and will be placed about six inches apart. They will be carried on every third yoke, and the yokes will only be about 70 per cent of the weight of those on Lenox Avenue line. The rails will be of the Crimmins type, which is designed to reduce the injurious effects from the wheels of street traffic. They will be exceptionally heavy, weighing no less than one hundred and seven pounds per yard, which is seven pounds heavier than the heaviest rail at present used on the trunk railroads of the country.

The estimated cost of the new lines completely equipped is between $6,000,000 and $7,000,000.

THE "ROTARY" STEAM ENGINE.

BY PROF. R. H. THURSTON, CORNELL UNIVERSITY.

The "rotary" steam engine, as it has been for a century called, is one of those seductive classes of mechanism which have been tantalizing the inventor and engineer for generations. From the time of James Watt, who a century and a half ago, nearly, devised this form of engine, it has been continually coming forward in shapes various, new and old, only to disappear promptly on being put to the test of daily operation under conditions permitting its exact performance to be ascertained. In Watt's patent of 1769, in its fifth claim, we read:

"5thly —Where motions round an axis are required, I make the steam vessels in form of hollow rings or circular channels, with proper inlets and outlets for the steam, mounted on horizontal axles, like the wheels of a water mill. Within are placed a number of valves that suffer any body to go round the channel in one direction only. In these steam vessels are placed weights, so fitted to them as to fill up part or portion of their channels, and yet capable of moving freely in them by the means hereinafter mentioned or specified. When the steam is admitted in these engines between these weights and the valves, it acts equal on both, and so as to raise the weight on one side of the wheel, and, by the reaction of the valves successively, to give a circular motion to the wheel, the valves opening in the direction in which the weights are pressed, but not in the contrary."

But far back of the days of James Watt are found the originals, the prototypes of the most successful of recent forms of rotary engines, of the steam turbines. Hero, of Alexandria, a century and more before the Christian era, published descriptions of the reaction steam wheel, and gave drawings showing its form and method of action. In 1629 Branca described the companion form, the "impact" steam turbine, which is to-day a favorite and successful machine in certain fields of work.*

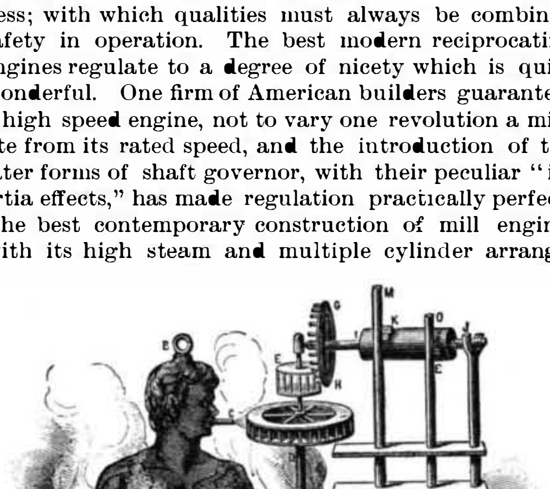
Since the beginning of the century thousands of inventors have attacked the problem, and hundreds of such inventions have been made, not one of which has been successful in competition with the reciprocating engine in its own wide field. The steam turbines are coming into use in the special field of high speed machinery, mainly in driving electric machinery. Here, too, it is only the simplest of all these forms, and the most ancient of types, which are in any sense successful. The steam turbines seem to have come to stay. For this there exist interesting and special reasons, both theoretical and practical. The reasons for the failure of rotary engines as a class is a marked feature of the century of growth of the steam engine. Those reasons are readily discovered, as we shall presently see.

In the accompanying issue of the SCIENTIFIC AMERICAN SUPPLEMENT† will be found an historical review of the inventions of this class of engines, and its illustrations include practically every class of machine of this type yet produced, and even among these many resemblances will be noted, closely relating one to another. It will be seen that all come into one or another of these classes: (1) the simple system of gearing without valves, of which the now well known Holly engine and pump are typical examples; (2) the system in which the steam chamber revolves, and work is performed by reaction in a manner first investigated by Sir Isaac Newton; (3) the system in which the issuing jet of steam impinges upon the vanes of a revolving "steam wheel;" (4) that in which a rotary motion is given a wheel having fixed vanes, or some equivalent, by introducing sliding abutments and valves between which and the vanes of the wheel steam may be introduced and there may expand; (5) revolving wheels or disks, set eccentrically with the cylindrical casing, in such manner that sliding vanes, passing into and out of the wheel, may intercept the steam and compel it to act in such a way as to force the disk to turn. A wonderfully interesting collection, illustrating the ingenuity of the mechanic and inventor in a remarkable manner, is shown in the historical article referred to, and our readers will do well to study it minutely.

The claims made by inventors of the rotary engine usually are that it is superior to the reciprocating machine in simplicity, in its lower cost, its greater compactness, its less volume and weight as well, and, sometimes, that it is more economical of fuel. The latter claim need not be here discussed further than to say that it has no foundation in any case known to us. Fabulous claims are often advanced relative to the reduction of weight and volume effected by the use of these machines, and these are sustained in the case of the steam turbine, of whatever form; as its enormous speed of best effect permits corresponding reduction of size for a stated power. The other forms have not yet proved superior to the now common high speed engine; which, in fact, has probably attained a higher speed than is usual with the rotary engines. For many years, a small engine, designed by Captain Ericsson, was in operation at the Delamater Iron Works, in this city, driving an electric lighting system, one of the earliest ever installed, and was regularly speeded at 1,250 revolutions a minute.* The Brotherhood, a balanced reciprocating engine, is said to have been experimentally driven up to 2,700 revolutions a minute; but the steam turbines range between 5,000 and 20,000 with varying sizes, the smallest having, of course, the highest speed.

THE GRECIAN IDEA OF HERO'S STEAM ENGINE. 120 B. C.

The essential, economical and practical characteristics of a thoroughly good steam engine to-day are: (1) Regular speed; (2) economy in the use of steam; (3) inexpensive construction; (4) compactness and lightness; with which qualities must always be combined safety in operation. The best modern reciprocating engines regulate to a degree of nicety which is quite wonderful. One firm of American builders guarantees a high speed engine, not to vary one revolution a minute from its rated speed, and the introduction of the later forms of shaft governor, with their peculiar "inertia effects," has made regulation practically perfect. The best contemporary construction of mill engine, with its high steam and multiple cylinder arrangement, has brought down the consumption of steam to 12 pounds per horse power per hour. The costs of construction have become not far from $10 per horse power for such engines as are supplied our light and power stations. The weights of reciprocating steam engines have been brought down from the half ton of a half century ago, per horse power, to one-tenth that figure ordinarily; and in marine, and especially torpedo boat construction, to one-twentieth and even less; while the aeronauts are building, as in the cases of Maxim and of Langley, steam engines lighter for their power than the swiftest birds that Nature has produced in her ages of steady evolution. Six pounds per horse power is now regarded by these inventors as a heavy weight for their work. The birds weigh 25 to 50 pounds and sometimes more, as computed by the best authorities to date.



BRANCA'S STEAM TURBINE, A. D. 1629.

In all these respects the rotary engine has usually failed to satisfy the market up to the present time, and it would seem that the mechanical and kinematic possibilities have been fully exhausted in the endeavor to solve the problem in this way. No perfect regulation of the rotary engine has been made integral with either of the constructions illustrated by us; no rotary has reduced the cost of power in steam consumed below the figures attained by even the ordinary reciprocating machine; none has attained a higher maximum speed, the turbines excepted; none has been proved to have inherent possibilities of giving out power in larger proportion of work performed to weight or cost of the machine, when placed in competition with the reciprocating engine of similar commercial class.

The inherent difficulties meeting the inventor in this field are principally those of securing satisfactory regulation and especially of attaining a satisfactory economy of steam and fuel. A variable cutoff, adjustable by the governor. seems to be the essential feature productive of both economy and steady speed, and this has not been realized in such manner as to satisfy the market in this class of engines. Further, it seems practically impossible to avoid serious wastes by leakage in these engines, after a little wear, however carefully the machine may have been originally constructed. It soon loses its tightness, and steam pours past its valves and abutments.

The steam turbines, however, must be set apart from the other rotary engines, as possessing some peculiar and promising features, especially in respect to wastes of heat and steam. The common forms of steam engine waste enormously, especially in their smaller sizes, by the condensation of steam, at entrance, by the then comparatively cold cylinder wall, which is continually alternately heated and cooled by the prime steam and the exhaust. This fluctuation of temperature of the metal and of the water which is precipitated in the cylinder causes a waste of from twenty per cent, in the largest and best engines using dry steam, to fifty per cent, and often much more, of steam entering from the boiler; thus adding from twenty-five to one hundred per cent or more to the otherwise purely thermodynamic demand for steam and fuel. In the steam turbines, on the other hand, there is no such fluctuation of temperature of cylinder wall, and this machine is thus entirely free from the most serious, and often enormous, waste of the reciprocating engine. It is this fact which accounts for the remarkable economy often now attained with this class of engine, and once its speed is made satisfactory, or conveniently adaptable to ordinary machinery, it would seem that it might prove a formidable rival in many cases to the now standard forms of engine.*

Should this prove to be the fact, we shall have the singular and interesting spectacle of the world going back to the time of Hero, two thousand years, to find the simplest and cheapest and most economical of steam engines.

DIPHTHERIA IN COLD AND HOT COUNTRIES.

Dr. Schellong, of Königsberg, has recently published a valuable monograph in Virchow's Archiv on "Diphtheria in the Tropics." He admits the correctness of Trousseau's saying, that the disease in question is to be seen in all seasons and also in all climates. He shows, however, that this opinion is correct as far as mere distribution of the malady is concerned, but is otherwise misleading. Diphtheria is, in fact, very unusual in any tropical country, and when it occurs it is purely sporadic and always mild. Schellong has carefully investigated the sanitary records of low lying malarious plains in tropical islands and continents, but diphtheria has proved no more prevalent there than in high ground. The disease is very rare in the West Indies, Guiana, the coast of Brazil, tropical East and West Africa, Madagascar, Hindostan, and the Indian Archipelago. Hence dampness of the soil is not necessarily a cause of diphtheria, nor does it in any way promote its diffusion. It is not prevalent even in the poor districts of crowded tropical towns. On the other hand, it is frequent in the highland villages of Peru, and in subtropical districts and warm temperate climates—Havana, Jerusalem, Cairo, Santiago, Montevideo, the north of South Africa, and Brisbane, in Queensland. In temperate climates, south as well as north, it is almost universally distributed, the Cape, Adelaide, Sydney, Melbourne, Tasmania, New Zealand, and the south of Chile and Argentina being as little free from diphtheria as are the cities and villages of Europe, the United States, Japan, and northern China. As intense heat is experienced in summer in several of the places just mentioned, it would appear that perpetual heat is necessary to kill the germs of diphtheria, while a few weeks of cold keep it alive and allow the disease to be endemic even in Cairo and Brisbane. Schellong, who illustrates his monograph by means of a good chart, does not believe in racial immunity.—British Medical Journal.

* "History of the Growth of the Steam Engine." R. H. Thurston. "International Series." New York, London and Paris. Pp. 8, 17, 100.

† The first of a series of articles upon the history, peculiarities and defects of the rotary engine will be found in this week's issue of the SCIENTIFIC AMERICAN SUPPLEMENT, which article will be continued in the two issues following.—ED.

* "Stationary Steam Engines for Electric Lighting." New York: J. Wiley & Sons.

* The theoretically best speed of orifice is infinity for the "Hero engine" and about 1,000 feet per second for the single wheel guide curve turbine.