to carry on mining operations, and rejecting all seams of less than two feet in thickness, the entire quantity of available coal existing in these islands has been calculated to amount to about 80,000 millions of tons, which, at the present rate of consumption, would be exhausted in 930 years, but, with a continued yearly increase of 2¾ millions of tons, would only last 212 years. It is clear that long before complete exhaustion takes place, England will have ceased to be a coal-producing country on an extensive scale. Other nations, and especially the United States of America, which possess coal-fields thirty-seven times more extensive than ours, will then be working more accessible beds at a smaller cost, and will be able to displace the English coal from every market. The question is, not how long our coal will endure before absolute exhaustion is effected, but how long will those particular coal-seams last which yield coal of a quality and at a price to enable this country to maintain her present supremacy in manufacturing industry. So far as this particular district is concerned, it is generally admitted that 200 years will be sufficient to exhaust the principal seams even at the present rate of working. If the production should continue to increase, as it is now doing, the duration of those seams will not reach half that period. How the case may stand in other coal-mining districts I have not the means of ascertaining; but as the best and most accessible coal will always be worked in preference to any other, I fear the same rapid exhaustion of our most valuable seams is everywhere taking place. Were we reaping the full advantage of all the coal we burnt, no objection could be made to the largeness of the quantity, but we are using it wastefully and extravagantly in all its applications. It is probable that fully one-fourth of the entire quantity of coal raised from our mines is used in the production of heat for motive power; but, much as we are in the habit of admiring the powers of the steam-engine, our present knowledge of the mechanical energy of heat shows that we realize in that engine only a small part of the thermic effect of the fuel. That a pound of coal should, in our best engines, produce an effect equal to raising a weight of a million pounds a foot high, is a result which bears the character of the marvellous, and seems to defy all further improvement. Yet the investigations of recent years have demonstrated the fact that the mechanical energy resident in a pound of coal, and liberated by its combustion, is capable of raising to the same height 10 times that weight. But although the power of our most economical steam-engines has reached, or perhaps somewhat exceeded, the limit of a million pounds raised a foot high per lb. of coal, yet, if we take the average effect obtained from steam-engines of the various constructions now in use, we shall not be justified in assuming it at more than one-third of that amount. It follows, therefore, that the average quantity of coal which we expend on realizing a given effect by means of the steam-engine is about 30 times greater than would be requisite with an absolutely perfect heat-engine.

The causes which render the application of heat so uneconomic in the steam-engine have been brought to light by the discovery of the dynamical theory of heat; and it now remains for mechanicians, guided by the light they have thus received, to devise improved practical methods of converting the heat of combustion into available power.

Engines in which the motive power is excited by the communication of heat to fluids already existing in the aëriform condition, as in those of Stirling, Ericsson and Siemens, promise to afford results greatly superior to those obtained from the steam-engine. They are all based upon the principle of employing fuel to generate sensible heat, to the exclusion of latent heat, which is only another name for heat which has taken the form of unprofitable motion amongst the particles of the fluid to which it is applied. They also embrace what is called the regenerative principle—a term which has, with reason, been objected to, as implying a restoration of expended heat. The so-called "regenerator" is a contrivance for arresting unutilized heat rejected by the engine, and causing it to operate in aid and consequent reduction of fuel.

It is a common observation that before coal is exhausted some other motive agent will be discovered to take its place, and electricity is generally cited as the coming power. Electricity, like heat, may be converted into motion, and both theory and practice have demonstrated that its mechanical application does not involve so much waste of power as takes place in a steam-engine; but whether we use heat or electricity as a motive power, we must equally depend upon chemical affinity as the source of supply. The act of uniting to form a chemical product liberates an energy which assumes the form of heat or electricity, from either of which states it is convertible into mechanical effect. In contemplating, therefore, the application of electricity as a motive power, we must bear in mind that we shall still require to effect chemical combinations, and in so doing to consume materials. But where are we to find materials so economical for this purpose as the coal we derive from the earth and the oxygen we obtain from the air? The latter costs absolutely nothing; and every pound of coal, which in the act of combustion enters into chemical combination, renders more than two-and a-half pounds of oxygen available for power. We cannot look to water as a practical source of oxygen, for there it exists in the combined state, requiring expenditure of chemical energy for its separation from hydrogen. It is in the atmosphere alone that it can be found in that free state in which we require it, and there does not appear to me to be the remotest chance, in an economic point of view, of being able to dispense with the oxygen of the air as a source either of thermo-dynamic or electro-dynamic effect. But to use this oxygen we must consume some oxidizable substance, and coal is the cheapest we can procure.

There is another source of motive power to which I am induced to refer, as exhibiting a further instance in which solar influence affords the means of obtaining mechanical effects from inanimate agents. I allude to the power of water descending from heights to which it has been lifted by the evaporative action of the sun. To illustrate the great advantage of collecting water for power in elevated situations, I may refer to the waterworks of Greenock, where the collecting-reservoirs are situated at an elevation of 512 feet above the river Clyde. The daily yield of these reservoirs is said to be nearly 100,000 tons of water, which is derived from the rainfall on an area of 5,000 acres. The