mum area occurs when T_1 equals 1130 deg and T_2 equals 836 F. For T_1 greater than 1130 R the area increases rapidly to approximately 80 sq ft/kw at 1165 R, the critical temperature of water. There are other disadvantages to water, too; the turbine inlet pressure corresponding to 1130 R is approximately 2530 psia and would therefore require high-pressure components of rugged construction. When operating at the temperature limits indicated, however, the available energy per pound of water exceeds that of other working fluids. This high available energy will require a turbine with multiple pressure stages to be effectively absorbed. For these reasons, water is not as attractive as mercury as a working fluid.

The two other fluids, diphenyl and Dowtherm A, were also disappointing. Chemically stable at temperatures approaching 1300 F, these fluids, unfortunately, exhibited poor cycle efficiencies and require large mirror areas. The areas shown in Fig. 16 can probably be reduced to some degree by altering mirror configuration. The pressures associated with the T_2 values in obtaining these curves are relatively high, and the vapor is in the superheat region. Because of these conditions, the high moisture problem does not exist and lower temperatures and pressures are permissible. Therefore a configuration with a higher radiator efficiency Ω should be investigated if these fluids are to be given further serious consideration.

Conclusions and Recommendations

This investigation has demonstrated the feasibility of a solar turbo power plant. A rugged, compact unit requiring an approximate 35 sq ft of mirror area per kilowatt was predicted with 1350 R (890 F) mercury inlet temperature, to the turbine. Lower areas are possible at higher inlet temperatures, but these, however, are only modest reductions. The design of an efficient vapor generator was found to be extremely important in obtaining an optimum power plant. A gain in efficiency in transferring solar energy to heat energy in the working fluid creates a change of effects which result in a more efficient power plant. It permits the use of higher temperatures in the working fluid. These higher temperatures result in increases in cycle efficiency—reducing radiator area and/or the temperature T_2.

For these reasons special attention should be given the surface finishes of the mirror and boiler tubes.

Few satisfactory working fluids were found during the course of this study—due, in all probability, to the small amount of time invested in this area. More effort could be profitably spent in this area of research. Further efforts should be expended also in the analysis and development of power-plant systems to permit plant operation during off-design conditions. Probably, the greatest departure from the design conditions is represented during the time interval when the sun has just appeared over the horizon. In this instance, the radiator heat rejection rate would be much greater than it would be at noon. This possible increased heat rejection rate will cause the uncontrolled temperature to fall, necessitating the development of some form of back pressure regulation. A bypass vapor system, orifices in the condenser section, regulation of liquid removal from the condenser tubes, thermostatic valves, or other types of automatic devices, are possible control devices.

The performance of this power plant should be compared to other electrical generator systems, such as the static electrical generators of the solar series—thermo-ionics, Peltier effect.

The operation of a prototype unit of a solar turbo power plant will be very profitable because it can provide engineering data applicable in the improvement and refinement of later designs.

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DISCUSSION

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The authors are to be congratulated on the comprehensive work they presented. As an evidence that the subject is indeed of common interest, the company with which these discussers

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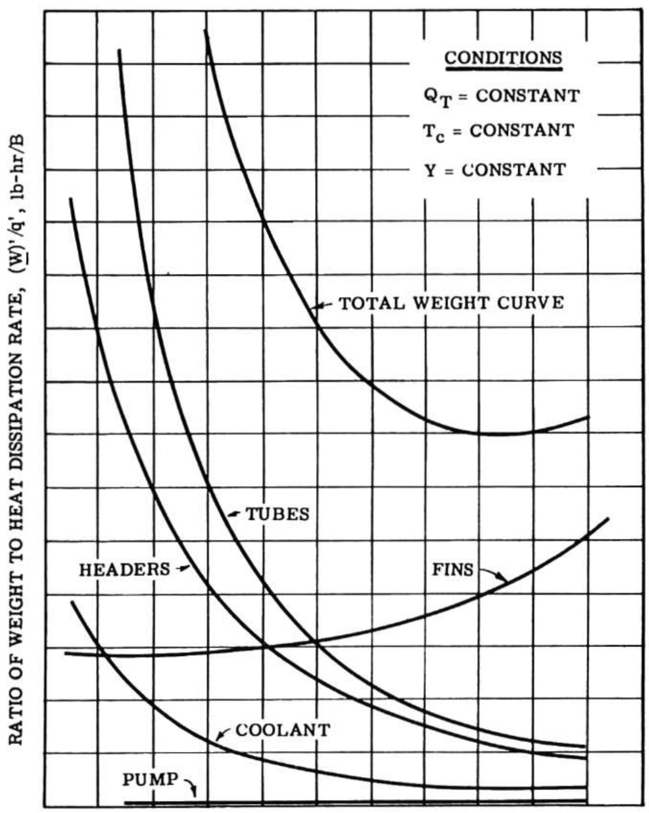

Fig. 18 Sketch of optimum design point determination method

are associated has also been actively investigating similar power plants for some time. The problem of optimizing the design involves study of quite a number of alternative systems.

It probably is worth while to mention in the paper the basis of selection of such a configuration of collector as described. For instance, a comparison between the performance of three-dimensional parabolic dish type and that of two-dimensional parabolic trough-type collectors will shed additional light on the area of development required. The idea of combining collector surface with radiator surface was well taken in the system described. It might be added, however, according to our analysis of weight optimization of a space radiator, the fin surface does not usually constitute the major part of the total weight.

Fig. 18 illustrates a typical set of curves in weight analysis, where

W' = weight per foot of tubing
q' = heat dissipation per foot of tubing
Q_t = total heat load to be dissipated
T_c = average temperature of radiator coolant
Y = length of one coolant tube

The saving in weight as a result of eliminating radiator fin surface may not be as appreciable as it first appears. The attendant mechanical considerations necessary to prevent distortion of the collector, due to temperature variations in the condenser tubes, may also be worth noting.