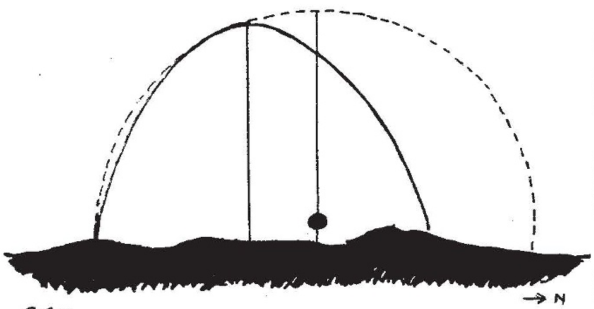
about a few degrees from the horizon (the horizon at the place of observation was not the true one, for a large but not very distant hill intervenes towards the west), there seemed to be suddenly formed a halo of peculiar shape. Its form may be described as nearly, if not quite, parabolic, the axis of the parabola being vertical. Curiously enough, this parabolic form was not symmetrical with regard to the position of the sun, but the latter was situated some distance to the north of the axis. The above phenomenon was observed at about 5h. 50m.–5h. 55m. p.m.

A few minutes afterwards (6h. 5m.), this parobolic form slowly underwent a change, and after a minute or two a circular




Halo at sunset, February 17, 1896, Göttingen.

halo concentric about the sun was distinctly visible. While the concentric halo was in the act of being formed, that portion of the parabolic halo towards the south seemed to maintain its position, but the northern end moved distinctly more north until the position of the sun was half-way between the two. The parabolic form *may* have been caused by the positions of the light fleecy clouds, apparently distorting the halo on the northern side and making the whole appear parabolic; but the change of shape was so considerable, that this explanation seems hardly satisfactory. WILLIAM J. S. LOCKYER.

### Remarkable Sounds.

MR. GODWIN-AUSTEN'S letter in NATURE of January 16, reminds me of similar sounds heard at Java in the year 1881. I was then building a railway tunnel through the Gunung Kendang, a range of hills about 100 metres high, situated between the towns of Sukabumi and Tjiandjor, Preanger Regencies, a district where more seismic disturbances take place than in almost any other district of Java.

One morning at about six o'clock, when at breakfast, I was startled by a very loud detonation which made me fear that one of our small vertical boilers at the other side of the works had exploded. I at once sent a man over the hill to ask for information, and received a note from my European assistant stating that no accident had taken place, but that he also heard the detonation and took it for an accidental explosion of some cases of dynamite at Tjiperda, a kampong about six miles from the tunnel, the headquarters of one of the European railway contractors. He at once went thither to see whether any assistance might be wanted, but found that nothing unusual had happened. The contractor, however, told him that at the very moment that we had heard the detonation he had felt a very severe vertical shock of earthquake, but had heard no sound.

In this same tunnel I experienced twice a very severe horizontal shock of earthquake which made a creaking sound in the timbering from end to end in the adits, causing some of the horizontal timbers which had not yet been spiked to fall down. The first time that this happened the coolies bolted, but the second time I managed to keep them in the works to watch the timbering. TH. DELPRAT.

Malang, Java, February 18.

### An Excellent View of the Retinal Circulation.

ON a cycling tour recently, after riding some forty miles, with much hill-climbing and against a strong wind, I lay down on a grassy bank facing the east, towards sunset. Viewing the clear eastern sky, I obtained a most remarkable view of my own retinal circulation. A companion also got an excellent view of his own blood corpuscles. The apparent circulation occupied a considerable portion of the visual field, and a most vivid conception was obtained of the relative slowness of movement in the capillaries. It occurred to me afterwards that the reason of the phenomenon was the hyperæsthesia of the retina, caused by the dilatation of the arterioles, which is a characteristic of excessive cycling. It would be interesting to learn whether others have obtained similar experiences. JAMES W. BARRETT.

Melbourne, Australia.

### Butterflies and Hybernation.

SOME time late in last autumn, a tortoiseshell butterfly took refuge in a small bath-room in this house, established itself on the ceiling, and there remained, immovable, throughout the winter. On the 10th of this month it shifted its position, and on the 12th flew out of the open window. On the 19th, and again to-day, I have seen a tortoiseshell butterfly fluttering about the garden, and should not be surprised if this early rover were the same individual as that which has undoubtedly wintered here. Half a dozen gauzy-winged green flies also hybernated in close company with the butterfly, but they woke up and flew a fortnight or so before the tortoiseshell butterfly stirred. DAN. PIDGEON.

The Long House, Letherhead, March 24.

### Children's Drawings.

As supplementary to the interesting note in NATURE of February 20, on children's drawings, I may mention that some children of my acquaintance show what seems a strong native tendency to reverse right and left in drawing such letters as L and J, making them J and ⅃. It is possible this confusion is akin to that confusion of right and left which one first feels on using a mirror for toilet purposes, as shaving, &c.

Lake Forest, Illinois, March 16. HIRAM M. STANLEY.

### "Testacella haliotidea."

ON addressing you some time ago on the subject of Worcestershire being a habitat of what I regard as this mollusc, some of your contributors applied for specimens. I have now six to give away. One of your contributors doubted whether the specimen I then had was Haliotidea, on account of alleged rarity. The same doubt applies now.

Worcester Museum, March 23. J. LLOYD BOZWARD.

### An Early Swarm of Bees.

A SWARM of bees on March 23 is, I think, so unusual, that you may perhaps like to be informed that one was taken here yesterday. A. PAGE.

Tendring, Essex, March 24.

## *THE MANAGEMENT AND PROTECTION OF FORESTS.*[1]

I.

PROF. SCHLICH'S important work is approaching completion. The two first volumes were noticed in December 1889 and July 1891.[2] Of these, it is understood, a new edition will soon be necessary. The third volume, which deals with forest management, is about to appear in a Spanish translation. Vol. iv. is an English adaptation of an excellent German book on forest protection, by Dr. Richard Hess, Professor of Forestry at the University of Giessen. It is the work of Mr. Fisher, formerly Conservator of Forests and Directo f the Imperial Forest School at Dèhra Dùn in North-Western India. The last volume will deal with forest utilisation. In the present article, we propose to deal with the subjects of the third and fourth volumes, viz. the management and the protection of forests.

1 "A Manual of Forestry," by William Schlich, C.I.E., Ph.D. Vol. iii. (pp. xix + 397). "Forest Management," by William Schlich. Vol. iv. (pp. xix + 593). "Forest Protection," by W. R. Fisher, B.A. (London: Bradbury, Agnew, and Co., 1895.)

2 NATURE, vol. xli. p. 121; vol. xliv. p. 265.

The management of forests depends upon the objects which the proprietor desires to realise. These objects may be of two kinds: they are either indirect, such as landscape beauty, protection against erosion, landslips, avalanches; or they are direct, the production of timber or other forest produce, so as to yield the largest possible permanent income to the proprietor. Dr. Schlich deals with the attainment of the direct objects, that is, with the economic working of forests; but he justly observes, that a forest under good economic management, as a rule, is capable of yielding all those indirect advantages that may reasonably be expected from it.

As explained on a previous occasion, Dr. Schlich's manual is, in the first instance, intended for the instruction of students preparing for the Indian Forest Service at Coopers Hill College. At the same time, there seems good ground for hoping that eventually it may also be useful to proprietors, land-agents, and wood-managers in Great Britain, as well as in the Colonies and the United States of North America. The third volume of the manual has a special value for persons interested in the management of woodlands in Great Britain; it is the first really comprehensive work upon this subject that has been published in English, and those who may take the trouble to work through its pages, will find that it will enable them to strike out a new line in the management of their woodlands. In 1883, another Indian forest officer, who had received his professional education in Germany, Mr. J. L. Laird MacGregor, now Conservator of Forests in the Bombay Presidency, attempted to place portions of the subject before English readers, under the title "Organisation and Valuation of Forests." (London: Wyman and Sons.)

At the outset, it will be necessary clearly to understand what the author intends by the term "forest management." Forestry, like medicine, engineering, or agriculture, originally commenced as an empirical routine; but its operations are now built upon the results obtained by researches in numerous branches of pure science. The most important of these are mathematics, botany, zoology, chemistry, geology, law, and political economy. Apart from these auxiliary sciences, forestry proper deals with the following subjects: (1) the raising and maintenance of woods, or sylviculture; (2) the protection of forests against damage; (3) the utilisation of forest produce; (4) forest management; (5) forest law.

The last-named subject has been dealt with in a separate work,[1] which, though not published as part of Dr. Schlich's manual, essentially belongs to this series of forest publications. The author, Mr. B. H. Baden-Powell, in 1868 was Small Cause Court Judge at Lahore, and consented to be employed during a series of years in the Indian Forest Service, then a small and humble concern, the progress of which was not generally regarded with favour. The main object of this measure was to secure his assistance in the matter of forest legislation. After doing excellent work as Conservator of Forests in the Punjab, and as Inspector General of Forests to the Government of India, Mr. Baden-Powell resumed his judicial work, and closed his Indian career as Judge in the Chief Court of the Punjab.

The first volume of Dr. Schlich's manual is introductory, the second deals with sylviculture, the third with forest management, the fourth with forest protection, while the fifth will teach utilisation of forest produce. Forest management is built upon the other branches, and under a strictly logical arrangement it ought to be the last volume of the series. This, however, would have delayed its publication. It may be objected that the term "forest management" has a wider meaning in English than that attributed to it by Dr. Schlich, that it comprises all operations of forestry, including sylviculture protection and utilisation of forest produce. In his manual the author uses it in a somewhat restricted sense, but this restriction is justified; it is convenient, and cannot lead to misconception. In French this branch of forestry is called *aménagement des forêts*, in German the usual term is *Forsteinrichtung*. MacGregor, in the work quoted, designates a portion of it as *Forest Organisation*. The term selected by Dr. Schlich seems the most suitable.

[1] "Forest Law," by B. H. Baden-Powell, C.I.E., late of the Bengal Civil Service. (London: Bradbury, Agnew, and Co., 1893.)

Forest management, as here understood, comprises three main subjects: mensuration, valuation, and working plans. Forest mensuration deals with the instruments used, the measurement of timber, standing and felled, it determines the volume of entire woods, the age of trees and woods, as well as the increment of woods. It appears necessary here to draw attention to another technical term, which, though English, is used in a definite sense. Dr. Schlich employs the term "wood" to designate what in German is called *Bestand*, meaning part of a forest forming a unit of fairly the same description. It might be objected that a "wood" is generally understood to mean an isolated small forest block, surrounded by clearings or by prominent natural boundaries. It will be a great convenience if Dr. Schlich's use of the term "wood" is accepted. The volume of a wood standing, say, on one acre of ground, is the product of two factors, the number of trees per acre and the mean volume of those trees. Again, the volume of a tree is the cylinder, height × sectional area, multiplied by a coefficient, called the form factor, which is different for each species, and in each species varies according to age and size of the tree. By a most elaborate system of measurements of many hundred thousand trees of all ages grown in different localities, form factors have now been established in Germany for most of the principal species. These form factors are governed by laws peculiar to each species. Thus, for trees 50 and 100 feet high of Scotch pine and Beech, the following factors are used to calculate the volume of timber down to three inches diameter:

| | 50 ft. | 100 ft. |
|---|---|---|
| Scotch Pine ... ... ... | 0·48 ... ... ... | 0·45 |
| Beech ... ... ... ... | 0·40 ... ... ... | 0·51 |

It must be distinctly understood that these form factors are only applicable to forests managed upon proper economic principles, where the trees, while young, are allowed to grow up crowded in compact masses, so as to form straight well-shaped stems, free from knots and branches, and are afterwards thinned out methodically, with the object of leaving in the final crop only well-shaped sound trees, likely to yield the most valuable timber. To trees grown in open park-like woods, these form factors would not be applicable.

Hand in hand with the determination of form factors, yield tables have been prepared in Germany for the principal species. These yield tables give the volume of timber in completely stocked woods of the different species standing on a given area at different ages, and in localities of the different quality classes. The work of examining the data, upon which these yield tables have been based, has led to an important result, viz. that the mean height of a wood as a rule indicates the quality of the locality. On good soil and under conditions otherwise favourable, the mean height of a wood is much greater than one of the same age which has grown up under less favourable conditions. Indeed, it is possible, with the help of yield tables to ascertain the volume of an even aged wood, the age of which is known, by determining the mean height of the trees composing it. The following extract from the yield table for Scotch pine in Germany, mainly taken from the figures given by Dr. Schlich, may serve to explain this.

*Volume and Volume-increment of Timber down to 3 inches diam. Net value and Value-increment. All on one Acre, stocked with Scotch Pine of middling quality.*

| | | | | | |
|---|---|---|---|---|---|
| Age, years ... ... ... | 60 | 70 | 80 | 90 | 100 |
| Number of trees per acre ... | 516 | 393 | 316 | 266 | 230 |
| Mean height, feet ... ... | 51 | 57 | 63 | 67 | 71 |
| Volume, cubic feet, solid ... | 3713 | 4183 | 4587 | 4902 | 5158 |
| Current annual increment, cubic feet, solid ... ... | | 47·0 | 40·4 | 31·5 | 25·6 |
| Volume increment, per cent. | | 1·2 | 0·93 | 0·60 | 0·51 |
| Net value of stock (shillings) | 1186 | 1683 | 2225 | 2789 | 3376 |
| Volume- and value-increment, per cent. ... ... | | 3·76 | 2·83 | 2·29 | 1·93 |

If two woods, known to be 60 and 100 years old, have a mean height of 51 and 71 feet respectively, it follows that they belong to the class, of which an extract is here given, which is known as the third or middling class; and, if completely stocked, the volume standing on one acre would be 3713 cubic feet in the one, and 5158 cubic feet in the other case. Other Scotch pine woods of the same age, if their mean height were greater, would belong to a higher quality class, and if fully stocked, their volume would be that recorded in the yield tables under their class. It stands to reason that in woods not fully stocked the timber per acre is less in inverse proportion to the degree of completeness.

The great practical importance of height-growth will perhaps be better understood by reference to matters which, many years ago, have exercised considerable influence upon the development of regular forest management in India. The writer of these lines, on taking charge, in January 1856, of the Pegu teak forests, made it his first duty to ascertain which were the most valuable forest tracts in that country. The number of teak trees of the different age classes on the square mile, he ascertained by a system of linear valuation surveys, laid through the forests in all directions. At the same time he measured the height of trees in all districts. The data thus obtained, the timber standing on the ground, and the height of the trees, particularly of the younger classes, enabled him to classify the forests, and to pick out those which were the most valuable. The measures which he had introduced, had gained him the confidence and goodwill of the Karen and other inhabitants of the forests, for those measures gave to the people profitable employment in timber operations, and this made them allies, instead of enemies, in regard to forest protection. The merchants of Rangoon, on the other hand, naturally desired to get the forests into their own hands, and, backed by the influence of the powerful mercantile firms of Calcutta, they induced the Government of India to order the Pegu forests to be thrown open to private enterprise. These orders had to be carried out; but, fortunately, they did not require that the whole of the forests should be thrown open at once. Those districts, therefore, in which the growing stock of teak timber, in regard to height and otherwise, was most promising, were for a time retained under control of the Forest Department, while the rest were thrown open to private enterprise, in accordance with the orders received. This was in 1861. Subsequently a different view of the question was taken by Government; the arrangements which had been made could not, however, be cancelled. The mischief had been done; but, fortunately, it had been limited to the less valuable districts. The really valuable forests, which had been reserved in 1861, had been saved, and this made it possible to maintain a profitable system of regular management.

The little table, entered on page 511, illustrates the growth of a Scotch pine wood of middling quality between the ages of sixty and a hundred years. As the wood advances in age, the number of trees diminishes, but the remaining trees are taller and heavier, and hence the total volume increases. During these 40 years no less than 286 trees have died or been thinned out, and the skill of the forester consists in this, that the final crop is composed of sound and well-shaped trees, so that their timber may fetch the highest price obtainable. These figures show further, that, while in the first period of 10 years, between 60 and 70, the timber produced per acre amounted to 470 cubic feet, or 47 cubic feet a year, only 256 cubic feet, or 25·6 cubic feet annually, were produced from the 90th to the 100th year.

The current annual increment is greatest while the forest is young, in the case of Scotch pine between the ages of 30 and 40, after which it diminishes steadily. The annual increment may be regarded as a percentage of the growing forest capital. Between the years 60 and 70 the increment per cent. ($p$) would be determined by the formula: $4183 = 3713 \times 1{\cdot}0p^{10}$, which makes $p = 1{\cdot}2$. Between the years 90 and 100 the increment per cent. is only 0·51. The maintenance of a forest, which increases at a rate so slow and so steadily diminishing, at first sight appears to be a most unprofitable undertaking. Fortunately the market value of the timber up to a certain point increases with the age of the wood. The net value of the growing stock (less the cost of cutting, carriage, and other expenses) of the wood exhibited in the table at the age of 60 years is 1186 shillings, rising to 1683 shillings at the age of 70. During this period the value- and volume-increment per cent. is 3·76, but it falls steadily to 1·93 per cent. between the years 90 and 100. Obviously, from a purely financial point of view, it is best to cut the wood when it is between 80 and 90 years old, and to invest the proceeds in Consols at 2½ per cent., for its maintenance beyond that age entails a loss of interest. The increment, that is the interest on the growing capital of the forest, is less than can otherwise be obtained on perfect security.

It is also evident that the value- and volume-increment per cent. may be used to aid in determining the most profitable rotation to adopt in the management of a forest. In the vicinity of coal- or other large mines, where pit-props find a ready sale, a rotation between 60 and 70 years, and even lower, would be most profitable. Where, however, the chief demand is for building timber, or there is a risk lest an over-production of smaller wood might lower prices, the rotation should be higher, 70 to 80 or 80 to 100 years. The value- and volume-increment per cent. does not, however, correctly express the rate at which the forest capital works. For this purpose the formula must be completed by inserting the annual expenses for taxes, administration, &c., as well as the rent of the soil. The result is called the *forest per cent.* To discuss this part of the subject would, however, lead too far on the present occasion.

Part ii. deals with forest valuation. Obviously it is often necessary, when a forest is to be divided, or assessed or sold, to determine its capital value. The English reader may be disposed to think this an extremely simple matter. The value of a piece of property is either its selling value or its productive value, and these can readily be ascertained by the prices paid for forest land in the open market, or by the rent derived from forest land. Sales of forest land, however, do not often occur, and when a sale takes place, the price realised for one piece of forest does not give the value of another piece. Soil, aspect, elevation, and the other factors which influence the annual timber production and the rate at which the timber can be sold, must be considered, and more than these, the actual condition of the growing stock depending upon species, age, and previous treatment.

Nor does the rental of forests come to our aid; forest lands, as a matter of fact, are not often leased out, the difficulty being to make sure that the capital value of a forest has been maintained unimpaired during the lease. The rent obtainable from a field, or from a piece of grass-land, whether let as a sheep-walk or for shooting, is known or can readily be ascertained. The same holds good in the case of osier-beds, which are cut over annually or every second year, and, in the case of coppice woods, which are worked on a short rotation. In all these cases the yield is approximately the same every year, and so is the annual outlay for labour and manure. Matters are complicated where standards are held over in the coppice, and more complicated in the case of high forest. A piece of high forest consists of trees which require eighty or hundred years, or even longer, to come to maturity. It consists of woods of all ages, and in the same wood trees of different species and of different ages are often found mixed. Under good management, a piece of high forest, if of sufficient extent, ought to yield, year after year, approximately the same quantity of timber, and hence a forest under a good system of management, in accordance with a well-considered working plan, is analogous to a field or meadow. When this, however, is not the case, it obviously is not a simple operation to determine the annual yield and the capital value of a forest. The annual yield is derived, in the shape of thinnings and final cuttings, from certain compartments this year, and from other compartments another year. Data extending over a long series of years would be needed to ascertain its average amount.

It may be objected that the capital value of a forest consists of two items, the value of the land and the value of the growing stock; that the former can generally be estimated within narrow limits, and that the latter should be calculated by adding up the market value of the timber standing in each compartment. This method, however, would leave out of account all young woods, which do not yet contain marketable timber; it would, in fact, treat them as blanks. The result of such a proceeding would be misleading, for obviously the capital value of a forest depends upon the yield which may in future be expected from it. And the future yield depends quite as much upon the condition of the young woods, which eventually are to furnish thinnings and the final crop, as upon the timber which at the present time happens to be marketable.

On the assumption that a forest is worked in accordance with a system settled beforehand, its capital value and its rental can obviously be calculated with the aid of yield tables. All net income, that is, the amounts expected to be realised by the sale of timber, less the cost of cutting, carriage, and other expenses, is discounted to the present time, and from the present value of all income is deducted the present net value of all expenses expected to be incurred upon the property. The result thus obtained is called the expectation value. Starting from an area not stocked, the *soil expectation value* is obtained. Thus, on the assumption that Scotch pine is to be planted, the soil expectation value of an acre of land of middling quality, such as that to which the data given on page 512 relate, will be as follows:—

| Under a rotation of | | With a net rental of |
|---|---|---|
| 60 years | 196*s.* | 4·90*s.* |
| 70 ,, | 236*s.* | 5·91*s.* |
| 80 ,, | 250*s.* | 6·25*s.* |
| 90 ,, | 245*s.* | 6·14*s.* |
| 100 ,, | 229*s.* | 5·73*s.* |

In calculating these values, the question had to be settled which rate of interest should be employed. As regards security, forest property has the drawback of possible damage by fire, storms, snowbreak, and insects. On the other hand, once placed under systematic management, a forest yields approximately equal returns annually, while those of fields and grass-lands vary according to the seasons. Once established, a forest requires less labour, and can be left alone for a time without much risk, for the timber continues to grow all the same. Lastly, the yield of several years may be anticipated, if money is wanted, or if it is desired to take advantage of a temporary rise in timber prices. These are substantial advantages of forest property, which make it a desirable investment, and therefore justify a low rate of interest. In these calculations, as well as in all others in this portion of his manual, the author has employed the interest of British Consols, that is, 2½ per cent. The calculation of the soil expectation value will be understood at a glance by stating the formula for a rotation of 80 years:

$$S_e = \frac{Y_{80} + T_{30} \cdot 1{\cdot}025^{50} + \ldots + T_{70} \cdot 1{\cdot}025^{10} - c \; 1{\cdot}025^{80}}{1{\cdot}025^{80} - 1} - \frac{e}{0{\cdot}025}$$

$Y_{80}$, the final yield at the end of the rotation is, according to the table given, worth 2225 shillings; the thinnings at the ages of 30, 40, 50, 60 and 70 years are worth $T_{30}=4$, $T_{40}=36$, $T_{50}=67$, $T_{60}=86$, $T_{70}=91$ shillings. These values are all prolonged to the end of the rotation, and the same is done with $c$, the cost of formation, here assumed to amount to 60 shillings, which is deducted from the sum of final and intermediate yields. The difference is the rent yielded by the forest every 80 years, that is, at the end of each rotation, and the present value $\frac{r}{1{\cdot}0p^{80} - 1}$ of this perpetual rent, after deducting the capital value of $e$, the annual expenses for administration, taxes, &c., ($e = 3s.$), represents the soil expectation value.

All other data remaining the same, the value of $S_e$ varies with the length of the rotation adopted, and in the present case its value culminates for a rotation of 80 years. Obviously this is financially the most profitable rotation which yields the highest net rental, 6·25 shillings per acre. Under this rotation the capital value of the growing stock is utilised to its full extent; if the wood is allowed to grow older, both soil expectation value and net rental diminish. It will be understood that on the data here assumed, it will pay to plant Scotch pine on land of middling quality, if that land can be purchased at 250 shillings (£12 10*s.*), or less, an acre.

The method here explained can be employed to determine the expectation value, not only of land, on the assumption that it is to be planted up with Scotch pine or other trees, but also of existing forests. The expectation value of a normal forest, for instance, consisting of 80 compartments of one acre each, all of the same middling quality, completely stocked with Scotch pine, in a regular succession of ages, the wood on the youngest compartment being 1, that on the oldest 80 years old, would stand as follows:—

| | £ | | £ | *s.* | *d.* |
|---|---|---|---|---|---|
| Growing stock ... | 3418 | or, per acre ... | 42 | 14 | 6 |
| Soil ... ... | 1000 | ,, ... | 12 | 10 | 0 |
| | 4418 | ,, ... | 55 | 4 | 6 |

It must be distinctly understood that these calculations are based upon assumptions, which may not in all cases be realised. The first assumption is that the plan adopted, upon which the formula is based, will be strictly carried out, that thinnings and other operations will not be interfered with by fires, storms, snowbreak, insects, or other damage, and that the areas will always be fully stocked with even aged timber. The second is, that the data of the yield tables will actually hold good in the case in point. The third assumption is, that the prices realised by sale of the timber, that wages and other circumstances which govern the value of $c$ and $e$, will be, and remain, as entered in the calculations.

There is some analogy with engineering formulæ. These the practical engineer uses as his guide, not blindly, but with circumspection and with due consideration of all circumstances which may affect the result. The difference is this, that the forester attempts to express by a mathematical formula the growth of trees, of organised beings, the development of which is governed by a multitude of influences, varying incessantly. Nevertheless, if used with due caution, these mathematical formulæ, elaborated with praiseworthy perseverance by foresters in Germany, will be found most useful aids in considering the difficult problems which forestry presents in all countries. Some of these problems can, others cannot, in the present state of our knowledge, be solved by the use of mathematical formulæ. Space forbids a further discussion of this subject.

In the kingdom of Saxony the State owns a forest area of 430,000 acres, which, after deducting all expenses, yields a mean annual net revenue of £390,000, or 18*s.* per acre. For many years it has been an established practice to determine, at intervals of ten years, the capital value of each forest range, soil and growing stock, and to calculate the rate of interest which, under existing management, that capital yields. The total area consists of 107 forest ranges or executive charges, and authentic statements, giving the financial result of forest management in each range, are published annually. During the five years ending with 1892 the average capital value of the entire area (soil and growing stock) amounted to 15 millions, or about £36 an acre. During this period, therefore, these forests have yielded interest on the capital involved at the rate of 2·6 per cent. Many of the 107 forest ranges have yielded less than 2 per cent., but a large number regularly yield more than 3 per cent. Compared with the State forests in other countries of Germany, those of Saxony have great advantages. The country is densely inhabited, up to the edge of the forests, factories and other industrial establishments are numerous, and there is a complete system of roads and railways. The consequence is, that timber, even of moderate dimensions, commands high prices, and that the produce of thinnings finds a ready market. Under these favourable circumstances, most of these forests are worked on a short rotation, which, it will be evident from the preceding remarks, is always more likely to lead to good financial results, than if the woods were permitted to attain a great age. A large portion of this area has gradually been converted into pure spruce forests, managed on a rotation of eighty years. On other grounds, it may, perhaps, not have been wise to rely upon pure spruce forests. Up to the present time, however, there has been no serious damage from insects or fungi.

In most other countries of Germany the public forests—that is, those which belong to the State, to towns, village communities, and other public corporations, and most of the larger private forests—are managed on rotations considerably longer, and the consequence is, that the capital involved (soil and growing stock) does not yield as high interest as in the State forests of Saxony. The Spessart, for instance, an extensive forest area belonging to the State in the kingdom of Bavaria, contains a large growing stock of old oak timber, 250 to 450 years old, which, if cut and sold at the present time, would fetch about £1,500,000. The existing working plan governs operations during a period of 120 years, from 1888 to 2007, and particularly prescribes the manner in which the old standing oak timber shall be utilised. About 60 per cent. of the quantity alluded to consists of trees 300 to 450 years old, with hardly any volume- or value-increment. These it is proposed to cut during the next forty years. If they were cut now, and the proceeds were used to redeem part of the State debt, upwards of £27,000 a year would be saved in interest. The remaining 40 per cent. consists of trees now about 250 years old. These will furnish the yield in oak timber from 1936 to 1983, and when they are cut the volume will be greater, and the timber, being larger, will fetch much higher prices. Nevertheless, in the case of this portion, also, there will be considerable loss of interest. This sacrifice of interest is made deliberately by the Government of Bavaria, with the full consent of the Parliament at Munich, because it is considered desirable to maintain a regular supply of oak timber from this source, upon which numerous industrial establishments in the large villages all round the Spessart to a great extent depend.

And there are many other forest tracts in Germany of large extent, both public and private, which still contain enormous stores of old-growing timber, the inheritance of several centuries. In such cases it is right on many grounds to spread the removal of the old timber over a long series of years, and rather to work the forests on conservative than on purely financial principles. In Great Britain, however, circumstances are more similar to those which exist in Saxony, and hence, in the management of its woodlands, financial considerations will probably preponderate.

Part iii. deals with working plans; and this portion of the book cannot be sufficiently recommended to forest proprietors in Great Britain. In the first volume of his manual, Dr. Schlich justly drew attention to the large importation into the United Kingdom of timber and other forest produce, and he estimated that £12,000,000 a year represented the value of oak, birch, coniferous and other woods imported from abroad, that might be produced in Great Britain. This was in 1889; it was a cautious estimate, and since it was made, the imports into the United Kingdom have increased steadily.

Landed proprietors in Great Britain have fortunately not yet suffered to the same extent by the decline in the price of wheat and other agricultural produce, as proprietors in some parts of Germany. Yet their income has diminished, and in many cases it doubtless would be desirable to increase that income. Much might be done in this direction, if the management of existing woodlands were improved, and if land which it does not pay to keep under the plough, or to convert into grass land, were planted up and converted into forest. One objection commonly raised to this proposal is, that timber traders prefer imported to home-grown timber. That this is the case there is no doubt, and in the preface to the present volume Dr. Schlich explains the reason. Home-grown timber cannot, as a rule, compete with imported timber, because it has not grown up in dense compact masses. The woods are open, hence the bole is short, branched, and knotty. There are exceptions, but open park-like woods are the rule, and these cannot be expected to yield timber of good quality. A different system of sylviculture must be adopted. Of greater importance still is the adoption of regular systems of management. Timber of different kinds and of the exact qualities required by the market is imported regularly in sufficient quantities at the principal ports of the United Kingdom; the timber trader is able to make the needful arrangements to supply his customers, because he is certain that whatever he may require to meet their demands, will be available at the right time. Home-grown timber, on the other hand, is thrown upon the market in an irregular fashion. All at once heavy cuttings are made at one place, to provide money, or for other reasons, and then perhaps nothing is cut in the same district for years to come. The necessary consequence of such a system, or rather want of system, is that the timber is not sold at its full value. And when a calamity occurs, such as the storm of 1894, the timber blown down cannot be sold, except at ruinously low rates. The only remedy is the adoption of methodically arranged working plans in all forest tracts throughout the country. Among other things, such working plans determine the annual yield of each forest district. It does not follow that the yield once fixed must be pedantically maintained. A good working plan is elastic, and permits deviations to suit the interests of the proprietor. But if a methodical system of working is the rule in all forest districts, these deviations will generally compensate each 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

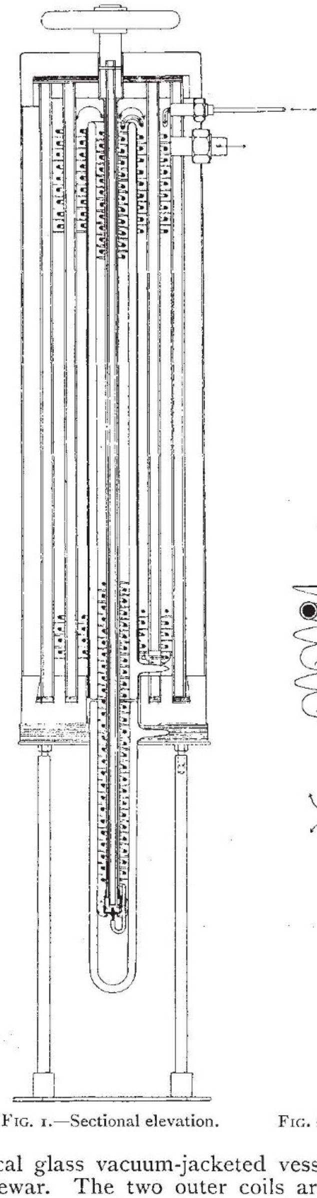


FIG. 1.—Sectional elevation.

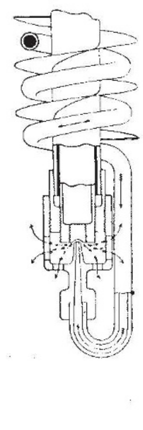


FIG. 2.—Detail of valve.

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