furnace; a regenerator, composed of wire cloth of great superficial area, extending from the cooler to the bottom of the reverser heater; a cooler, composed of a large number of thin copper tubes, which are surrounded by water; and a displacer piston, having metallic packing rings, and adapted to reciprocate within the cooler. Each working cylinder is provided with a working piston having metallic packing rings. Each reverser is connected by means of pipes with the working cylinders, as follows: the hot chamber below the displacer piston is connected with the bottom of the working cylinder directly opposite, and the cold chamber above the displacer piston is connected with the top of the working cylinder diagonally opposite.

A small single-acting air-pump, having a leather-packed piston, is operated by an eccentric fastened to the main shaft. This pump is used, first, to compress the air to the initial pressure required; second, to maintain the initial pressure so attained, which is subjected to loss by leakage around the piston-rods. The regulation of the speed of the engine is obtained by a balanced equalizing valve of simple construction, placed in an equalizing pipe which connects the top of the working cylinders together, the valve being operated by a common centrifugal governor.

The power produced is due to the energy exerted upon the working pistons by the alternate raising and lowering of the temperature of the same mass of air within the reversers. The cooling medium used is any kind of water, or a blast of air circulated through the coolers. A very small quantity of water is required, and the same body of water may be used over and over again.

In operation, the alternate raising and lowering of the temperature of the same mass of air is accomplished as follows: in the upward stroke of the displacer piston, the mass of air in the cold chamber above the piston is forced through the cooling tubes, in its downward passage through which its temperature is not materially changed. The air then enters the regenerator, in its passage through which it absorbs heat which has been imparted to the regenerator. It next passes over the heated surface of the reverser heater, thereby becoming further heated, and enters the hot chamber below the displacer piston.

The temperature of the air in the cold chamber is about 120° F., and the temperature of the air in the hot chamber is about 600° F.

In the downward stroke of the displacer piston, the mass of air is forced into the regenerator, in its passage through which it deposits therein the greater portion of its heat. It then passes through the cooling tubes, where its temperature is reduced to about 120° F., and then into the cold chamber above the displacer piston. Therefore, at each upward and downward stroke of the displacer piston, the temperature of the same mass of air is alternately raised and lowered. The reversers being in duplicate, it is obvious that the same alternate raising and lowering of the temperature of the displaced air would take place in one reverser as in the other, but at opposite times; that is to say, both displacer pistons being operated by the reverser beam, whenever one displacer piston is making its upward stroke, the other displacer piston is making its downward stroke. It is therefore evident, that, when the displaced air in one reverser is being heated, the displacer air in the other reverser is being cooled.

The alternate raising and lowering of the temperature of the displaced air (in both reversers) generates a power in accordance with the well-known laws of the expansion of gases, which power is developed by the working cylinders, as follows: while one displacer piston is making its upward stroke, and is heating and expanding the displaced air, thereby producing a pressure which is exerted against the bottom of the piston of the working cylinder directly opposite the reverser, and against the top of the piston of the working cylinder diagonally opposite, the other displacer piston is making its downward stroke, and is cooling and contracting the displaced air, thereby reducing the pressure against the bottom of the piston of the working cylinder directly opposite the reverser, and the top of the piston of the working cylinder diagonally opposite. Thus each working piston is subjected to differential pressures, which are alternately reversed as the displaced air is alternately heated and cooled. Thus a power is exerted to cause the working pistons to have a reciprocating motion, which is changed to a rotary motion by means of the working-cylinder beam and its connected parts to the main shaft and the fly-wheel, from which the power may be taken off by a belt. A portion of the power developed is absorbed in the friction of the engine, and a portion is used to operate the displacer pistons. The engine is designed to run on an initial pressure of air of about forty-five pounds, at a speed of 115 revolutions per minute.

PRODUCTION OF ESSENCE OF LEMON IN SICILY.

LEMONS in Sicily are divided into two classes, — the true lemon and the bastard lemon. The United States consul at Messina says that the true lemon is produced by the April and May blooms; the bastard, by the irregular blooms of February, March, June, and July, which depend upon the rainfall or regular irrigation, and the intensity of the heat during the summer and winter seasons. There are but three harvests of the true lemon. The first is the November, cut when the lemon is green in appearance, and not fully ripe. Lemons of this cut are the most highly prized: they possess remarkable qualities for keeping, and are admirably preserved in boxes or warehouses from November until March, and sometimes as late as May, and then shipped. The second cut occurs in December and January, and the third in March and April.

Bastard lemons present well-defined peculiarities in shape and appearance: their inner skin is fine, and adheres tenaciously to the fruit; they are hard, rich in acid, and seedless. The bastard lemon produced from the bloom of June is still green the following April, and ripens only towards the end of July. It remains on the tree over a year. The true lemon can be left on the tree until the end of May or the first week in June; but it interferes with the new crop, drops off from over-maturity, and is liable to be attacked by insects. The bastards, on the contrary, withstand bad weather and parasites, and they mature from June to October.

In obtaining the essence from the lemon, the following operations are performed by the Sicilian workman. He peels the fruit lengthwise with three strokes of a sharp knife, and lets the peel fall into a tub under the chopping-block. He then cuts the lemon in two, and throws it from his knife into a bucket. He works with wonderful rapidity, and fills from ten to twelve tubs with peel a day, and is paid about five cents a tub, weighing 77 pounds. His left hand and right index are protected with bands of osnaburgs or leather. Decayed fruit is not peeled. Fresh peel is soaked in water fifteen minutes before the essence is extracted. Peel that has stood a day or two should remain in soak from thirty to forty minutes, so that it may swell and offer a greater resistance to the sponge. The operative holds a small sponge in his left hand, against which he presses each piece of peel two or three times, — simple pressure followed by rotary pressure. The women employed in this work run a piece of cane through their sponges to enable them to hold them more firmly. The outside of the peel is pressed against the sponge, as the oil-glands are in the epicarp. The crushing of the oil-cells liberates the essence therein contained. The sponge, when saturated with the essence, is squeezed into an earthenware vessel which the operative holds in his lap. He is expected to press the peel so thoroughly as not to overlook a single cell. This is ascertained by holding the pressed peel to the flame of a candle. Should it neither crackle nor diminish the brilliancy of the flame, the cells are empty. This process yields, besides the essence, a small quantity of juice and dregs. The separation of the essence, juice, and dregs soon takes place if the vessels are not disturbed: the oil floats on the juice, and the dregs fall to the bottom. These three products derived from the peel have no affinity with each other. As the essence rises to the surface, it is skimmed off, bottled, and left to settle for a few days. It is then drawn off with a glass siphon into copper cans, which are hermetically sealed. After the essence has been expressed, a small quantity of juice is pressed from the peels, which are then either given as food to oxen and goats or thrown away.

The yield of essence is very variable, and the industry is carried on five months in the year. Immature fruit contains the most oil. From November to April, in the province of Messina, 1,000 lemons yield about 14 ounces of essence and 17 gallons of juice. An operative expresses three baskets of lemon-peel (weighing 190 pounds) a day, and is paid at the rate of about twenty cents a basket. The essence is so valuable, that the operatives are closely watched. Six men can work up 8,000 lemons a day: two cut off the peel, while four extract the essence, and obtain 136 gallons of lemon-juice and 7 pounds of essence. In the extraction of essence, defective fruit — thorn-picked fruit, blown down by the wind or attacked by rust — is used. This fruit is sold by the "thousand," equivalent to 119 kilograms, and thus classified: (1) mixed lemons as they come from the groves during December and January, of good quality but not always marketable, often from top branches; (2) lemons from March blooms; (3) lemons refused at the packing-houses; (4) dropped fruit; and (5) shrivelled or deformed fruit.

Lemons grown on clay soil yield more essence and juice than those grown on sandy or rocky soil. Dealers sometimes adulterate their essences with fixed oils, alcohol, or turpentine. Adulteration by fixed oils is detected by pouring a few drops of essence on a sheet of paper, and heating it: upon the evaporation of the essence, a greasy spot will remain. Alcohol is detected by pouring a few drops of the essence into a glass tube in which a small quantity of chloride of lime has been dissolved. The tube is then heated and well shaken, and, its contents being allowed to settle, the essence will float on the denser liquid. For the production of raw and concentrated lemon-juice, the following is the system employed. When the lemons have been peeled and cut in two, as described above, they are carried to the press and thrown into large wicker bags, circular in form, and then well pressed. If the juice is to be exported raw, only perfectly sound lemons can be used; but if the juice is to be boiled down, one-fifth of the lemons may be of an inferior quality. The juice from sound lemons is yellowish in color, and has a pleasant aroma: its density decreases with age.

With all classes of lemons the yield of juice and its acidity vary considerably from month to month. The amount of juice increases from October to April, its acidity and density decrease; and the same is the case with the density of the essence, owing to winter rains. An addition of five per cent of alcohol will prevent raw lemon-juice from spoiling. Lemon-juice is adulterated with salt or tartaric acid. Raw and concentrated lemon-juice is exported in casks of 130 gallons capacity. It requires about 1,500 lemons to yield 26 gallons of juice, while it takes 2,500 to yield the same quantity of concentrated juice, and 2,000,000, more or less, according to their acidity, to give a cask. Experience has shown that the lemons of the province of Messina, especially from the eastern shore, contain more acidity than the lemons grown elsewhere in Sicily. The value of lemon-juice is governed by its acidity. The rule is that concentrated lemon-juice shall show 60 degrees of acidity (the juice extracted from the bergamot or the sour orange must show 48 degrees, or one-fifth less than that derived from the lemon; it also sells for one-fifth less than lemon-juice). Formerly a citrometer, known as Rouchetti's gauge, was used to ascertain the percentage of acidity; now, however, resort is had to chemical analysis, which is said to be more satisfactory to both buyer and seller. Of late years a new article, known as vacuum pan concentrated natural juice of the lemon, has been manufactured at Messina. The juice concentrated by this method contains 600 grains of crystallizable citric acid for every quart. It is exported in casks containing 112 gallons, and in half and quarter casks. It is also shipped in bottles of 500, 300, and 150 grains each. Consul Jones says, in conclusion, that there is an establishment at Messina, probably the only one of its kind in Italy, in which crystallized citric acid is prepared. It takes from 340 to 380 lemons to make a pound of citric acid, which sells at about forty-four cents. The quantity of essence of lemon exported from Messina during the year 1887 amounted to 440,000 pounds avoirdupois, valued at $625,000; while of lemon-juice, 4,438 pipes were exported during the twelve months ended Nov. 30, 1887.

ARTIFICIAL SILK.

SCIENCE and industry are ever combining to copy Nature, and even dare to attempt improvements on her processes. The Champ de Mars contains many illustrations of this; but perhaps the boldest and most curious attempt of this kind is to be seen in the manufacture of artificial silk, described in a recent number of *Engineering*. Near the end of the Machinery Hall, that end by the Avenue du Suffren, and quite close to the elevator which raises passengers to the travelling bridges, there is an exhibit showing the manufacture of silk without any aid from silkworms, and on a system which appears to be entirely novel, and is certainly of wonderful simplicity. The silk industry has seen great vicissitudes, and has had to suffer many cruel troubles from disease both of the worms and of the trees they feed upon; but up to the present we believe that it has been spared the struggles of competition. If this new process should prove to be what it promises, a new and dangerous rival to the silk-trade will have to be reckoned with.

The composition of silk may be briefly described as follows: it is a relatively strong, brilliant material, the produce of the digestive juices of the worm acting on the leaves of the mulberry that constitute its food. The cellulose of the leaf is triturated by the worm, and transformed by its special organism into a peculiar substance, transparent, and somewhat resembling horn. This is called kerotine, and it fills two glands, from which it exudes in the form of two threads, which unite as soon as they leave the body of the worm. But this material no longer possesses the chemical composition of cellulose: it is largely combined with a new element characteristic of animal tissues, — nitrogen. The silk-fibre thus discharged forms a continuous thread, which often reaches the great length of 350 metres, the diameter of the fibre being only eighteen thousandths of a millimetre.

It was reserved for the present generation of inventors to devise a means of imitating by science the mechanical and chemical functions of the silkworm.

An old student of the Ecole Polytechnique, M. le Comte de Chardonnet, set himself some time ago to try and solve the problem. He took as his material pure cellulose, — a material, as we have seen, entirely different to that of which natural silk is composed. Cellulose is, as is well known, the basis of vegetable tissues, and particularly of wood. Thus all soft woods appeared to be well adapted for the purpose: in fact, any material suitable for the production of a good quality of paper — white wood, cotton waste, etc. — appeared fitted for the production of artificial silk. Paper pulp is, in fact, the starting-point of the industry. The first operation to which the pulp is subjected is that of nitration, which transforms it into pyroxile. This is done by steeping the pulp in a perfectly defined mixture of sulphuric acid and nitric acid. After thorough washing and drying, the nitrated cellulose is formed into collodion by dissolving it in a mixture of 38 parts of ether and 42 parts of alcohol. The collodion thus made is drawn into fibre by the mechanical means which will be described presently, but the thread requires further and very important preparation. The fibre, as it issues from the apparatus that imitates the glands of the silkworm, is one of the most inflammable of substances, and in that state would be absolutely useless: an absolute process of denitration is therefore a necessity. Of this operation nothing can be said, because it is kept a secret by the inventor. Its object is of course to extract from the filament the greater part of the nitric acid that it contains, and it would be curious to know if the nitrogen that does remain after the process is in the same proportion as that contained in natural silk.

However this may be, the thread after treatment ceases to be inflammable to any marked extent; but it may, if desired, be rendered still less liable to burn. After the denitration process, the filament becomes gelatinous, and other substances can be incorporated with it. Thus, when in this state, it can be impregnated with incombustible material, such as ammonia phosphate; and it is at this stage that the filament can be dyed to any desired color. This latter operation cannot precede the denitration process, as all the color would be taken out during that operation.

The mode of manufacture is very simple, and in the exhibition three apparatus are shown in operation to the public. The first of these is only a model to illustrate the principle. The chief feature consists of a glass tube reduced at the upper end to a capillary passage. It is through this passage that the filament of collodion is forced out under pressure. As it issues, the fibre is in a pasty state, and would have no consistency if it did not consolidate immediately. This solidification is secured by means of a second glass tube, which surrounds the first one, and extends beyond it.