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April, 1932.

Design Memorandum No. 120.

Steam Power Plant for Airships, Proposed by the Great Lakes Aircraft Corporation.

By

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SUMMARY.

Extraordinarily high performance is claimed for the proposed steam power plant in respect to both weight and specific fuel consumption. Unfortunately, the calculations submitted with the technical report, dated February 11, 1932, are purely theoretical, unsubstantiated by any data from experiment or experience with other high pressure steam installations. A maximum pressure of 1,000 lbs./in.^{2} is proposed, with superheat to 1,000° F. It is believed the designer's estimates of performance, particularly in regard to weight, are over optimistic; but they can be neither proved nor disproved without experimental data which has not been furnished, although it is understood that there are several Lamont boilers in operation.

The turbine is not novel, except in pressure and temperature, but no evidence is submitted to substantiate the claim for a steam consumption of only 7.04 lbs. per horsepower hour.

WEIGHT.

A great saving of weight is claimed for the steam plant in comparison with the Maybach engines of the U.S.S. AKRON. The following comparative tables are given for the weights of the steam and gasoline power plants:

Steam Plant (4600 hp).

Item	Weight, lbs.
Steam generators	3,448
Auxiliary pumps and controls	3,538
Turbines and gears	4,200
Condensers	3,468
Water recovery and air preheater	1,028
Propellers	3,920
Outriggers and transmission	2,400
Water	700
Total weight	22,702 lbs.

Gasoline Engines (8 at 560 hp = 4480 hp total).

Item	Weight, lbs.
Engines, dry	20,176
Propellers	2,000
Outriggers	3,640
Transmission	13,096
Cooling system	3,208
Water and oil in engine	760
Water recovery apparatus	12,528
Total weight	55,408 lbs.

The figures for the gasoline power plant are actual weights from the AKRON. The steam plant weights are designer's estimates, unsubstantiated by comparison with any existing power plants. A comparison of the items common to the two types of power plants indicates that the estimates for the steam plant are so exceedingly optimistic that very little credence can be given them. For example, the water recovery apparatus of the AKRON weighs 12,528 lbs.; but the weight allowance for a combined water recovery

and air preheating system for the steam plant is only 2,400 lbs. The engine cooling system of the AKRON weighs 3,208 lbs., but only 3,468 lbs. is allowed for the condensers of the steam plant, although they have to dissipate a much greater quantity of heat at about the same temperature gradient. The outriggers and transmission of the AKRON weigh 16,736 lbs.; while the estimate for the weight of the outriggers, turbines and transmission of the steam plant is only 6600 lbs.

FUEL CONSUMPTION

A specific fuel consumption of .549 lb./hph is claimed for the 4600 hp steam plant at 2986 hp, and .618 lb./hph at full power. The corresponding overall thermal efficiency at cruising power is 24.8%. It is claimed that the steam generator is 90% efficient, and the turbine 74%. No substantiating figures from existing steam generators or turbines are submitted. The estimated boiler efficiency seems very high, but it may be possible. The 74% efficiency claimed for the turbine is not clear. It may be the mechanical efficiency, including losses from friction and turbulence of the steam in the passages and on the blades. From these figures, the thermal efficiency of the turbine must be .248/(.90 x .74) = 37.3%. It is interesting to note that 38% is the limiting efficiency of a Carnot cycle engine working between the limits of temperature of saturated steam at 1015 lbs./in.^{2} absolute boiler pressure and 4 lbs./in.^{2} absolute pressure at the condenser. These temperatures are 545° F. and 153° F., respectively, or 1006° and 614° absolute. The steam is superheated to 1000° F., but the latent heat must be supplied at the temperature of the saturated steam; and it is very doubtful if an efficiency so close to the theoretical limit can be attained.

On the other hand, the turbine efficiency of 74% claimed by the designer may be the expected ratio of the actual overall mechanical and thermal efficiency of the turbine to the theoretical limiting efficiency for the temperature range.

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WATER RECOVERY APPARATUS.

In view of the difficulties experienced in obtaining a satisfactory water recovery apparatus for gasoline engines, the apparatus proposed for this steam plant is interesting. It is in two stages, the first stage serving as an air pre-heater, as well as a cooler for the gas. Each stage consists of 4150 aluminum tubes inclosed in an outer casing. The gas passes through the tubes, and the cooling air flows around them in the outer casing. The tubes have a mean diameter of .6", a mean length of 20'7", and a wall thickness of only .01". In view of the distortion and rapid deterioration of water recovery tubes 1" in diameter by 5'0" in length with .02" walls, the tube dimensions in the proposed apparatus seem wholly impracticable.

Powerful blowers would be required to force the stack gases through the tubes, and the cooling air around them. The designer's allowance of only 34 hp for the blowers at 3680 total hp is considered very inadequate.

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