filment of the functions of the body. Of these functions, those of digestion and assimilation are the most important. The digestive apparatus receives the gluten and the starch of the grain; the latter is pushed forward to be burned, the former enters the circulation; and out of its contained iron, potash, soda, magnesia, lime, nitrogen, etc., are manufactured all the important tissues and organs of the body. All of the iron is retained in the blood, together with much of the soda and phosphoric acid; the lime goes to the bones, and the magnesia very abruptly leaves the body, as it seems to be very plainly told that it is not wanted. Such, in brief, are the uses which the organic and inorganic constituents of a kernel of corn subserve in the chemistry of animal life.

The changes which they are made to undergo in the laboratory are almost equally interesting and important. Fecula, or starch, is a body of great interest, and is not found alone in corn. There is scarcely a plant or part of a plant which does not yield more or less of this substance. What a curious vegetable is the potato! Swollen or puffed out by the enormous distention of the cellular tissue in which the starch is contained, it seems almost ugly in its deformity. It is little less than a mass of starch when the watery part has been evaporated.

If we separate the starch from the gluten in corn, and boil it a few minutes with weak sulphuric acid, it undergoes a remarkable change, and becomes as fluid and limpid as water; and if we withdraw the acid, and evaporate to dryness, we have a new body, a kind of gum called dextrin. But if we do not interrupt the boiling when it becomes thin and clear, but continue it for several hours, and then withdraw the acid by chemical means, we have remaining a liquid, very sweet to the taste, which will, if allowed to separate, solidify to a mass of grape sugar. This is the method of changing corn into sirup and sugar. What is most extraordinary in this process is the fact that the acid undergoes no diminution or change. The play of chemical affinities lies between the amidine and the elements of water, grape sugar containing more oxygen and hydrogen, compared with the quantity of carbon, than the starch. Nothing can be more striking than these changes. From the kernel of corn we obtain starch, this we change easily into gum, and, by the aid of one of the most powerful and destructive acids, transform it into sirup and sugar.

We are now to consider another most extraordinary change which corn is capable of undergoing, that of being transformed into whiskey or alcohol. If we take the sweet liquid obtained by the infusion of malted corn, and subject it to a temperature of 60° or 70° Fah., it soon becomes turbid and muddy; bubbles of gas are seen to rise from all parts of the liquid, the temperature rises, and there are signs of chemical action going on in it. After a while, it slackens and soon stops altogether. Examination shows that it has now completely lost its sweet taste, and acquired another quite distinct. An intoxicating liquid is found, and if we place it in a still, we obtain a colorless, inflammable liquid, easily recognized as alcohol. By a peculiar arrangement of the condensing apparatus of the still, a portion of the grain, oils, and a large amount of water are allowed to go over with the alcohol, and this constitutes whiskey.

This is an example of the change called vinous fermentation. The influence of a ferment or decomposing azotized body upon sugar is strange and quite incomprehensible. Through its agency, we may cause the highly organized kernel of corn to take another step downward towards a dead inorganic condition. We can transform the alcohol over into acetic acid or vinegar, or the sugar may be formed into one of the most curious organic acids, the lactic. As in these processes, we follow the kernel of corn through the various changes, first into gum, then into sugar, then alcohol, then vinegar, and ultimately into carbonic acid and water, we obtain an imperfect idea of the marvels of vital chemistry. The chemistry of a kernel of corn is a comprehensive topic, and to be considered even in its outlines would supply material sufficient for a volume. The aim has been to group together a few of the most interesting points, and thus awaken a desire for a more complete and satisfactory investigation.

THE PRIME MOVERS AND THEIR RECENT PROGRESS.

The prime movers remaining unconsidered in our last issue are the heat engines. It was first pointed out by Benjamin Thompson, of New Hampshire, whose fame was won abroad at about the time of the war of the Revolution, and who was made Count Rumford in Europe, that heat was not a substance, as had been previously supposed, but that it was a kind of motion. In his paper, published by the Royal Society in 1798, he described experiments which not only proved this now well known and universally admitted fact, but also furnished *data* for estimating very closely the value of the "mechanical equivalent" of a unit of heat.* Sir Humphrey Davy, whose attention may have been called to the subject by Rumford's paper, in the following year made his celebrated corroborative experiment, melting ice, in an atmosphere below the freezing temperature, by friction, and published his acquiescence in the dynamic theory, becoming one of the earliest disciples of Rumford. Subsequently, the beautiful method of Mayer and the excellent work of Joule determined with precision the fact that the heat energy of a British thermal unit has an equivalent in mechanical power whose measure is 772 pounds raised one foot high. In heat engines, it is impossible to obtain all of this power from the heat obtainable from any source. If coal is burned, the heat developed becomes wasted, to a certain extent, in transmission to the prime mover, and a very large quantity is lost in the machine itself in many ways which have been already explained in these columns. It thus happens that, while the heat obtained from a pound of coal should do work equivalent to raising a pound weight to a hight of two thousand miles, our engines are so imperfect that our best builders decline to guarantee a tenth of this duty with even very large engines of the most perfect known design. In an editorial article, published in the SCIENTIFIC AMERICAN, January 11, 1873, we exhibited the reasons for this serious waste of power, and showed how far improvement is possible in heat engines working on known principles, and that the range of increased efficiency left to be effected by this improvement amounts to about 15 per cent in the engine and 30 per cent in the boiler of the steam engine, when working between the present limits of temperature. It is impossible to fix a limit to the gain by elevation of temperature and pressure and increased expansion.

We can record no important advance in steam engineering since that date. The use of the compound engine is becoming more general, and progress in the direction of higher steam pressure, and greater expansion is causing gradual modification of old forms of boilers to meet safely the higher pressures and the so-called "safety" or "sectional" boilers are coming into use still more extensively in consequence of this change. No great improvement has been recently effected either at home or abroad. In Europe, as was stated in the letters of our Vienna correspondent, the practice in steam engines is passing through the same phase of experiment and revolution which was witnessed in this country fifteen years ago in the period of the great contests of Sickles and Corliss for supremacy in the then just opening field.

To-day a pound and a half of coal per horse power per hour represents the highest economy of the best classes of large engines; and for ordinary sizes, such as drive our mills and our workshop machinery, double that expenditure is not considered extravagant. We can only hope to see these figures greatly reduced by some now unimagined and complete revolution in engineering. Such a revolution is by no means impossible or perhaps even improbable, and it would be unwise to neglect any suggestion which looks promisingly toward such an inestimably important advance.

The immediate and well known directions in which engineers are seeking to improve the steam engines look to the prevention of external losses of heat by radiation and conduction, and to the reduction of internal losses due to cooling of the steam cylinder and to condensation of the prime steam, or to liquefaction by expansion and re-evaporation during the exhaust.

The first is accomplished very thoroughly by means of the many sorts of excellent "felting" now in the market, and by "lagging." The second is secured by superheating and by mixture of steam with air to a slight extent in non-condensing engines, and by the adoption of the "compound" engine, invented by Wolff a half century or more ago, long before the use of high steam and great expansion gave it its proper field.

Attempts have been frequently made, and a very promising one has been chronicled in our columns during the past year, to save and utilize the exhaust heat of the non condensing steam engine, by applying it to the evaporation of some very volatile liquid, which is then applied to a supplementary engine. The real competition here lies between these "binary vapor" engines and the common condensing engine. The former would seem the more economical, and we are awaiting with interest the report of the performance of the engine which, it has been stated by the inventor, Mr. Ellis, is to be designed and tested by one of our most distinguished engineers. As we have already had occasion to remark, the effort to improve this class of prime movers is required to be exerted rather in removing the objections of the expense of the secondary fluid, the danger of loss by leakage, and the infinite annoyance, and generally the danger also, which attends its escape. These difficulties removed, a simple, durable, and properly designed machine of this class will find a ready market and will mark a decided advance, if in first cost and expense of maintenance it can compete successfully with the steam engine. Remembering that the economical value of a fluid depends simply upon the effectiveness with which it acts as a storehouse—a reservoir—of heat, and the advantages which it presents as a receiver and a dispenser of that heat, and remembering also that the mechanical effect depends just as much upon the volume as well as the density, upon the distance through which its pressure is exerted as well as upon the amount of that pressure, we can see that the value of any fluid as a medium of power transmission is not measured simply by its pressure at any given temperature. Up to the present time the vapor of water has been found, all things considered, the best single fluid for use in heat engines.

Air has been used very frequently in the production of power in heat engines, but it has not yet become a really successful and satisfactory motor. The convenience of obtaining an ample supply of air, its freedom from liability to produce destructive explosions, and the completeness of its expansive action, are important advantages, but they seem to be more than compensated by the difficulty of managing the fluid at the very high temperature at which it must be worked, the bulk and cost of construction and maintenance of the engine, and by difficulties, inherent in all known designs, of obtaining prompt and complete conveyance of heat into and out of the mass of air employed. Sixty years ago Dr. Robert Stirling proposed to use air in a heat engine, and his crude design was improved by James Stirling, who worked at the problem twenty years later. Our distinguished fellow citizen, Ericsson, still later, and nearly a quarter of century ago, designed a form of engine which was so successful that it still continues in use, as subsequently improved by its inventor. Shaw's engine and that of Rope have also met with some success; and the very promising engine of Wilcox, when just seeming most successful, disappeared, for reasons to us unknown. The superheated air engine of Leavitt is the latest example of this class which has come to our notice, but we now hear nothing more of that. At present, we see nothing specially noteworthy in this field of invention. We have indicated the difficulties of the problem, and leave the matter in the hands and minds of the ingenious and experienced mechanics who read our paper, and hope that we may yet be called upon to record the performance of an engine which shall produce the horse power for the expenditure of a pound of coal per hour, as is said already to have been done, and without burning itself out after a few weeks of good work. A "furnace gas engine," or one which uses in its cylinder the products of combustion, will probably prove the most economical form.

Gas engines are another class of prime movers from which much has been expected, but with which little success has been yet obtained. They offer nearly all the advantages of air engines, with the additional one of readily obtaining high pressure; but possess disadvantages peculiar to themselves which have, as yet, effectually prevented their introduction to any considerable extent. The first engine which came prominently before the public, the Lenoir engine, awakened much interest both among engineers and with the public. Using an explosive mixture, fired by electricity, the pressure was irregular, the engine noisy and wasteful of power, and the voltaic battery was a troublesome and costly appendage. The later use of a much smaller battery and the spark of the inductorium reduced but has not eliminated these objections. The Hugon engine next came into notice, and in this machine, by igniting the charge by means of an ingeniously arranged gas jet, this great objection to the use of exploding gases was done away with. In both these engines, the machine itself was quite similar in its details to the ordinary steam engine. The Otto and Langen engine, recently introduced abroad and noticed in our Vienna correspondence last summer, acts much like a Cornish pumping engine. The explosion of the gas drives the heavily loaded piston rapidly to the top of the cylinder, and, as it descends, its weight exerts a useful power. It is economical, using scarcely half the gas required by the earlier engines, but it is more rattling and irregular in its action than even they were. The most recent gas engine is, we believe, that of Brayton, in which explosion is avoided and of which, it is claimed, the economy equals that last mentioned. It seems a most promising invention, and we hope that time will prove its claims well founded. A good gas engine will find a large market. Its motion must be steady, its gases should be gradually burned instead of exploded, and it should not be injured by the high temperature of the products of combustion, nor should it be subject to rapid deterioration by wear or by any other cause.

We have but superficially glanced over this vast and important field, and have laid before our readers the present situation as respects the progress of the prime movers. Were not our limits so restricted, we should readily find much more to write on this subject, but we hope that we have at least set some active and fruitful brains and some experienced and skillful hands on the right track in a work of the highest importance to mankind.

We do not expect soon to see steam superseded, but we do anticipate that other motors will share the field with it to a far greater extent than has been yet the case, and we also are very greatly disinclined to believe that the steam engine itself has even approached the limit of its development.

*Professor Tait estimates this value, from Rumford's *data*, at within 20 per cent of the true value, and Professor Thurston, using a more correct measure of the horse power, estimates it at 784 foot pounds, or within about 1½ per cent of the value now accepted—772 foot pounds.

OBITUARY.

Jephtha A. Wilkinson.

The last day of the last year brought to a close the eventful life of this venerable and vigorous man. Born in Providence, R. I., at a very early age he exhibited a singular mental activity in the form of what is now popularly termed "go-ahead-itiveness." He was always engaged in driving forward some striking enterprise. He served in the war of 1812. Invented a machine for making weaver's reeds, was one of the first inventors of repeating fire arms and cannon also of the planing machine and of the rotary printing press He was a man of great intelligence and remarkable memory. He passed away in the 83d year of his age.

Lloyd A. Williams.

Lloyd A. Williams, late Chief Engineer in the navy, died recently at his residence on Rood street, Georgetown, D. C., in the forty-second year of his age. Chief Engineer Williams was a native of Washington, and entered the service of the United States on the 16th of February, 1852. His total sea service was eight years and five months. His last cruise was on the Colorado, which arrived at the Portsmouth, N. H., navy yard in June, 1872. During this cruise he contracted rheumatism, while in the Gulf of Mexico, from which disease he suffered greatly, and retired in consequence shortly after, in conformity with the act of August 3, 1861.

Draper Ruggles.

Draper Ruggles, of the firm of Ruggles, Nourse & Mason, predecessors of the Ames Plow Company (thirty years ago), in making agricultural implements at Worcester, died a few days ago, aged seventy-four.