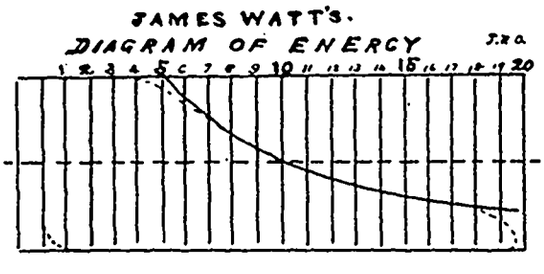
of plagiarism. For my own part I would no more think of writing a general article on the steam engine without mentioning Watt's achievements than I would attempt to write an essay on the laws of motion without acknowledging the debt due by all physicists to Sir Isaac Newton.

At a time when the greatest crisis in the history of a free people had about reached its maturity by the signing of the Declaration of Independence, another crisis was also nearing its fulfilment some three thousand miles away from here, for coincident with the dissipation of autocratic misrule forever over this country, came the dispersion of much ignorance in connection with steam and steam engines, by the enlightened labors, if not solely by the original discoveries of James Watt; parenthetically, let me remind you that these stupendous events happened just about half a century after "Great Newton spake and all was light." Fifty years after this date, the great pioneer of the steam engine was laboring assiduously to perfect the most civilizing and peace distributing agent known either to the arts or sciences (I hazard this opinion, notwithstanding William Ewart Gladstone's assertion that "The violin has done more to civilize mankind than the steam engine"). For it was in the same year that our colonists declared their independence that Watt declared the nature of his invention, in the British patent office, for utilizing steam expansively. Think of that, and then cast your retrospective mental vision up at those stupendous buildings which were in Chicago some two years ago, and on which the name of Watt stood emblazoned, and consider "What a mighty leap was that." Without the steam engine, no such buildings could have been constructed in ten times the period available, and if Watt had not discovered the advantages of using steam expansively, that wonder of the centuries (the White City at Chicago) might have been delayed for many years, and thereby culture, science, art, and the highest type of civilization been kept back for a decade or more.

It appears that as early as 1776, a date well known to all Americans, Watt made experiments on the expansion of steam, and about that time he altered an engine at the Soho works so as to test the result of an early cut-off. Six years later he took out a patent, in the specifications of which he states that his improvements consist in admitting steam into the cylinders of the engine only during some part or portion of the stroke of the piston and using the elastic forces, wherewith the said steam expands itself in proceeding to occupy larger spaces, as the acting powers on the piston through the other part or portions of the length of the stroke of the said piston. This was the first published example of the diagram of energy as applied to a steam engine.



In the accompanying sketch consider the horizontal lines above and below the centre line as a sectional view of the walls of a cylinder. Divide the length of the cylinder into, say, twenty equal parts, allowing for clearance. Assume that steam at the atmospheric pressure (14 pounds on the square inch) is admitted freely while the piston travels over five divisions and is then cut off. Hence at division 10 the pressure will have fallen to $\frac{1}{2} \times 14$, or 7 pounds. At division 15 it will be $\frac{1}{3} \times 14$, or $4\frac{2}{3}$ pounds, and at division 20 it will be $\frac{1}{4} \times 14$, or $3\frac{1}{2}$ pounds. Whereby it appears that only one-fourth of the steam necessary to fill the whole cylinder is employed, and that the effect produced, stated briefly, is equal to more than one-half of the effect which would have been produced by one whole cylinder full of steam. The expansive principle is the same, though steam be expanded in one cylinder, as above described, or in several cylinders.

A Brown hoist would not be made any higher by substituting a six ply rope for the single steel wire now used, nor would any absolute gain result from the change. It is the same with the bulk of steam, the energy of which is not increased by the addition of any number of cylinders; the steam will give up the same amount of energy if expanded in one (low pressure) cylinder, only as it would if previously expanded by steps in several cylinders, though practical difficulties make it necessary to subdivide the total expansion into separate stages, but this has nothing to do with the principle of expansion as delineated by Watt.

WATT'S EXPERIMENTS.

Although increase in steam pressure has been the chief aid to progress in marine engineering, it is remarkable to observe how cautiously and slowly such increase came about. Up to the year 1850 the load on the safety valves, as a rule, did not exceed 10 pounds per square inch. Ten years later the corresponding boiler pressure was 20 pounds. In 1865 it had risen to 30 pounds. In 1872 the load on safety values of a number of typical steamers was $52\frac{1}{2}$ pounds per square inch, but in 1874 a mighty leap was taken by the late Dr. A. C. Kirk, of the firm of Robt. Napier & Sons, who designed the triple expansion engines of the "Propontis," which were worked by the Rowan water tube boiler, with about double the last pressure mentioned; a few years later several small steamers—notably the S.S. "Anthracite," which was constructed under the superintendence of the writer—were fitted with the Perkins engines and boilers, working at about 300 pounds pressure, but such high pressures were rapidly abandoned, and in 1891 the average was $158\frac{1}{2}$ pounds. Steam pressures are now rapidly increasing, and it may be that before many years such pressures as the "Anthracite" carried with her Perkins boiler will be the rule rather than the exception.