entering into the minor details, will find in this little book a most useful guide. The author has dealt with the subject rather curtly, but nevertheless in this space the reader will find descriptions of various lanterns for different methods of projection; hints on the most suitable positions in which screens should be placed to be best viewed by audiences; the best kinds of burners for the lamps, both oil and oxy-hydrogen, and the different adjustments for producing good results. Many other useful hints are given, accompanied by several woodcuts. W.

LETTERS TO THE EDITOR.

[*The Editor does not hold himself responsible for opinions expressed by his correspondents. Neither can he undertake to return, or to correspond with the writers of, rejected manuscripts intended for this or any other part of* NATURE. *No notice is taken of anonymous communications.*]

Heat-Engines and Saline Solutions.

MR. MACFARLANE GRAY (p. 414) appears to call in question my assertion that in a vapour-engine a saline solution may take the place of a simple liquid when it is desired to replace water by a substance of less volatility, and that the advantage which Carnot proved to attend a high temperature can thus be attained without encountering an unduly high pressure. He contends that "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."

Perhaps the simplest way of meeting this objection is to point out that Maxwell's exposition of Carnot's engine ("Theory of Heat," chapter viii.) applies *without the change of a single word*, whether the substance in the cylinder be water, mercury, or an aqueous solution of chloride of calcium. In each case there is a definite relation between pressure and temperature; and (so far as the substance is concerned), all that is necessary for the reversible operation of the engine is that the various parts of the working substance should be in equilibrium with one another throughout.

Let us compare the behaviour of water in Carnot's engine before and after the addition of chloride of calcium, supposing that the maximum and minimum pressures are the same in the two cases. The only effect of the addition is to raise both the superior and the inferior temperatures. The heat rejected at the inferior temperature may still be available for the convenient operation of an engine working with pure water. At the upper limit, *all* the heat is received at the highest point of temperature—a state of things strongly contrasted with that which obtains when vapour rising from pure water is afterwards superheated. RAYLEIGH.

Superheated Steam.

LORD RAYLEIGH touches on a most important question (February 18, p. 375), which merits the attention of all interested in the economy of prime movers. Few have troubled themselves with determinations of temperatures and pressures within a steam generator. Ebullition means work, and the performance of work involves cooling; hence the temperature of steam in the steam space of any boiler is lower by several degrees than the temperature of the steaming water. I have failed to find any record of this important truth, and shall be glad to know if my observations have been anticipated.

Prof. Cotterill, in his work on the steam-engine (p. 33), referring to the process of formation of steam under rising pressure in a closed vessel, says:—"The mixture of steam and water must be supposed so treated that the temperature is sensibly uniform. If the experiment were tried without proper precautions, the steam would probably be found to be of higher temperature than the water—that is, it would be superheated." So far as my observations go, this is impossible, and the steam is never superheated by compression in a closed vessel, in contact with water.

In a small experimental boiler the records of temperature indicated as follows:—

Temperatures in Model Boiler working up to 10 *pounds pressure*

Water temperature $1\frac{1}{4}$ inches below upper level.	Steam temperature. Thermometer in steam space.	Pressure, pounds per square inch.
° F.	° F.	
100	87	—
120	106	—
140	126	—
158	145	—
174	164	—
188	179	—
200	192	—
212	205	—
215	212	—
226	222	$5\frac{1}{2}$
236	233	$9\frac{1}{2}$
239	235	10
239	235	10
239	235	10

To avoid supersaturation of the steam it must be separated as promptly as possible from the water, which it projects, more or less, into the steam space. It is this which renders it so important in practice to secure the most active circulation. Provision for this, whereby the water falls, whilst the steam rises, can be made.

Uniformity of temperature of the boiler contents is of the utmost importance; and I was recently told by an able engineer, connected with the Midland Railway, that the unequal expansion of the boiler plates in locomotives on getting up steam was not only disastrous in its consequences, but *impossible* of prevention. Pursuing thermometric experiments, I found this not to be the case, and on a first trial of suitable apparatus, I obtained the following result:—

Model Locomotive Boiler, showing Hottest Water at the Bottom under 212° (*October* 24, 1891).

Upper level above fire...	60°	80°	90°	100°	110°	120°	130°	140°	150°
Temperature below furnace ...	60	65	70	76	82	90	96	107	114
Upper level above fire...	160	170	180	190	196	198	199	204	209
Temperature below furnace ...	122	134	156	176	200	204	206	208	209
Upper level above fire...	212	212	—	—	—	—	—	—	—
Temperature below furnace ...	210	212	—	—	—	—	—	—	—

Lord Rayleigh's suggestion to use liquids of higher boiling-point than water, such as saline solutions, to get hotter steam whereby to raise the upper limit of temperature in a steam-engine, is not feasible. Increased elasticity of steam or increased tension was long since shown by John Sharpe ("Annals of Philosophy," vol. i. p. 459, 1813) to be due to a corresponding increase in its density. He pointed out that at 212° the density of steam was 150 times greater than at 32°, and at 252° it was twice as great as at 212°. Increasing the density of the liquid does not help us, but liquids of lower boiling-point yield vapours of higher density than steam at equivalent temperatures. Anhydrous ammonia vapour exerts a pressure of 4 atmospheres at 32°, and its density is about 0·2, whereas at 120° F. the pressure is in round figures 285 pounds on the square inch, and its density 0·850.

Properties of Saturated Steam as compared with Saturated (Anhydrous) Ammonia Vapour.

Steam.			Anhydrous ammonia.		
Pounds per square inch above the atmosphere.	Temperature in ° F.	Weight of steam in pounds per cubic foot.	Pounds per square inch above the atmosphere.	Temperature in ° F.	Weight of vapour in pounds per cubic foot.
15	249°·8	·07344	14·744	0°	·1060
30	273·9	·10790	32	20	·1639
60	307·2	·17493	57·607	40	·2428
120	349·8	·30503	113	70	·4096
165	372·8	·40053	164·7	90	·5587