Steam Engines in the Automotive Field*

Many Advantages That May Again Bring Them to the Front

By E. T. Adams

In the general power field this is the era of steam. In the field of automotive power, even more absolutely, this is the era of gasoline.

The supremacy of steam for general power purposes has been attained only after years of competitive development. The gasoline engine has developed without serious competition and in a very short time. We therefore lack the assurance that its present preeminence in all departments of the automotive field may not be based on causes other than superior fitness for the service, such, for example, as a condition of the oil industry, now outworn, or upon the initial unreadiness of the other types of engines.

At the present time the question as to the relative fitness of the gasoline as compared with the steam engine for automotive service is receiving most serious attention. New developments and new inventions in steam engines have revolutionized the status of steam at the very time when the oil industry has reached a position absolutely the reverse of that which led to, and fostered the growth of, the gasoline engine. Two interrelated economic developments are especially noteworthy. First is the tremendous increase in the demand for automotive power. The use of the automobile has become universal, the use of the truck is at the beginning of an era of expansion which may prove equally great, and the farm tractor marks the beginning of a demand greater than all the others. The farm is the greatest single user of power, few people realize how huge a portion of the earth's surface must annually be cut into slices, turned upside down and pulverized to form a seed bed, and the expenditure of power which this involves. The excellence of the gasoline engine has led to its adoption for this and for other service for which it is economically unfitted, and we are fast working toward a condition where gasoline alone is not produced in sufficient quantity to meet the demand.

Second is the fuel situation. When the automobile industry was young the oil industry was dependent on the use of oil for light, and gasoline was a by-product—cheap, abundant and of excellent quality. Today the oil industry is based on oil for power, and gasoline is its foremost product. The supply, even with lowered quality and new processes of manufacture, is not equal to the demand, and the price is too high for many commercial uses. There will be some gain due to the perfection of vaporizing types of carbureters which will permit further lowering of the quality of gasoline, and some gain due to increased attention to economy, but the growth of the use of power in this field will be greatly hampered unless there is an increase in the quantity of fuel available far greater than can be expected from this source alone. This means the use of oils other than gasoline, and of methods other than carburetion and burning in an internal combustion engine.

The steam-driven engine is the type which most readily meets this condition, and its use will receive a further impetus because the demand for gasoline is a seasonal demand and a steam unit using unpurified kerosene or similar light distillates will use these by-products of gasoline manufacture during the season in which they are produced. These by-products are produced in great quantities, are relatively cheap, and furnish an ideal fuel for the small-power steam boiler.

ADVANTAGES OF STEAM UNIT

The steam unit has many advantages for automotive service. Its high torque at low speed, its overload capacity, its smooth, flexible speed and power control have remained the standards of excellence, reached for but never attained by any gasoline engine. The connection from engine to axle is simple and direct, without clutch, reverse or change gears. Steam is available at full boiler pressure and for practically full stroke to give torque to lift a loaded rear axle slowly and gently from a rut. Ahead and reverse follow the movement of a single lever, and acceleration and hill-climbing capacity hitherto unknown are at the operator's command.

High steam pressures and temperatures have been the rule, but a light, compact engine construction and high economy are attainable with steam pressures between 400 and 500 lb. gage, and thereby we avoid the tendency to carbonize the lubricating oil which is found at higher temperatures. There has been much interesting speculation on the economies due to the use of higher steam pressures and the best division of a given total heat between superheat and the temperature due to evaporation. But in the small units here considered, practical considerations, such as have been outlined, will doubtless govern design.

The chief force which is bringing about the increased use of the steam engine is its superior fitness for autmotive service, especially in the commercial field. First, in truck service the upkeep of the gasoline truck, even with expert service, is now beyond reason and is a serious handicap to the business. Overloading and incompetent handling are blamed for this condition, but, practically, overloading is not preventable, and starting from a bad position is an unavoidable hazard. Racing the engine, coupled with the sudden application of the clutch, is the only answer to these conditions which the gasoline engine affords. The result is destructive to both power plant and transmission. The steam engine meets this situation by using steam for practically the full stroke of the piston and at any pressure which the tractive power of the wheel will permit. The available mean effective pressure on the steam piston under these conditions is fully five times the maximum available with a gasoline engine, and the engine speed for the same torque may be correspondingly low. With the steam unit the load is picked up gently, exactly as a locomotive starts a train. This tends toward low cost of upkeep.

SIMPLICITY OF TRANSMISSION

Another point in favor of the steam unit is the extreme simplicity of the transmission—one pair of bevel or spur gears or direct drive on the worm shaft is all that is required for light and moderate power work, with one additional reduction for heavy work and tractor service. There is no clutch, no reverse gear, only a simple direct drive from engine to axle. This again tends toward low upkeep and long life.

In early construction the engine naturally followed locomotive or marine lines. Modern steam engines are preferably of the multiple-cylinder type, designed for quantity production, using the tool equipment and shop methods of the modern gasoline-engine manufacturer. They are carefully balanced, are light and simple and capable of as high speed as may be desired. The uniflow type is largely used because of its simplicity and its high economy when operated non-condensing. Because of the high steam pressure, the most economical mean effective pressure is about the same as full-load mean effective pressure of the gasoline engine, and for the same power the cylinder sizes are about the same in the two cases. With this construction piston and valve require but little lubrication, the amount of lubricating oil necessary being far less than that used by older types of steam or by modern types of gasoline engines. The pistons and rods follow automobile practice. Alloy steel and aluminum are freely used and ball-bearing construction is employed where possible. Crankshafts and pins are oiled by a forced lubrication system, bearing areas are ample, and the labor cost for adjustment and repair is naturally extremely low.

TYPES OF BOILER DESIGN

Boiler design exhibits greater variety than any other portion of the steam unit. The cylindrical fire-tube type, both with and without a water leg, have their advocates. The ordinary flash type is in use, but not so much in favor, because, among other things, of its especial tendency to carbonize any lubricating oil introduced with the steam. Tube boilers with natural or forced circulation are popular and effective. A forced-circulation, contra-flow-tube type seems especially commendable in that it may be forced to almost any degree and is therefore responsive, light, compact and economical. The stack temperatures are readily brought down to 50 deg. above feed temperatures; the superheat is under good control and danger of burning or injury to the tubes is negligible. One advantage of the tube type is its absolute safety from destructive explosions.

All these features exhibit a very great advance over older constructions. They are popular because of their economy and safety, and because all these improvements tend toward longer life and lower cost of upkeep.

The furnace is the most important feature of the modern unit. All precedent is swept aside. With a light power oil as the established fuel there is no excuse for following old practice and merely firing oil into a combustion space originally designed for coal, and in later designs this is not done. First are established proper conditions for burning the oil; second are established proper conditions for utilizing the heat thus generated, and these are then combined. In one installation this leads to a design with the furnace practically at the top of the boiler, with forced feed of oil and air; this has proved a most acceptable and desirable location.

Various methods of controlling the oil are in general service. In the oldest type the oil under pressure is converted into a highly superheated vapor, which discharges past an adjustable needle valve drawing with it an air supply, fed and controlled as in a Bunsen burner. After proper mixing the mixture is burned as it issues from fine perforations in the grate. A pilot light which keeps the oil supply superheated is a necessary part of the equipment. In spite of its high economy and its honorable record in service, this system is steadily being displaced in the more modern designs. Objection is made that under certain conditions the pilot light and the heated oil under pressure are highly dangerous, and the clogging of the control valve by carbon and tars formed by the cracking of the oil is objectionable and expensive.

CONTROL MECHANISMS

The mechanical atomizer of the type used in larger furnaces with heavier oils does not appear in use, but would seem to be well suited to the service. New systems of this general class are being tried out very extensively. These systems are important because they consider not only the proper burning of the oil, but also the commercially more important item of control. Considered as a unit, the vital control of the engine must be at the furnace. There must be control in proportion to load, in proportion to steam pressure and to maximum steam temperature, and also control directly responsive to the demands of the public. In a passenger car with a cold boiler enough steam must be generated to enable the car to be driven away in one minute. The mechanism of control, to be commercially successful, must be no more burdensome than the movement of a lever or the throwing of a switch. In a truck or tractor the demands are somewhat more moderate; but in general the steam unit must be practically on a par in the matter of starting with the gasoline unit, and the fact that in this respect also steam is now on a par with gasoline is one reason for the present impetus toward steam.

Where both air and oil are metered in under forced draft and in a boiler so flexible as those here described, it appears that a simple and entirely satisfactory method of heat graduation is to "cut in and cut out"; that is, to stop the supply of both oil and air entirely where it is desired to limit pressure or temperature, and to cut in again at full power when the pressure or temperature falls, this action of course being entirely automatic. With the safety which a tube boiler provides, a satisfactory system of water supply is a feed-pump operated by any means whose speed or time of operation is directly proportional to the load. This involves attention to the water level and occasional adjustment by the operator, but as there is no serious penalty for his failure, this seems an entirely satisfactory method—perhaps more satisfactory than a type more strictly automatic.

Next to the fuel situation and the desire for reduced cost of upkeep, this new system of control is the most important development affecting the renaissance of the steam engine in the automotive field.

The exhuast is condensed to atmospheric pressure in an ordinary type of automobile radiator. The type with wide surfaces and thin water spaces has proved most effective. In a passenger car complete condensation is secured in a small radiator often without the use of a fan. The efficiency of the radiator is reduced by excessive oil in the feed, but otherwise there are no disagreeable effects. Under these conditions fresh-water supply is needed only at rare intervals, which again is a feature that has served greatly to increase the demand for the steam engine.

COMPARISON OF ECONOMIES

It is characteristic of the internal-combustion engine that it gives its highest economy at its maximum load, with rapid reduction in economy as the load is decreased. The reverse is true of the steam unit. It results from this that under usual operating conditions the steam unit is operating at its maximum efficiency, whereas the gasoline unit is operating at only fair efficiency. These efficiencies tend to meet, and in the two cases in actual service the quantity of fuel per brake horse-power per hour should not be different, at least to any material extent.

The difference in cost between gasoline and power oil, when coupled with a reduced cost of lubricating oil, represents an appreciable reduction in fuel cost in favor of the steam unit and one of importance to the truck and

*A paper presented at the annual meeting of The American Society of Mechanical Engineers. Reported in the *Journal* of the Society of Automotive Engineers.

tractor operator. In the case of the automobile, where a small horse-power represents great mileage, this item is of lesser importance; but it lends romance to engineering to note that the joy of driving the smooth, flexible steam engine is likely to cause its extensive adoption, first in the field which commercially needs it least.

In our interest in newer conditions and later developments we should not overlook the splendid record of the builders who have long been prominent in this field. It is this pioneer work which has demonstrated the advantages and emphasized the deficiencies of the steam unit and has formed the basis on which the engineer of today is building.

From the earlier experience with steam power we have learned the necessity of treating the various elements of a steam-power plant as parts of a single unit. From the internal combustion engine we have learned the necessity for design on a production basis. From the oil industry we have learned what fuels are most readily available, considering both method of manufacture and distribution. And from the public we have clear-cut demands based on extended experience with both gasoline and steam in all classes of service. The designer of the steam unit, therefore, has before him unusually complete data relative to all phases of the problem.

On the part of the manufacturer and of the public there is evidence of tremendous interest. Numbers of new trucks, tractors and passenger cars are in service, or in process of manufacture or design. This effort and this demand will have a profound influence on the automotive industry. Whether it shall result in the supremacy of steam over gasoline is of minor import. The important fact is that it will surely result in a tremendous broadening of the usefulness and influence of automotive powers.

The Freedom of the Rhine*

WHILE the German Government is indulging in eulogies of what it calls "the freedom of the seas," and is at the same time sinking hospital and neutral ships, it is quietly doing its utmost to ignore Switzerland's rights to the freedom of the Rhine and Rhine navigation.

Now, this freedom of the Rhine and of navigation thereon may seem a mere local question, but in reality it is not so. It is a European question, and the danger is that owing to the multiplicity of great events now happening, and great problems now arising, this question of free Rhine navigation may be overlooked. Undoubtedly this is what Germany hopes and expects, and that is why she has selected the present moment for endeavouring to enforce claims to which she has no justification.

Germany, in short, desires to carry out a number of vast enterprises on the Rhine between Strassburg and Basle. These enterprises consist mainly in the utilization of water-power, which would necessitate the construction of several electrical works and the canalization of the river. The German Empire has already come to an understanding with the German provincial States bordering on the Rhine to execute the works. These German projects, however, if carried out, would place many obstacles in the way of the free navigation of the Rhine.

Now, Switzerland is very anxious to use the Rhine after the war, and to use it far more than before. By means of the Rhine she hopes, in conjunction with Holland, to secure an outlet to the sea. Germany says that Switzerland has no right to raise any objections to her constructing either her proposed electrical works or the sixteen or more dams and locks across the Rhine, which would be necessary to canalize it. Switzerland, however, claims that she has a right to object to Germany's carrying on her plans. First, because of Art. 5 of the Treaty of Paris (May 30th, 1814), stipulating that "navigation on the Rhine from the point where it becomes navigable unto the sea, and *vice versa*, shall be free, and in such a way that it cannot be forbidden to anyone." Secondly, because of the international rules drawn up in 1815 by the Congress of Vienna, regarding the Rhine and its tributaries. Art. 108 of that document states that "the Powers whose territories are separated or traversed by one and the same navigable river, undertake to settle by mutual arrangement everything connected with the navigation of that river." Furthermore, in 1868, by the Rhine Navigation Act, the Treaty of Paris and the Vienna Congress stipulations were confirmed, *not* abrogated, and the navigation of the Rhine further and more definitely regulated.

Germany is now trying to excuse her action by alleging that Switzerland did not sign the Treaties of Paris and Vienna, which is true. But the Swiss rejoin that these treaties were not made merely for the benefit of the Great Powers who drafted and signed them, but also for the benefit of the small Powers, and particularly Switzerland—which, indeed, is obvious from their wording. The independent Swiss newspapers, German-Swiss and French-Swiss, newspapers not under German control, have been writing very plainly about this last exhibition of the German mailed fist. For instance, the *Stadtan eiger* of St. Gallen says: "We shall see whether in this matter Germany will again dare to act with regard to the Treaty of Vienna and the Rhine Navigation Act, so as to treat them as mere scraps of paper, as she has already done with regard to other treaties of international law."

The Vienna Congress of 1815 forbids States bordering on an international river—that is, a river whose course is between or through the territories of more than one nation—to put any obstacle in the way of free navigation; and ordains that these States are to regulate river navigation on the lines of this Congress. This was done in 1868 by the Rhine Navigation Act; and although Switzerland has not adhered to this Act, she has unquestionably a right to do so. Holland, for instance, has done so. Art. 1 laid down the principle that no obstacle of any description whatsoever may be placed in the way of the free navigation of the Rhine. Art. 30 states that no mill, bridge, or other construction may impede traffic on the Rhine. By Art. 28, the States bordering on the Rhine undertook to maintain it in a fit state for navigation. Technical knowledge proves that regularization of the Rhine is the best method of doing this—regularization which is just what the Swiss are advocating and what the Germans do not desire. The free use of the Rhine is guaranteed by the Rhine Navigation Act of 1868, and guaranteed not only to States bordering on the Rhine, but to all the world. Before the war British, and other vessels used to navigate the Rhine.

Now let us see why Germany is so anxious to treat the Rhine Navigation Act, and other international documents connected with the Rhine, as scraps of paper. What she has to gain by so doing?

First, she desires to erect electrical works to utilize the falls caused by the artificial dams which she wishes to erect across the Rhine between Strassburg and Basle. These electrical works would, it is calculated, yield 5,000,000 kilowatt-hours of energy per annum.

It would take Germany about ten years to construct the works, and in the meantime navigation between Strassburg and Basle would be completely paralyzed. Moreover, she might do the work at different times, and thus indefinitely prolong it, and consequently indefinitely paralyze navigation on the Rhine. Switzerland, therefore, would be cut off for a long time, perhaps for ever, from that outlet to the sea, *via* Holland, for which she has long hoped. Again, when Germany has finished her works, she could, and certainly would, charge a toll for the passage of each dam or lock. Moreover, the journey up-stream from Strassburg to Basle would be made 42 hours longer than it now is owing to all these artificial obstructions across the river.

Finally, Germany desires to do just what experts, Swiss and other, consider undesirable, and that is to canalize the Rhine, whereas, regularizing it is what presents far greater advantages, at any rate from the point of view of everyone except Germany.

This Rhine question has been discussed in the Swiss Parliament on several occasions lately. On June 10th Federal Councillor Ador, of Geneva, referred to the urgency of the question of river navigation for Switzerland. "Our economic independence and the extension of our trade," he said, "are bound up with the problem of access to the sea—access from Geneva to Marseilles and access from Basle *via* Strassburg and Holland to the North Sea." Another French-Swiss deputy said: "We are living in a position of economic servitude as regards our neighbours. The only way to get out of it is to secure access to the sea."

All these German manœuvres aiming at isolating Switzerland and acquiring rights upon the Rhine to which Germany is not entitled, are part of her vast scheme for "Central Europe." As M. de Rabours, an eloquent Genevese deputy, pointed out the other day in the Swiss Parliament, a press campaign is being waged in Germany at present against Switzerland's rights on the Rhine, and an attempt being made to *diviser pour mieux régner*, to divide the German-Swiss and the French-Swiss, and thus get more hold over the country. The interests of all Swiss alike, however, are bound up with river navigation, he said, and a navigable Rhone was the best guarantee which could be given for a navigable Rhine—referring to the project for making the Rhone navigable and connecting it with the Rhine, a plan which, of course, does not interest Germany, or only in so far as she thinks she might kill it. "Germany," said M. de Rabours, "is now proposing to construct a system of canals from west to east, from the Rhine to the Danube. If a river system from north to south be not opposed to this German west-to-east line, what will be Switzerland's fate? To be a tributary of Germany. What would really be to Switzerland's interest," he urged, "would be a 'River League' from Rotterdam to Marseilles, Switzerland being a kind of river navigation clearing house or clearing docks of Europe."

So far almost the only navigation that has taken place since the war between Basle and Strassburg has been a service of tugs, resumed in 1917, carrying almost exclusively coal and coke to Switzerland, and conveying chemical products to Germany in return.

To show how keen an interest Germany takes in this question of Rhine navigation, I may say that at the last annual meeting, the fourteenth, of the Association (Swiss) for Navigation on the Upper Rhine, several Germans were present, who, however, had no authority to act or speak for their Government. Here again, it was insisted that the Rhine must be regularized, and not canalized with dams and locks constructed; otherwise Dutch shipowners would take no interest in Rhine navigation as far as Basle, and Switzerland would be hopelessly cut off from the sea. The Association called upon the Swiss Government to protest, basing its protest on the Congress of Vienna and the Rhine Navigation Act of 1868, against the construction of the electrical works which Germany is planning on her side of the Rhine, and thus defend Switzerland's rights on the law of nations, and also her legitimate interests.

The *Journal de Genève*, referring to this Rhine navigation question says: "Our national programme may be summarized as follows: a free Rhine, a navigable Rhone, and junction of the Rhone and the Rhine. Here is already something worthy to occupy a whole generation."

None but those living in a country on the borders of Germany, in an atmosphere thick with German intrigue, can perhaps fully realize the importance of this German manœuvering about the Rhine. It might be thought that she would have abundant occupation now for all her energies, without troubling about constructing a series of electrical works along the Rhine to supply her with a vast quantity of power. This, however, is obviously not the case. Her leading organs find plenty of time and plenty of space for articles intended to prove that Germany is entitled to that to which she is not entitled. In other words, that Might is Right. In Berne, since the war, the Germans have rented several large hotels which they have converted into commercial offices, full of experts in all branches of trade and industry. They are flooding the country with their prospectuses, with commercial travellers and agents of all kinds, in order to impress their views upon the people. Weekly, fortnightly, and monthly papers, dealing with all manner of questions of trade and manufacture, showing the advantages of adherence to Central Europe, and expounding Germany's trade preparations for "after the war" in Turkey and the Near East generally, are sent free to all who desire them, and to many who do not. The moment an independent Swiss raises his voice against this German penetration, Germany sets her press agents in Switzerland to work to contradict him. She has no less than three well-known press agencies now operating in the country. Nevertheless, and in spite of it all, the Swiss public fully realizes the danger of Germany's Rhine plans, and none, save hopelessly pro-German organs, have a word to say in support of them.

*From *The Engineer*.

The Schoop Metal-Spray Process

BY increasing the "atomizing pressure" in the "pistol" of the Schoop apparatus, metal deposits of very fine grain and high density and strength have recently been obtained according to a note by K. Matzinger, of Hönggh-Zurich in the *Anzeiger für Elektroteknik und Maschinenbau*, April 28th, 1918, the *Anzeiger* is a supplement to the Vienna journal of the latter name. The pistol is a blow pipe in which the metallic bead, fused by the flame, is torn away and atomized by the current of compressed air. The ordinary working pressure of the air is 3.5 atmospheres, but the pistol operates on the injector principle, and the actual atomizing pressure was so far only 1.5 atmospheres. This atomizing pressure has recently been raised to 2.5 and 3 atmospheres without increasing the working pressure, with very promising results. A lead pipe 1 mm. wall thickness made by the improved process was filled with hydrogen at 5 atmospheric pressure while lying in water; no hydrogen escaped, while hydrogen bubbles forced their way through a lead pipe made by the old process. In another experiment plates of sheet-iron were covered with lead, one or two coatings at pressures of 1.5 or of 2.5 atmospheres. The one or two coatings of the old process did not prevent subsequent rusting of iron, but both the one coating and the two coatings of lead deposited at the higher pressure kept the plates free of rust when they were placed in water.—*Engineering*.