changes, energy may be liberated and applied to producing the motions of other portions of matter required in doing work.

From the earliest times, and in the rudest conditions, men have used the liberated energy of changing molar systems to do their work; and centuries of slow experience had led to considerable skill in using it, before scientific knowledge conferred the power of most efficient utilization. Along with this was used, in total ignorance of its source and laws, the energy of changing molecular systems in animal mechanisms. And as early, certainly, as 130 B. C., the energy of these began to be used independently of living organisms, as in the eolipile and other machines of Hiero of Alexandria. Yet, more than eighteen centuries passed before such use was made to really contribute to the world's work, in Savary's apparatus, 1698, "for raising water and occasioning motion to all kinds of mill work by the impellent force of fire." It took the larger part of another century to develop the engine of Watt, 1769, containing all the essential features of the present steam engine.

To-day, in civilized nations, nearly all work is obtained from the change of molecular dynamic systems in (1) living organisms and (2) thermic engines. The first of these mechanisms has a very high "efficiency"; that is, a large percentage (fifty) of the power of action of the material systems used in it can be drawn off as energy available for doing work. The efficiency of the second is very small, and can never be otherwise.

After many centuries of developing from a toy to a first rude useful form, and nearly another from that stage to its perfection, the steam engine has been for a little over a century the work agent of the world. Inefficient as it is and must be, it has been the instrument of converting so much of the energy of molecular dynamic systems of the cruder, more abundant, and cheaper forms of matter into useful work that in its one century it has advanced civilization, intelligence, and all the material comforts of life by many centuries.

Our debt to the steam-engine is very great: let it have high honor and esteem. But we are compelled to bring an arraignment against it. Its efficiency, (percentage of energy delivered in work from a given amount in the system used,) is too low to be endured much longer in a scientific age. This fact is the doom of the steam-engine, at an early date. It must soon give way to a more efficient agent of work. From radiation and conduction from the furnace and boiler, from absorption of heat in the nitrogen and products of combustion, from further consumption in internal work in the substance used to transmit the energy to the engine, from heat thrown out in the exhaust of this, and from other losses, practically the steam engine wastes about ninety per cent of the energy of the systems supplied to it, and utilizes but nine or ten per cent. [The latest invention, the Triple Thermic Motor, will, possibly, deliver seventeen per cent; but it remains yet to be proved how practical the apparatus is.] The steam engine must go.

Little more than a quarter of a century has passed since electric motors were but playthings like the apparatus of Hiero, 130 B. C. Indeed, they were little more than this ten years ago. To-day electric motors are practically perfect. They will deliver in work over ninety per cent of the energy supplied to them. They are coming rapidly into use.

One discovery, now, will relegate the steam engine to a place among the crude and disused instruments of the world's barbarous ages. That discovery is to find how, from changes of molecular dynamic systems, to liberate cheaply and in unlimited quantity energy in the form of electrical currents. The engine, electric motor, is ready and perfect for the conversion of these into work. This discovery will reduce by hundreds of millions of dollars the value of coal lands, mining plants, and carrying roads, will render