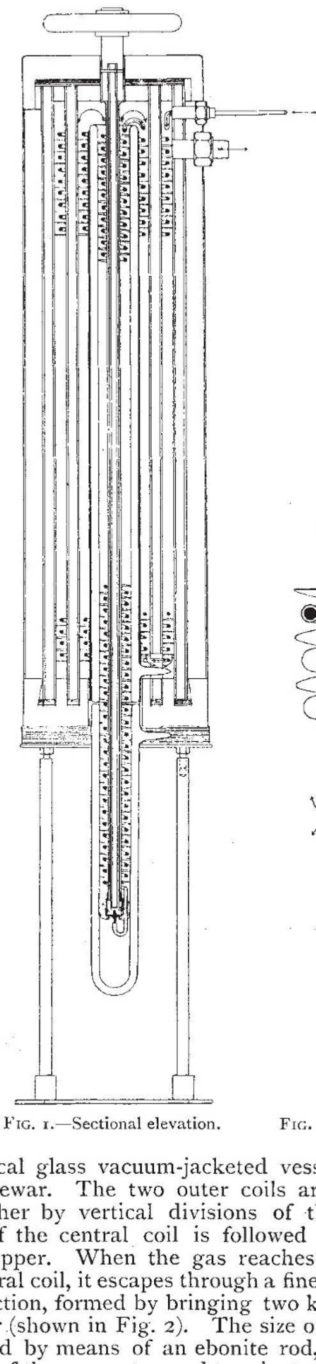
other, and the market will nevertheless be regularly supplied.

What, then, is a working plan? The German term is Wirthschafts plan, and the English term (working plan) was first used in 1856, when the writer of these lines commenced to work the Pegu teak forests on a regular system. The number of teak trees of the different age classes was approximately determined by an elaborate system of valuation surveys. It was found that the trees of the second class were sufficiently numerous to take the place of the first class trees, and that the same was the case with the younger classes. It was also ascertained, that twenty-four years on an average would be required for the trees of the second class to attain first class size. The result was that the removal of the first class trees, those which were fit to yield marketable timber, must be spread over at least twenty-four years; and upon this very simple principle, a working plan, intended to provide, in the first instance, for six years only, was established for the different forest districts. After the expiration of the first six years, this plan was renewed, and subsequently modified and elaborated in detail. The principle, however, has been maintained to the present day. These are the bare outlines of the scheme, which has not only ensured a sustained yield, but, and that is very important, has been readily intelligible to all.

(*To be continued.*)

THE NEW PROCESS FOR THE LIQUEFACTION OF AIR AND OTHER GASES.

THE liquefaction of air, and the rest of the so-called permanent gases, is an achievement which belongs to quite recent times. Faraday cooled and compressed gases by such means as were at his disposal, with results which are well known; but it was the experiments of Andrews, published in 1869, which taught physicists the fact that until the cooling has been effectual no amount of pressure will liquefy the gas; in fact, that every gas has a critical point below which its temperature must be reduced before pressure can bring about liquefaction. The critical points of oxygen and the components of air are very low. Hence it was not till 1877 that these gases were liquefied by Pictet and by Cailletet. The former reached the necessary temperature by two stages, using first liquid sulphur dioxide, then liquid carbon dioxide, both boiling under reduced pressure. Cailletet used the principle of cooling by sudden release from higher to lower pressure. The introduction of liquid ethylene as a cooling agent enabled experimenters to make another step forward; for, with the help of liquid ethylene, Wroblewski and Olszewski first obtained liquid oxygen in quantity far larger than would be possible in any form of Cailletet's apparatus, and without the complicated machinery of Pictet. Liquid oxygen itself thus became available as a refrigerating agent, and afforded the means of cooling a tube containing any other gas to a temperature lower than ever; namely, about 211° below zero Centigrade. With this cooling agent, and with the further cooling produced by expansion of the confined gas from a pressure of 150 atmospheres to 20 atmospheres, hydrogen has been liquefied by Olszewski. Suggestions have from time to time been made as to the possibility of applying the reduction of temperature, consequent upon the expansion of a gas when released from a high pressure, to the further cooling of the compressed gas; but no practical steps had been taken in this direction till the publication, in October last, of Herr Linde's successful liquefaction of air by the application of this principle. It now appears, however, that Linde has not only been anticipated in the application of the principle, but that a more effective apparatus than his has been devised. On Saturday, March 21, a demonstration was given, at Brin's Oxygen Works, of the construction and use of a new apparatus, the subject of an English patent, dated May 23, 1895, standing in the name of Dr. William Hampson. The apparatus consists of three coils of narrow copper tubing, arranged concentrically in a metal case, and connected successively together, as shown in the accompanying diagram (Fig. 1), which displays a vertical section of the apparatus. The gas, say oxygen, enters the outer coil under a pressure of 120 atmospheres, passing from this into the second, and from this into the central coil, which is surrounded by a



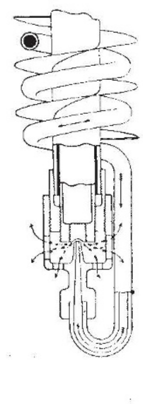


FIG. 1.—Sectional elevation. FIG. 2.—Detail of valve.

cylindrical glass vacuum-jacketed vessel as devised by Prof. Dewar. The two outer coils are separated from each other by vertical divisions of the case, and the spiral of the central coil is followed by a flat spiral of sheet copper. When the gas reaches the extremity of the central coil, it escapes through a fine orifice of peculiar construction, formed by bringing two knife-edges closely together (shown in Fig. 2). The size of the orifice can be regulated by means of an ebonite rod, which passes up the axis of the apparatus, and terminates in a handle at the top. After its escape the whole of the gas cooled by expansion passes through the spaces surrounding the pipe through which the compressed gas is passing to the point of expansion, and so makes this gas, still under pressure, cooler than it was itself while under compression. The compressed gas consequently becomes at the point of expansion cooler than that which preceded it, and in its turn follows backwards the course of the still compressed gas, and so makes the latter cooler than before expansion, and therefore also cooler than ever after expansion. This intensification of cooling (always assuming sufficient protection against access of heat from the outside) is only limited by the liquefaction of the gas, the temperature of liquefaction being in the case of oxygen $-180°$ C. The apparatus exhibited measures 28 inches deep by 7 inches in diameter, and when once cooled down, that is, in about half an hour, it yields liquid oxygen at the rate of about seven cubic centimetres in four minutes. No carbonic acid, nitrous oxide, or other artificial cooling agent is employed either inside or outside the apparatus. With the liquid oxygen obtained, a series of interesting experiments were shown, which, however, were not in themselves new, such as the freezing of ether and alcohol, and the pulverisation of india-rubber after cooling. The expanded gas, after leaving the apparatus by the wide tube shown in the diagram, was led back to the suction pipe from which the pump was drawing. The impulse of the pump thus caused rhythmical variation in the pressure of the expanded gas over the surface of the liquid which had collected, and this in its turn produced a rhythmical variation in the small amount of ebullition visible in the liquid. Dr. Hampson's experiments, performed in the presence of a considerable number of representative men, constitute the first complete demonstration in England of the efficiency of the process of self-intensification of cold produced by expansion alone without the aid of extraneous artificial refrigeration.

It is obvious that the model exhibited admits of modification, both as to size and in some details of arrangement; but this ingenious adaptation of a well-known principle cannot fail to receive important practical applications. In the meantime the results already attained have the highest scientific interest. Among the more immediate consequences, we may look for the liquefaction of hydrogen in such quantities as to admit of the more exact study of the physical properties of this element in the liquid, and perhaps even in the solid state; while following upon this, the attainment of, or approximation to, the absolute zero of temperature cannot be far off.

ANIANUS JEDLIK.

On the 12th of last December, a month before having completed his ninety-sixth year, Anianus Jedlik, who had for half a century been an active labourer in the field of experimental physics, ended his lengthy career at the cloister of the Benedictine Order, in Györ.

It was a strange sort of an investigator's life that came to a close with Jedlik's death. We scarcely meet with his name in the international literature of natural sciences, and yet he worked a great deal and wrote a great deal; but he totally lacked the ambition to obtain the appreciation of foreign fellow-labourers in his branch of learning, for the results attained by him. To him, his researches in the world of physical phenomena afforded in themselves sufficient enjoyment; and his laboratory work thoroughly satisfied his unpretending nature, which was free from all desire for fame.

Stephen Jedlik, who as Benedictine monk adopted for his monastic name that of Anianus, was born on January 11, 1800, at Szimö, in the county of Komárom (Hungary). He frequented the Latin schools at Nagy Szombat and Pozsony. In 1817 he entered the bonds of the Benedictine Order at Pannonhalma, in 1822 he became Doctor of Philosophy, and in 1825 was consecrated officiating priest.

The talented young priest was intended by his Order for a professor, and so he was employed in teaching natural philosophy successively at Pannonhalma, Györ, and Pozsony. In 1840 he was appointed Professor of Natural Philosophy at the University of Pest.

Jedlik's scientific researches extended to various branches of natural philosophy; nevertheless he turned his attention principally to those physical phenomena which chiefly absorbed the learned men of the time at which he started upon his career, namely, those connected with galvanism and electro-magnetism.

Within the sphere of these, Jedlik succeeded in making two important discoveries, as we can prove with total certainty. But these discoveries now bear the names of others, who happened to make them independently of Jedlik, and hastened to make the scientific world acquainted with them, while he merely laid them before his own pupils.

It was in the first years of his professorship—in 1827–1828—that, upon reading about electro-magnetism in the German periodicals to which he had access, he modified Schweigger's multiplicator in the following manner. He put in the place of the magnetic needle an electro-magnet, and thus, with the aid of a current-commutator, produced permanent rotation.

Jedlik relates, in his modest manner, that he never came upon any mention of such electro-magnetic rotatory apparatus in any of the periodicals or works with which he was acquainted, so that he could not but believe that he was their discoverer. But he kept it to himself, as he had repeatedly experienced that descriptions of apparatus constructed by him after his own original ideas, already existed elsewhere; and so he never thought of sending descriptions of the above to any of the foreign scientific periodicals of which he knew.

Jedlik's other discovery had reference to the fundamental principle of the dynamo-electric machine. In the collection of the physical department of the University of Budapest, there is a machine of very primitive construction, dating, as it appears, from somewhere about the year 1860, and probably the work of some mechanician of Pest, to which are joined directions as to its use in Jedlik's own handwriting.

In the fourth point of these instructions we find clearly defined the fundamental principle of the dynamo-electric engine, which principle Werner Siemens brought before the Academy of Berlin in 1867, and according to which the magneto-electric currents of augmenting force may be developed by means of mechanical force, with the aid of the slight amount of magnetism contained in ordinary soft iron.

Jedlik discoursed with great zest upon his investigations at the meetings of natural philosophers and physicians, in whose publications his dissertations are to be found. Several of his treatises appeared in the publications of the Hungarian Academy of Sciences, which elected him its regular member in 1858.

The topics of some of his more important treatises are as follows: "The Deflection of Beams" (1845); "The Application of the Electro-Magnet in Electro-Dynamic Rotations" (1856); "A Modification of Grove and Bunsen's Battery" (1857); "The Magneto-Motor" (1857); "Concatenation of Leyden Jars" (1863), through which peculiar modification he attained a remarkable degree of effect; "Modification of Fresnel and Pouillet's Interference Apparatus" (1865); "Tubular Electric Collectors" (1867); "Electro-magnetic Undulation Machine" (1868).

With Jedlik there expired one of the typical figures of