Vol. IV. June, 1935, No. 40,

# Steam Car Developments and Steam Aviation

*The FIRST Publication on Steam Aviation and The Modern Steam Car*

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Published by R. H. & H. W. Bolsover, 27 Castle Road, Whitby, Yorks.

Published Monthly Ninepence.

Printed by L. Warner, Middlefield Lane, Hinckley. Leics.

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Steam Car Developments and Steam Aviation. Vol.IV JUNE, 1935 No. 40

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# Supplement to "Engine Design Notes," of 1930.

By Abner Doble.

Since 1930 when these notes were written, much work has been done towards the perfection of steam power plants for road and rail vehicles, and it may be interesting to set forth in what way the original notes now may require modification.

The two-cylinder engine with piston-valves actuated by Stephenson Link valve gear, and constructed in the manner set forth in the notes, has been adopted by two important manufacturers. The Sentinel Waggon Works at Shrewsbury utilise such engines designed by the writer for rail-cars and locomotives of which numbers have been delivered to railways at home and abroad. These engines have been installed not only with Doble boilers, but also the water-tube boilers of conventional design. When used with Doble boiler, these engines use steam at 1200 pounds pressure and 800 degrees F. at full load, and the condenser maintains a vacuum of from 24 to 26 inches.

Henschel & Sohn, locomotive builders of Kassel, Germany, manufacture rail-cars, locomotives, heavy lorries and buses under Doble license, as well as the conventional types. In the vehicles produced in accordance with Doble designs the engine is the two cylinder compound type described in the notes, using steam supplied by Doble type boilers. Numbers of Henschel rail-cars fitted with Doble power-plants have been delivered to the German State Railways and to some private companies. Henschel also uses the two-cylinder compound engine for heavy lorries and buses.

The record to date of actual sales of modern steam vehicle thus seems to show that the engine put forth in the 1930 notes has proved suitable for present service; however, the continued search after improvement, particularly along the lines of improved economy and decreased bulk, has now resulted in the immediate possibility of considerably improved efficiency. As briefly touched on in the notes, improved steam-economy could be obtained only by an increase of the expansion ratio of the engine.

Development of the design of a small steam power-plant carried on under the supervision of the writer-since "Engine Design Notes" appeared. With the aim of perfecting a power-plant of universal application for road vehicles, has resulted in modifying some of the conclusions then arrived at, and the triple-expansion engine now promises a valuable improvement in economy. With the engine, boiler, auxiliaries and condenser, constructed as a unit; similar in principle to the I.C. engine, radiator clutch and gear-box; and interchangeable therewith, it has been possible to provide efficient and simple inter-stage re-superheaters and thus usefully employ the large expansion-ration allowed by the triple-expansion engine.

By using 4 cylinders in a 90 degree V, with the HP and MP cylinders actuating one crank, and the two LP cylinders operating on the other crank, and by setting the two cranks at 135 degrees, a very steady timing moment is secured, which eliminates difficulties with torsional vibrations. Proper counterweighting eliminates vibration from out-of-balance. For unusual pulling, the interceptor-valve changes the engine to compound operation, the MP cylinder then taking steam from the boiler at reduced pressure and the HP cylinder exhausting to the LP cylinders.

With the high-pressure, high-temperature steam safely produced by the Doble boiler, such an engine can be of small size. The cylinder sized for a power-unit suitable for the heaviest bus or lorry are: 2 1/2 inches HP, 4 inches MP, and two 4 1/2 inches LP cylinders with 4 inch stroke. Such a power-unit is sufficiently compact that it could be installed under the bonnet of a large motor car, and is capable of producing 150 h.p.

It seems to me that our news on the detailed discussion "Engine Design Notes" might be as follow:

- Number of cylinders: Two cylinder compound, proved suitable in service, particularly in the field of heavy rail and road vehicles. Four-cylinder triple, now an actuality and proved to give a much needed increase in economy. It is likely that it will prove satisfactory in service. It is unlikely that an increase of cylinders above four would serve any useful purpose.
- Single-Acting v. Double-Acting: This question seems conclusively answered by now, for all new steam engine designs for actual production within my knowledge are all double-acting. Valve-Type: All of the new engine designs employ piston valves for the reasons advanced in the notes.
- Valve-Gear: The Stephenson-Link has been fitted to all of the engines built by Sentinel and Henschel for heir output of Doble power plants. The four-cylinder V triple employs a shifting-eccentric, which gives the same results as the Stephenson-Link, and in the V-engine is somewhat more simple, due to the fact that one valve-gear actuates the valves for the two cylinders which operate on the same crank.The possible future improvements seem to lie in the other units of the power-plant, such as the provision for heating the combustion-air by the heat of the flue-gases; except for the possible further increase of useful expansion offered by a proper design for a rugged and simple low-pressure turbine to take steam from the exhaust of the low-pressure cylinder. However, the present economy of the steam-power-plant is good enough so that it can compete on more than equal terms with the petrol-engine in road vehicle work, and that the efficiency of the diesel-engine is considerably better than the best possible for the steam-engine. The many other factors, such as first-

cost, upkeep, flexibility, etc., which must be taken into consideration, leave the situation at present favourable to the use of the modern steam-power-plant.

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## Boiler Design Notes

By Sidney W. Taylor.(Continued.)

Correction, page 223 Vol. III lines 13 and 14 from the bottom of the page, 25,000 degrees F. should read 2,500 degrees F. and 12,000 degrees F. should read 1,200 degrees F.

### HEAT TRANSFER FORMULA.

Any formula derived for the purpose of calculating the radiant heat transfer in a boiler must, in the light of what has gone before, take cognizance of the fact that the total heat absorbed by the fluid is the sum of the heat received by radiation and that remove by convection from the gases as they are cooled from the temperature of the furnace to the temperature at which they are discharged to the stack. Such a formula, however, can at best be only approximately correct, for, as we have seen, the principles underlying all of the phenomena of heat transfer are not definitely known. It is quite impossible by means of thermometer readings of thermo-couple indications to determine the mean temperature of gases when such gases are surrounded by cooling surfaces unless true average samples thereof are quickly removed from the cooling influence of the surface and thoroughly mixed. This procedure is not practicable in the testing except at the flue.

The temperature within the furnace, however, may be computed with fair accuracy. Since these two temperature limits alone are obtainable in practice, our heat transfer rate calculation must of necessity relate to the boiler as a whole and not to its separate parts.

The engineers of The Babcock & Wilcox Co. have developed the formula for calculating the average transfer rate in a boiler which we give below:

$R = (WC)/S \log_e(T1 - t)/(T2 - t)$

In which R equals the average rate of transfer

W equals the weight of gas in pounds per hour

C equals the mean specific heat of the gas

S equals the total heating surface in square feet

T1 equals the temperature in the furnace

T2 equals the temperature of the gas leaving the boiler

t equals the temperature of the tube surface

When t, the temperature of the tube surface, is not sensibly constant throughout the boiler--and it varies considerably, as we have seen, in the Doble boiler--the temperature function becomes rather more complex, since account must be taken of this variation in the equation.

When R is plotted against W for a series of tests over quite a wide range of driving rates, it is found that the points fall almost exactly in line and the line prolonged cuts the R-axis at a point above the origin. This straight line law seems to hold when checked against many tests with different boilers. The inclination of the line, however, varies inversely with the average area of the gas passage through the boiler, and directly with the temperature difference; and this is what you would expect from the known effect on efficiency of a variation of the temperature difference and the ratio of length of gas path to the hydraulic mean depth of the gas passage.

The straight line law led to the development of an equation of the following form to express the relation between the average heat transfer rate in a boiler and the rate of gas flow for a constant temperature difference.

R equals a plus b/(W/A) (1) Considering R and W/A as the variables, this is the equation of a straight line cutting the R-axis at a (whose slope referred to the W/A axis is ten) lb. The notation is the same as the foregoing; a and b are constants and A is the average area for all of the passes of the boiler. Since the radio W/A is equivalent to the product obtained by multiplying the density of the gas by its velocity, the heat transfer rate varies directly as these two factors, and this is in agreement with experimental determinations. The accuracy of an equation of this term is further verified by the results of experiments conducted by The Babcock & Wilcox Co., and published under the title, "Experiments on the Rate of Heat Transfer from a Hot Gas to a Cooler Metallic Surface." Equation (2) is to be considered, however, as holding to a very close approximation only, over the range of driving rates of the tests. The true curve in, reality is not continuously straight but bends gradually downward at each end, the straight line represented by the equation being tangent to these two end curves. The actual curve, also will be discontinuous toward the origin since the motion of the gas as its velocity decreases will change from that due to turbulent flow to that due to viscous flow when its critical velocity is approached. We shall see later on now the Doble boiler characteristic heat transfer curve conforms to the straight line law.

## BOILER PERFORMANCE SHOWINGS.

The Doble automobile boiler in the course of its development has been subjected to many tests for the purpose of determining its performance under the various conditions of loading. Data relating to some of these tests are presented herein in tabular and graph form. (See Appendix)

The Doble boiler performance curve of Plate 1, showing boiler efficiency in percent plotted against equivalent evaporation in pounds per hour per average square foot of total heating surface represents the mean of four tests, one of the tests being Test No. 186 (Table A). The others are not included in the tabulations presented, although results developed from other tests (Table B & Table C) as well as those developed from Test No.186 have been spotted on the graph for reference. Run No. 16 of Test

No. 186 records conditions of highest driving rate of any of the tests, viz. 27.19 lbs per sq.ft. per hour equivalent evaporation, at which rating the efficiency is 77 percent. This showing is all the more remarkable when it is remembered that the devisor employed to reduce evaporation to a sq. foot basis is not merely the number of sq. ft. of evaporative surface, as it is in the case of the other curves spread on the sheet for purposes of comparison, but total heating surface including superheat. The Doble performance line is prolonged to 34 lbs equivalent evaporation at which point, if the line as drawn is truly representative, the efficiency would be 73 per cent.

If we prolong the Kent theoretical curve for oil (Plate 1) an evaporation rate of about 23 lbs. at an efficiency of about 64 per cent is indicated, and rates of this magnitude have keen realized in locomotive and destroyer practice with forced draft. The curve might be still further produced to say, 30 lbs, at which point the indicated efficiency is 57 per cent, and this rate too, is quite possible of accomplishment with forced draft since it is well known that the maximum evaporation of a boiler is limited only by the ability of its furnace to burn fuel. It will be seen, however, from the evidence of the curves that, due to the inherent limitations of boilers of the conventional model, the efficiency falls off rapidly the driving rate increases. It is very doubtful, in fact, whether a boiler of this class could be forced to the point of evaporating 30 lbs per hour per average sq. foot of surface at an efficiency as high as 57 per cent.

The highest evaporative rate proposed in central station practice under ordinary operating conditions will probably be that to be developed by the two new Babcock & Wilcox units installed at the Edgar Station of Edison Electric Illumination Company of Boston ("Power," August 14th, 1928, p. 273.) These units are equipped with air heaters, economizers and re-heaters; their furnaces are water cooled and the usual upper bank of 2 in. tubes has been entirely removed leaving only the lower bank of 3 1/4 in. tubes which represents only 6,971 sq. ft. of surface per unit. Steam is delivered at 1400-lb pressure and 750 degrees. The rating is 250,000 lbs of steam per hour, which, if the temperature of the feed approximately close to 400 degrees, as it probably does, works out at the same amount, or 250,000 lbs per hour equivalent evaporation. Estimating the superheater surface and water walls respectively at 3,860 sq. ft. and 910 sq. ft. and apportioning to each zone of the boiler its pro rata of the total heat absorbed, we find that the average evaporation rate for the surface represented by the water walls and boiler proper combined, is 28.4 lbs; the rate for the superheater being 6.8 lbs. The rate for the total heating surface would be 21.3 lbs per sq. ft. A projected boiler of the same general design with a rating of 300.000 lbs per hour will develop an evaporation rate of 19.3 lbs of water per hour per average sq. ft. of total surface. These two examples of boiler design exhibit the modern tendency toward increasing the amount of surface exposed to radiant heat and the curtailment of surface toward the end of the process, the terminal being cooled in an air heater before finally passing to the stack.

## RATES OF HEAT TRANSFER.

Plate II shows the results of Test No. 186 (Table A; items 11 & 13) plotted in conformity with the method suggested by equation (2); that is to say. heat absorption in BTU per average sq. ft. of total boiler surface per hour is plotted against pounds of gas per hour per average sq. ft. of gas passage area. The tendency of the plotted points to fall into a straight line cutting the heat absorption axis just above the origin is well illustrated: so that the results of the several runs exhibit marked consistency with the experimental showings of boilers of other types. It is interesting to note in this connection that the Babcock & Wilcox experiments in heat transfer" indicated a gas flow rate of 2,800 lbs per sq. ft. for the lowest transfer rate of the test, viz., 10,450 BTU per sq. ft. and 9,800 lbs for the highest viz., 26,420 BTU per sq. ft. when the temperature difference between the entering and terminal gas (in the B & W experiments) was 2,000 degrees. In the Babcock & Wilcox experiments, as we have seen, the hot gas was caused to pass through a tube 2 in. in diameter and 20 ft long surrounded by water jackets. The corresponding gas flow rates in Test No. 186 were 1,310 and 3,780 lbs per sq.ft., and this shows that the efficiency of heat transfer is much higher through an arrangement of surface such as we find in the Doble boiler than it can possibly be in a long straight tube, because the Doble arrangement promotes a high degree of turbulence.

In the Babcock & Wilcox experiments, the hot gas was first made to flow through a 2 in. unobstructed tube. After a series of such experiments the channel was then altered, without disturbing the set-up of the apparatus, by the insertion of a 1 in. diam. steel core, the core being held central by small pins. The core was not cooled in any way and hence it could absorb heat from the gas and radiate the same back to the gas and to the water-cooled wall of the 2 in. tube. The effect of its presence, however, was to decrease the gas passage area and hence its hydraulic mean depth, and thereby increase the number of impacts of hot gas molecules against the absorbing surface. This arrangement, as would be expected, increased the rate of heat transfer such that the gas flow rates for an overall temperature of 2,000 degrees were about 1,500 and 7,000 lbs respectively for transfer rates of 10,450 and 26,240 BTU per average sq. ft. per hour. The same effect has been observed in cored superheater tubes.

Before leaving this matter we include hereunder, as indicating quantitatively the amount of heat which can be absorbed per hour from hot gas by cooling surface under certain fixed conditions, some of the results obtained during the Babcock & Wilcox experiments. The upper and lower limits of the several ranges of the experiments only, are given and the figures are in BTU per hour per average sq. ft. of total absorbing surface for specified temperature differences and corresponding rates of gas flow in lbs per hour per sq. ft. of average gas passage area.

Unobstructed Bore With 1 inch Core

Lbs. Gas/hr. 4,100 14,400 8,300 16,500

2,000 deg. diff. 13,600 36,800 29,600 52,800

400 deg. diff. 2,080 5,240 4,160 7,120

These tests show that it is possible to absorb heat at the very high rate of 52,800 Btu. per sq. ft. per hour by passing hot gas through a tube 2 in. in diameter and 20 ft long (about the dimensions of a locomotive boiler tube if the tube is provided with a 1 in. core when hot gas is supplied at the rate of 16,500 lbs. per hour entering and leaving the tube at temperatures such that the overall temperature drop is 2,000 deg. The same tube without the core will absorb heat at the rate of 36,800 BTU per hour per sq. ft. when hot gas is passed through it at the rate of 14,400 lbs per hour and the gas temperature drop is 2,000 deg. In both instances the gas is cooled by radiation and convection. (To be concluded.)

* Experiments on the rate of heat transfer from a hot gas to a cooler metallic surface, previously alluded to herein.

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## A scheme for a Coal-fired Automobile Boiler.

From a London Correspondent.

The effect of penal taxation on hydrocarbon fuels is to raise the cost of running a steam car to a figure well above that of an internal combustion engine car. A Ford V8 does about 13 to 16 m.p.g. A steamer of the same power would do 8 to 10 m.p.g. The cost of fuel for either system is now rendered the same within one penny or twopence. This reverse will deprive the steam car of its best talking point. We are forced to investigate solid fuel in the hope that it may not be such a nuisance as we first think. A solid fuel generator should be arranged to utilize radiant heat primarily and to subtract hat from the hot gasses as a secondary object. Forced draught is necessary in order to make the performance elastic. The fit of all under-fire casing joints must be so tight that the fire can be deprived of all air. A combustion rate of 40 lbs per sq.ft. of grate is quite practicable, and 2 lbs of coal per h.p. hour. A 15 inch square grate should give up to 30 h.p. burning 60 lbs per hour and using 1 1/2 lbs coal per mile.

Suppose the fire to be started and steam initially raised by intense oil burner or spray, with forced draught from batteries. A piece of oily waste would he thrown onto the coal bed through a tight fire door and lighted. The draught would be switched on and the door shut, and immediately the oil spray would be turned on. This would use up the air supply until the fuel began to function, when smoke would appear from the exhaust pipe. This would be an indication to begin cutting down the oil supply. With a tube, generator steam would be available in a few minutes and would provide steam for the draught engine, and water pump. The draught engine would blow until the steam pressure rose to 500 Ibs and would then idle round at a very low speed. This engine would actuate the riddling grate mechanism which incidentally would be arranged so as to maintain a constant depth of fuel all over the grate, admitting fuel from the hopper only when the general level in the grate necessitated it. Once steam is up therefore steam kept up until the hopper is empty. The main water pump can be combined with the draught engine, but a separate pump has points. The draught engine may run at 1000 revolutions while the water pump must run at 120 strokes. The water pump would be thermostat controlled. 45 sq. ft. would give 30 h.p. with a compound, and would mean only about ~11 tax if all the surfaces were classed as horizontal.All this sounds fine. The generator and bunker to run at least 100 miles could easily be contained in a 3-foot bonnet.What about clinker? With briquette fuel you will not get clinker, but the firebars being in constant motion and of non scaling flat steel they should free themselves. Draught would be admitted through the firebars and also down onto the fire on one side to give a proper circulation of gas above the fire. The proportion admitted to these two exits would be made variable by a distributing throttle in order to vary the effect of the draught. If smoke occurs you must reduce the under draught and increase the upper air.

The generator would supply steam to the main throttle and auxiliary engines through a reducing valve, reducing to 500 lbs but permitting the main generator to rise to 2,000 lbs before the Serpollet water release valve operated, The steam water pump would slow automatically, being supplied with steam at 500 lbs and working against much higher pressure.

The refinements possible with this system are concerned with the conservation of heat. The draught air should be drawn from the casing of the generator, and the upper air should be still further heated as hot as passable before being blown across the fire. The engine cylinders should be cowled and heated by the flue gas.

In operation we may imagine that steam is maintained day in and day out. All night the fire would consume about 15 lbs of fuel to maintain itself. If the water pump failed the draught would die away and the fire would go out. It would cost 2/- a week to keep the fire going. It would not be too awful to get up steam by a hand blower or one of the artful "Allball" mechanisms of Messrs. Heyden of Redruth. Charcoal fuel would be ideal, and would permit the lone settler to make fuel himself.

Bunkering would be performed through an 8 inch cover in the bunker occupying the space for 12 inches in front of the dash board, and sacks of rubber proofed canvas would contain the fuel. The 28 lbs sack would be hoisted into position over the opening in the bunker--the "zipp" fastener of the sack would be drawn, and the small fuel would run into the hopper. Eight sacks would mean a day's run.

The great virtue of the Doble system becomes apparent in such a plant as this, where the steam temperature is maintained by the pump irrespective of variations in the state of fire or of ultra high pressure in the main generator. The discharge of ash is simple too. The under air would blow it through a small opening in the bottom of the tray if it was momentarily opened.

## The last Hill-climbing Contest in which Steam Cars were permitted to compete with Petrol Cars.

RAGPATH SIDE, NEAR LANCHESTER, DURHAM. June 15, 1907.

This was one of the annual hill-climbing contests promoted by The North Eastern Automobile Association, and it was run under The Royal Automobile Club's rules. The Ragpath Side would not, nowadays, be considered a very formidable hill, but in 1907--28 years ago--it was thought to be a severe test for the cars of that period.

The actual hill is just over half a mile long, and it rises 240 feet in that distance. The gradients are 1 in 220 for 608 feet, 1 in 25 for 182 feet, 1 in 10.6 for 328 feet, 1 in 13 for 288 feet, 1 in 9 for 316 feet, 1 in 8 for 212 feet, 1 in 6 for 238 feet, l in 5 for 146 feet, 1 in 7 for 142 feet, 1 in 9 for 146 feet, finishing at in 20 for 84 feet. It will be noticed, therefore, that the hill is fairly severe.

The competition attracted many famous cars and drivers of that day, including Mr. S. F. Edge, who brought two cars--a 60 h.p. Napier, and a 40 h.p. of the same make. There also ran 40 h.p. and 36 h.p. Daimlers, 40 h.p. Berliet, 32 h.p. Mercedes, 22 h.p. Isotta-Fraschini; and the entries included in addition, Siddleys, Darracqs, Argyll, Arrol-Johnston, Weigel, and Humbers (3).

The three steam, cars entered were all Stanleys, viz.: (1) Mr. W. E. Galloway's 20 h.p. Model H, 2 seater--which weighed unladen 12 1/2 cwts. The size of the engine (2 cylinder double-acting) was 3-5/8 inches bore by 5 inches stroke. The boiler was a 23 inches diameter by 13 inches high Stanley fire-tube, with copper tubes. (2) Mr. B. M. Dodd's 20 h.p. Model F, 5 seater touring car, which had a similar power plant to Mr. Galloway's car, and (a) Mrs. S. E. Galloway's 10 h.p Model EX, 2 seater, with a 3 inches bore by 4 inches stroke engine, and an 18 inches diameter boiler.

We give below the Official Times of the Competitors :

FIRST, Winner of the Association Cup for Fastest time of the day.

Mr. W. E. Galloway's 20 h.p. Stanley 75-3/5 secs.

(2) Mr. S. F. Edge's 60 h.p. Napier 77-4/5 secs.

(3) Mr. G. S. Barwick's 35 h.p. Daimler 85-2/5 secs.

(4) Mr. E. W. Leather's 40 h.p. Berliet 93-2/5 secs.

(5) Mr. B. M. Dodd's 20 h.p. Stanley 94-1/5 secs.

(6) Mrs. H. E. Galloway's 10 h.p. Stanley 95-3/5 secs.

(7) Mr. S. F. Edge's 40 h.p. Napier 96-3/5 secs.

(8) Mr. G. S. Barwick's 30-40 h.p. Daimler 97-2/5 secs.

(9) Mr. Rowland Hedge's 28-36 h.p. Daimler 99-2/5 secs.

(10) Mr. A. Fraser's 28-36 h.p. Daimler 116-2/5 secs.

(11) Messrs. Arrol-Johnston Co's 16-25 h.p. Arrol-Johnston 119-2/5 secs.

(12) Mr. D. A. Haggle's 40 h.p. Weigel 122-2/5 secs.

(13) Mr. F. Little's 30 h.p. Belsize 125-4/5 secs.

(14) Mr. F. Turvey's 30 h.p. Humber 126 secs.

(15) Mr. S. Davies 16-22 h.p. Isotta-Fraschini 141-3/5 secs.

(16) Mr. T. S. Short's 28-32 h.p. Mercedes 145-3/5 secs.

(17) Messrs. George & Jobling's 18 h.p. Siddeley 145-4/5 secs.

(18) Mr. S. S. Dixon's 18 h.p. Darracq 149-4/5 secs.

(19) Messrs. Humber's 30 h.p. Humber 153-4/5 secs.

(20) Mr. T. C. Wilson's 30 h.p. Siddeley 161-3/5 secs.

The comparison of the times of the various cars for the climb is interesting, and shows that even the small 10 h.p. Model EX Stanley driven by Mrs. Galloway beat a Napier of four times its horsepower, to say nothing of Daimlers, Mercedes, etc.

Mr. Galloway's 20 h.p. Stanley carried two passengers during the ascent and was, in addition, weighted with 20 stone in sandbags, and his time of 753/5 seconds would be creditable even for an ultra-modern I.C. car.

The wonderful performance of the steamers in this competition was too much for the Internal Combustion Magnates to endure. They put their heads together, and, by fair means or foul, took care that steam cars for the future were absolutely debarred from open competition with their petrol-driven rivals.

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## Where Leon Serpollet left off.

Our Air Ministry is naturally watching very closely the developments and flights that are taking place in Germany and the U.S.A. with steam planes. It is quite as difficult to get correct information as to the number of steam planes Germany has actually got in action, or in building, as it is to find out how many petrol-driven machines she possesses, but certain facts present themselves clearly.

Germany has been alive to the possibilities of steam for aviation for a considerable time. She not only sees the potentiality of steam from a point of view of general utility, silence and so on, but the state of her exchequer is such that she has of necessity to turn her thoughts to aircraft that show the lowest possible manufacturing cost, and are afterwards, the cheapest machines to maintain and run. She sees in the steam driven plane a machine that is capable of standing up to long and continuous flying with the minimum amount of wear and stress; and one, which owing to its simplicity and its absence of small delicate moving parts is easier and cheaply made. This, and other facts such as economy--particularly in expensive lubricating oil and petrol--makes the proposition still more attractive.

But what concerns us more than anything is that she may be quickly developing a large fleet of silent planes, capable of a long range of action, and very difficult to detect and locate in flight. We might thus be entirely taken by surprise, and find ourselves without any steam driven aircraft to combat them or to undertake reprisals. We are behindhand in our experiments with steam driven aircraft. Germany is undoubtedly in advance of us in this respect.

May we here put forward me or two important suggestions to our Air Ministry, in the hope of establishing a stop gap until further time and money can be spared for a more elaborate development? It is evident that what is mat required at the present time is a steam plane that can be quickly and easily made from which not only useful service could he expected, but also very valuable data with a minimum of expenditure and experiment.

To accomplish such an end we suggest the building of a steam aircraft plant on Serpollet's system--starting just where he left off. Most of us are aware of how much the genius of Serpollet did for development of the flash steam generator, and, although it is 36 years since he died, it is doubtful if any system since developed can improve on it for efficiency and straightforwardness of design. Certainly no steam system attains its end with such simplicity and directness. Serpollet did not believe in complicated and expensive automatic devices subject to derangement and dependent upon electricity for their functioning.

All he found necessary was a flash steam generator, a suitable engine and burner, and an auxiliary steam pump which delivered water to the generator and fuel to the burner in such proportions that no more water could he delivered to the generator than there was oil pumped to the burner sufficient to produce the required quantity of superheated steam at any time. What could be simpler or more direct than that? I can see no better method of achieving immediate success.

We have all Serpollet's data for his proportional pumps, data also is available of his steam generator and burner. All that remains therefore to obtain a perfectly dependable and highly efficient power plant for a steam plane is to enlarge upon Serpollet's lines to give us the desired power for our purpose. You have then without further ado an ideal power unit, ready for any amount of hard work. You know how much water is required to be evaporated to give 5 h.p. or 500. You know how much fuel must be pumped to the burner to give the required power. You know how much heating surface is necessary, and how to build the boiler, burner, and pumps. It is also known, to a few degrees, the temperature of steam a certain proportion of oil and water will deliver to the engine. Why experiment? Start, with certainty, where Serpollet left off, the results will prove equally certain, as they did in Serpollet's day.There is one feature about the Serpollet system, which would be valuable in an aircraft plant and one so important that it was largely for this reason that the writer singled out Serpollet's system above all others, as being the most suitable for a steam plane. Serpollet, with his usual thoroughness, designed a burner which was light and strong, one that, by the undoing of a single union could be withdrawn entirely from the boiler for cleaning or instant replacement--a point of much practical value.

It is not, however, in this desirable feature alone where the true value of a quickly detachable burner concerns the issue we have in mind. For a steam plane to be of true military value, it is essential, one might even say vital. that, in an emergency, it can be capable of being switched over from liquid to solid fuel. The Serpollet system lends itself admirably to such a change over. With certain modifications, and with the simple addition of a suitable light high speed auxiliary engine and blower, the Serpollet firebox is directly suitable for the change from liquid to solid fuel. The opening of a small steam valve would put the whole system into action, including the automatic coke feed stoker, which would draw its fuel from a hopper. Natural draught could be used once the initial start up had been made, and the blower engine would only be run as a booster, when forced speeds were called for.

It does not require a great amount of imagination to foresee planes in the near future being entirely driven on solid fuel. The advantages to be thus gained in economy and dependability are much too apparent to be lightly disregarded. It is only a matter of time--a shorter time than many people suppose--before steam will hold its own for aircraft purposes, and the use of solid fuel will be widely adopted.

It may well be that the first steam planes will be slightly less speedy when using solid fuel, though with research and experiment that will soon be remedied: but extreme dependability, high economy silence, and safety they would possess. At the present stage of development, it is as second line defense machines that they would show up to the best advantage; the services they would render would be similar to those rendered in the last war to the Navy by trawlers, drifters, and other craft. These latter are good examples of what a fleet of steam planes might mean to our Air Force-rugged, dogged, sturdy little fellows. ready for anything, anywhere, at any time.

## A Steam Engine which does not need a separate Boiler.

The object of this design. [Provisional Patent No. 28258 by Mr. H. S. White. 205 Fallodon Way, Hampstead Garden Suburb, London, N.W.11,) is to eliminate any separate- boiler or vaporizer, and to reduce heat losses to a minimum; render the power unit portable and self-contained, and therefore suitable for aircraft and locomotive purposes generally.In the case of a single-acting; reciprocating engine having stationary cylinders, we have four steam generating chambers communicating directly with their appropriate cylinders. The generating chambers are made up by pressing specially formed tubes into the cast cylinder heads, the eccentric shaped portions of the outside being the steam generating side, while the inside of the tube forms the fire chamber.

The generating chambers are made in this way, by being flared in one dimension and reduced a corresponding amount in the other, maintaining the same area throughout, in order to dry the steam in its contact with the heated surfaces before entering the cylinders. When the four separate heads are bolted on to the cylinder block the inside of the tubes makes one leg cylinder. The fire chamber is heated by means of a burner situated within, and at one end, and using oil, gas fuel or the like. The water is pressure-fed by means of a pump, or compressed air, to the rotary valve running at engine speed.The valve is bored to provide a central port passage to receive the water. This valve is suitably pierced with ports on its periphery at intervals along its length, each of which opening communicates directly with the appropriate jet in the cylinder head. Each rotating terminal port is cut preferably at an angle with respect to the axis of the valve, so that the admission valve water to the jet leading into the generating chamber is both graduated and under control. Such control is obtained by sliding the valve laterally, its oblique ports opening across the ports leading to the jets. The exhaust steam is exuded at the end of the stroke by the opening of a port in the cylinder liner. The steam then travels round the outside of the liners, and is drawn away on the opposite side of the cylinder block by means of a vacuum pump, condensed and returned to the supply tank. The outside of the cylinder heads are entirely enclosed by a metal cover, suitably lined, to assist in retaining all the heat possible, and to cause the heated gases to circulate round the fins on the way out.

By turning the valve housing liners a little in an anti-clockwise direction, the engine reverses. The action is that of an I.C. Engine when the ignition lever is over advanced.

Fuller particulars and illustrations can be obtained by anyone interested from the inventor. We understand that Mr. White is at present working on a new design of a double expansion, multi-cylinder engine incorporating this invention. Mr. White states that the fact that the steam is in contact with the heating surfaces of the vaporizer until it leaves the cylinder at the end of the stroke, makes it possible to employ double--or even triple expansion, with minimum amount of fuel.

## Some more Steam Owners.

*Brause, J. H.; 6016 Normal Ave., Chicago, Ill., U.S.A.--740 Stanley tourer.

*Dalling, E. H.; 3 Hemenway, Boston, Mass.--740 tourer American boiler.

Grunder, Lawrence; Richfield Oil Co., 6th & Flower, Hollywood, California.--Special.

*Hawyer, Francis; McGraw, New York.--740 Stanley.

Hughes, Howard; Hollywood, California.--Own design.

Lewis, Howard; Smoot-Holman Co., Inglewood, Cal.--Own design.

*McCord, R. G.; 9403 Ashly Ave., Berkeley, Cal.-740 Stanley

*Mudd, Dr.; California Inst. Technology, Pasadena, California. --1927 Doble.

Robert, Prof. James M.; Tulane University, New Orleans, La. --Stanley.

*Shaw; Lockport, New York. --Brooks Sedan.

*Weeks; Hyde Park, RD.1, Cooperstown, N.Y. --Stanley.

*-Indicates the car is in operation at present time, so far as is known.

## Correspondence

The Editor is not responsible for opinions expressed by Correspondents.

I have just finished reading the April issue of "S.C.D. &. S.A." and find it very interesting, and it contains much material that is helpful to anyone interested in steampowered units. I think magazine very useful in stimulating interest in steam, and look forward to receiving copies in the future. I am an engineer with Steam Motors Incorporated.

JAY RICKS

Cambridge, Mass., U.S.A.

I have much enjoyed the April No. 38 copy of "S.C.D. & S.A." and think the notes by Mr. Abner Doble are some of the most interesting I have read for a long time. From my point of view, as a Locomotive and Marine Engineer, he emphasizes so clearly different requirements of motor car engines running at 2,000 revs. per minute, and the larger and slower running loco. and marine engines at revs. per minute. from 76 to 300. I look forward with the utmost eagerness to the May copy of " S.C.D. @ S.A." and to Mr. Doble's further

remarks.

L. W. SHARPE

Exeter.

I am still enthusiastic and await the monthly appearance of "S.C.D. & S.A." I only wish you would make it weekly. The glimpses we are given of future possibilities in advanced designs and application of steam are most intriguing and keep one on tiptoe of expectation. While this feature is full of interest, cannot you bring out some articles on re-building old Stanleys and Whites? These are some of the things I would like to see.

I repeat again what I have told you before, that any criticism from me is intended to be helpful, and not destructive, as I quite well the difficulties you have to cope with.

D. A. DAVIES

Newport, Pembroke

Dr. Tressler's Stanley car.

as rebuilt by The American Steam Automobile Co.

Since writing to you I have had my steam car in running condition and have driven it some six hundred miles, It performs better than ever, now that the new spark plugs have been installed. I got steam up for the first time April 5th and the car has been in constant use ever since. Two weeks ago we took a trip down in the hills to Attica and back, a distance of about 85 miles. On the trip we made 8.2 miles per gallon of fuel oil and our water mileage was at the rate of 340 miles per tank. It was a good day, but the hills negotiated were long and fairly steep.

The condenser is the original one which came with the 750 Stanley and has had no fan behind it. It was re-soldered and made tight by the American Steam Automobile Company at the time the car was rebuilt last summer.

I am at present running the water level in the boiler quite high and find that it works better that way. At ordinary water level I have never experienced priming, but with the raised level on steep hills when good speed is kept up I have noticed a little tendency to prime. It is not enough to cause sluggishness, however.

I was much interested in your account of the car you are building, and shall hope to see some reports an it in Steam Car Developments.

Mr. Frank Dolton of Niagara Falls, who has the twin of my car, has his car running now and reports good performance. Mr. William Hinds of Youngstown, New York is re-assembling his Brooks Sedan which he has improved in many respects, and expects to have it on the road within the next month.

WILLIS L. TRESSLER.

Department of Biology, University of Buffalo, New York.

In the very interesting and informative " Boiler Design Notes" in your issue of May, the writer remarks that it is unprofitable to attempt the recovery of waste heat at a temperature below 12,000 deg. F. and adds "If the gases available are as hot as 25,000 deg. F. the waste heat boiler installation may be substantially of standard proportions."

It is unfortunate that the one person to whom this information would be of greatest value has no recognised postal address; otherwise it would be a much appreciated compliment to send a copy (written on sheet asbestos), to that enthusiastic student of high temperature combustion, His Satanic Majesty.

NEWTON B. TROTTER.

Coleford, Glos.

(It is much regretted that a printer's error has caused so much heat.-Ed.)

The late articles by Abner Doble are fine and the data given really means something, coming from such an authority. I note the design by Mr. Beilschmidt, which is certainly novel, but it seem to me that what is really need, is a good simple design for a conversion set to plant into a popular-and therefore easily obtainable chassis--such as the Ford or Chevrolet (U.S.A.)

No reason to spend money building a special chassis, when it seems to be the very lack of funds which keeps the vast majority of steam believers from being owners. Of course this is only repeating the obvious, but if enough people demand a thing it is usually forthcoming, as a natural result, and so I put in my vote for what I think desirable.

In closing, why not ignore such remarks as those by "Vulcan"? Constructive criticism is good but the less space accorded the other kind, the better the cause.

W. LYTTON SCOTT

San Francisco.

This April issue is a very interesting number. I am unable to understand the backwardness of the steam car in getting on the market in quantity production. I believe there are literally thousands of customers waiting in this country, not to speak of yours and others four-spring front suspension is the patented property of Lundelius & Eccleson, here in Los Angeles, patented also in your country. A better end cheaper front end suspension would be the same as Mr. Beilschmidt shows at the rear, but reversed, and using two of these triangular members on each side, one above the other, with the wheel- spindle-king-pin assembly working between them. Take the drive shaft to the wheel through a suitable opening in the spindle and use a two-piece king pin. I believe it would help to do away with all leaf springs also, using either coil springs, or rubber in compression in a small centre unit above or below the backbone. Details, of course, but all point the way towards a really low priced steam car.

C. L. JOHNSON.

Glendale. California.

I find your journal most interesting, but so far, have not seen Turbines mentioned as a means of propulsion. In my opinion, if steam is to be generally used again on cars it will be due to it being more adaptable to an engine in which reciprocating parts could be eliminated.

I think everyone will agree that the entire elimination of reciprocating parts is desirable in any engine, whether steam or internal combustion, although perhaps as yet it is not practicable.

T. R. GOLLING.

Walsall.

I was glad to see pictures of the steam aircraft in your No. 38 issue, though why engineers should cling to the reciprocating engine is a mystery to me. Revolutionary speed in the air will always be high and constant, so why not the combined boiler and turbine?

Unless we get moving a bit quicker along these lines we shall be left gaping after other Nations with their usual lead, and our loss.

Your efforts I feel sure must be deeply appreciated by your wide circle of readers.

McKINLAY HARGREAVES.

Caversham.

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ADVERTISEMENTS

STEAM CARS AND BOATS. I am investigating the market interest for a silent, trouble-free Steam Power Plant, at a popular price. Burning oil and steaming in 3 minutes by switch. Could be fitted by an amateur into any I.C. chassis 7 to 10 h.p. with shaft drive.

Will every reader interested send me his opinion on a p.c. If the census of opinions decides me to proceed, a full specification will be sent post free. Address to E. Rodgers, c/o Messrs. Rodgers & Geary, Carlisle Street, Leicester.

1911 WHITE STEAM CAR, with many improvements, L20.-- W. Cherry, "Restmore,-' Broxbourne, Herts.

COAL FIRED water tube boiler, 17 inches by 15 inches by 50 inches high. Heating surface 23 sq. ft. Grate area 11/4 sq. ft. Working Pressure 70 lbs. With all fittings. L30. Below:

NEW Stanley type Screw-down stop valves, English make. 1/8 inch gas thread for 600 lbs pressure, single branch type, 5/9 each, double branch, 6/4 each. Stanley pipe unions 1/4 inch, 1/3 each, 7/16 in, 1/6. We can now supply Stanley type safety valves for 650 lbs., prices on application. Below:

MERRYWEATHER No. 1 Combined Boiler and Pump. 6,000 g.p.h. against 100 feet head, 1,500 g.p.h. against 250 feet head. Boiler insurable at 120 lbs w.p. Complete with all fittings including injector, L42. Below:

PUMP by Shand and Mason, 4,000 g.p.h. hand operated, on 4 wheel bogie. 2 inch suction and delivery. Below :GARAGE belt-driven water cooled compressor, ADVERTISEMENTS are inserted in this paper at the rate of One Penny per word. Minimum charge for advertisement. One Shilling. Display, Full page, 1/2 page, etc., quoted for on application. Advertisers are requested to send in their advertisements as early as possible each month. Remittances should be made by Postal Orders, and sent to the Editors, R. H. & H. W. Bolsover, 27 Castle Road, Whitby, Yorks.