and with superheating,

$$E_s = \frac{W_s}{H_s}$$

$$= \frac{\left(\frac{A-B}{A+B} + \frac{1437}{A} - \cdot 7 + \frac{S-A}{S+A}\right)(A-B) + \frac{S-A}{2} \cdot \frac{S-A}{S+A}}{1437 + \frac{S}{2} - \frac{A}{5} - B}.$$

Numerical example. Say that A = 800°, B = 600°, S = 1000°. Substituting these values, we get—

$E = \cdot 2301$ without superheating,
$E_s = \cdot 2389$ with superheating.

That is, less than 4 per cent. is gained by superheating 200°.

So far, I support Lord Rayleigh's view, or, rather, he says what I have been impressing upon engineers for the last twenty years. If this had been all I had to say, I would not have written now; but Lord Rayleigh adds to his statement what is to me an astounding announcement, that, "by the addition of saline matters, such as chloride of calcium or acetate of soda, . . . the possible efficiency, according to Carnot, may be increased." I hasten to call this assertion into question, because there are so many people ready to bring engines on new principles into the field of joint-stock bubbles; and I am afraid we may be having, quite apart from Lord Rayleigh, a new field engine syndicated and floated on the strength of this communication and the signature thereto, before its meaning is understood.

As I understand thermodynamics there would be no gain from superheating by a saline solution, over the usual method of superheating steam raised from pure water. The saline mixture is not the working substance. Carnot's law refers to the working substance only, and not to anything left in the boiler. The first step in evaporation from the saline mixture is to separate a particle of water from the salt. In the act of separation, the temperature of the water particle falls to the temperature due to the pressure, and at that temperature it is evaporated into steam particles, which immediately become of the same temperature as the saline mixture. These steps are followed by every particle of water, each independently of every other particle. Of course, we cannot practically test those temperatures, as the complete series is run through for each particle in a fraction of the twinkling of an eye, and immersed in a liquid of greatly higher temperature. A thetaphi diagram for this would give, at B A, and extending upwards to temperature S, a very narrow figure 8, whose loops are equal, and drawn, as in a figure 8, one right-hand and the other left-hand. The line for the reception of latent heat would be identically the same line, the horizontal through A, as when the evaporation was from pure water. It is evident, therefore, that, according to my lights, the efficiency will be precisely the same as without the salt in solution.

Some ten years ago this plan was submitted to me for my opinion by an eminent mechanical engineer, Mr. S. Geoghegan, who, I understood, had then patented it. The above is the substance of the opinion I then expressed, and nothing I have learned since induces me to change my view of it now.

The "complete elaboration of this method," hinted at in the last paragraph of Lord Rayleigh's communication, is not clear to my mind; and it is just possible that a few sentences of explanation would show me that I have been hitting away at something that was not intended by the writer. If so, my excuse must be that I have read the statement, as every practical engineer would, to mean that the latent heat is imparted along the isothermal of the superheat. When I get to understand the first sentence of the last paragraph of the communication, I may be able to confirm the anticipation of higher economy. J. MACFARLANE GRAY.

THE passage quoted by Lord Rayleigh from my book on the steam-engine, in some remarks on this subject in your number of the 18th inst. (p. 375), is taken from one of the earlier chapters, which is devoted to engines which receive and reject heat at constant temperature. When such an engine is used as a standard of perfection, by comparison with which some other engine is tried, it appears to me that the maximum and minimum temperatures of the working fluid must in the first instance be adopted as the temperatures of reception and rejection of heat; and in fact, without entering on questions reserved for discussion in a later chapter, no lower value than the maximum could well have been adopted. There is no doubt that the practice of comparing together engines with different cycles has been a source of considerable misapprehension, and very probably the language used in the passage in question may be insufficiently guarded. The use of superheated steam on this method of comparison is not a gain, but a considerable loss, for the heat might ideally all have been used at the maximum temperature, and is so used in the standard of comparison.

The practical case in which the boiler pressure is given is, of course, quite different. There is a gain by superheating, but, putting aside cylinder condensation, the gain is small, because such a small percentage of the heat is employed at temperatures above that of the boiler.

The process was originally introduced with the object of drying the steam and diminishing cylinder condensation; and now that the practical difficulties attending its use have been in great measure removed (as I am informed), by the employment of mineral oil for lubricating purposes, it may be hoped that it may be revived, and be the means of a considerable economy.

The action of superheated steam in a cylinder was explained and its economy experimentally demonstrated by Hirn some fifteen or twenty years ago. I have given the explanation briefly on p. 352 of my book, but I purposely avoided discussing questions relating to it, being of opinion that, in the present state of our knowledge, theoretical investigations are of doubtful value. I am certainly, however, under the impression that the true nature of the economy obtained by its use has for a long period been very generally recognized, though some writers in dealing with the theory of heat engines may have expressed themselves incautiously. It would, I think, be very desirable, in teaching the subject, to introduce as early as possible the idea of a mean temperature of supply. I have dwelt on the importance of this conception in the latter part of my book, and I am sure its introduction would remove many difficulties.

Greenwich, February 24. JAMES H. COTTERILL.

LORD RAYLEIGH'S interesting communication on superheated steam in your last issue (p. 375) leads me to ask whether it is generally known that solutions can be heated up to temperatures higher than 100° by passing into them steam at 100°. The late Peter Spence at the Exeter meeting of the British Association in 1869 called attention to the fact that by simply passing steam at 100° directly into a strong solution of nitrate of soda (other salts will of course answer) it was possible to raise the liquor to its boiling-point, about 121°.

Superheated steam is frequently used for heating up liquors in chemical processes on the large scale, but where a slight dilution is no disadvantage, the simpler operation of heating with ordinary low pressure steam might be adopted more generally than it is. Spence used steam in this way for the purpose of extracting sulphate of alumina from alum shales.

G. H. BAILEY.

The Owens College, Manchester, February 22.

Poincaré's "Thermodynamics."

PERMETTEZ-MOI de repondre en quelques mots à l'article que M. Tait a consacré à ma thermodynamique, non que je veuille prendre la défense de mon imprimeur, ou réfuter des reproches généraux, contre lesquels ma préface proteste suffisamment.

J'abuserais ainsi de votre hospitalité et de la patience de vos lecteurs; je me bornerai donc à discuter une seule des critiques de M. Tait, et je choisirai celle que ce savant paraît regarder comme la plus importante et qu'il a formulée avec le plus de précision. Je commence par en reproduire le texte:—

"Even the elaborate thermo-electric experiments of Sir W. Thomson, Magnus, &c., are altogether ignored. What else can we gather from passages like the following?—

"'. . . Si l'effet Thomson a pu être mis en évidence par l'expérience, on n'a pu jusqu'ici constater l'existence des forces électromotrices qui lui donnent naissance. . . .'"

Rappelons d'abord que, dans l'étude des phénomènes électriques et thermiques qui se produisent au contact de deux métaux, il faut soigneusement distinguer trois choses:—

(1) Le phénomène calorifique connu sous le nom d'effet Peltier. Dans le cas d'un métal unique mais inégalement chauffé, le phénomène correspondant s'appelle *effet Thomson* et se manifeste par un transport de chaleur.

(2) La différence de potentiel vraie ou force électromotrice de contact.

(3) La force électromotrice apparente ou différence de potentiel entre les couches d'air voisines de la surface de deux métaux.