, of l3.25%, and compared with that indicated of 13.35%. If the heating value for gasoline be 20,400 B.T.U. per lb. the per cent of efficiency for these two cases becomes respectively 12.1 and l2.45%.

60 The above calculations are made to cover the extreme results of he heating values of gasoline, in order to make the results accord with either method of calculation.

SUMMARY OF TESTS MADE BY PROF. C. H. BENJAMIN

61 The test made of the White steam system by Prof. C H. Benjamin in 1903 has already been referred to and a summary of the results is given here for comparison with the tests which I made.

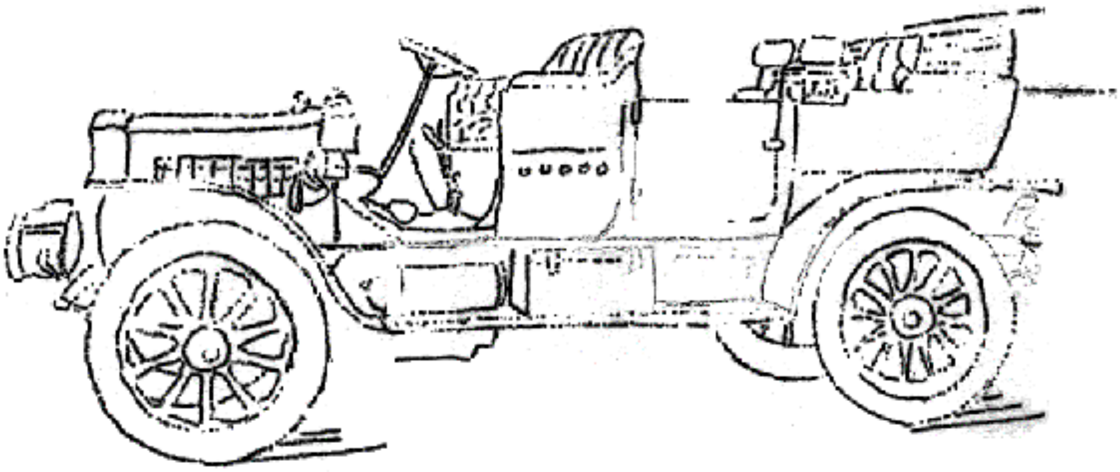
62 The engine tested by Prof. Benjamin was of the vertical cross compound type with high pressure cylinder 3 inches in diameter, low pressure cylinder 5 inches in diameter, and with a stroke of 3½ inches. Its general construction was in many respects similar to the 1907 engine, which has been fully described; it was not however, provided with ball bearings. The test was made by essentially the same method as described in the paper. During the

test the engine was operated at 675 R.P.M., the friction HP determined in Prof. Benjamin's test was approximately 2, which, however, included that of an extra countershaft, which was not required in my test.

63 Prof. Benjamin's tests show a consumption of water per brake horsepower pear hour varying from 12.6 to 19.9 and per indicated horsepower per hour an amount varying from 10.8 to 14 lb.

SUMMARY

64 Respecting these results Prof. Benjamin states: "This is a remarkable showing for an engine of this size. When the fact is considered that ordinary simple engines use from 25 to 35 lb. per indicated H. P. per hour, and that 12 lb. is considered good performance for triple expansion condensing engines the remarkable nature of this performance is better understood."



40 H.P. White
steam-car

MISCELLANEOUS

In the hill climbing carnival held in San Francisco (March 28,l909) a 20 HP Model "O" White Steamer made the fastest time of the day, Climbing the steep one mile grade in l.l2 2-5. This time was scored
In a match race, as the committee paid the White the usual compliment of having the regular events "open for gasoline cars only"

Three days later, at a hill climb held at Memphis, the Model "O" White again displayed its superb hill climbing qualities by making the fastest time of the day against a large and representative field of competitors.

(from White Bulletin # 16)

OFFICIAL COMMENTS on the Work of the White Steamers in the Massachusetts Military Maneuvers. By E. W. M. Bailey, Inspector General of the Blue Army.
"The 3 White Steamers attached to the Hdqtrs. of the Blue Army showed remarkable qualities of endurance. They were in constant use during the day and night, on sandy, unimproved roads, in wet and dry weather, and no matter at what time they were called upon or where they were to go, they were always ready. Their endurance and speed made it possible for the Commanding General to be continually in touch with all the elements of his command and demonstrated their usefulness for military purposes"

(from White Bulletin #16)

Pittsburgh, Pa. Oct. 1st, 1904 The White won 3 first prizes out of 4 races entered. 1st, a 2 mile race for all cars up to 24 horse power with road equipment. In this race the Whit defeated 4 24HP and 1 15HP cars. 2nd, a cupid 2 mile race contesting with cars all of which
had 24 HP or over. 3rd, a two mile race for cars up to l6HP with
road equipment.

(from 1905 White steam car catalog)

SPECIFICATIONS OF THE MODEL "M" AND "O" WHITE STEAM CARS:

	MODEL "M" 40 HP	MODEL " O" 20 HP
Diameter of high-pressure cylinder	3 in.	2½ in.
Diameter of low-pressure cy1inder	5 in.	3½ in.
Stroke	4½ in.	3 in.
Internal diameter of Generator tubing	½ in.	½ in.
Wheel-base	122 in.	104 in.
Front tires	36x5 in	32x3½ in.
Rear tires	36x5 in	32x3½ in.
Front springs	44 in.	37 in.
Rear springs	56 in.	45 in.
Gasoline tank capacity	22 gal.	15 gal.
Water tank capacity	18 gal.	13 gal.

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IT IS A SOURCE OF MUCH PRIDE both to the manufacturers and to the owners of White Steam Cars that the President of the United States uses a car of this make. Several months before his inauguration, Mr. Taft purchased a seven-passenger, forty horsepower White Steam Car, and this machine he has used exclusively since that time. The fact that there are other automobi1es availab1e for his use serves only to emphasize his marked preference for the White. While in Washington, the President uses his White car daily in going about the city, and whi1e he was spending his vacation at Beverly, a long ride out into the country in the White was a part of his daily routine. In addition to the President’s personal car, two White Steamers were used during his stay at Beverly by the secret service officials in the discharge of their highly important duties.

(From The White Bulletin, October, 1909)