influence of the ethereal whirls due to their axial rotation, cause simultaneously spots on the sun and cyclones on the earth.

We fail to follow M. Weyher here, and think it would have been better if he had not only hesitated, as he admits he did, but decided not to publish such wild speculations. His experiments are exceedingly instructive

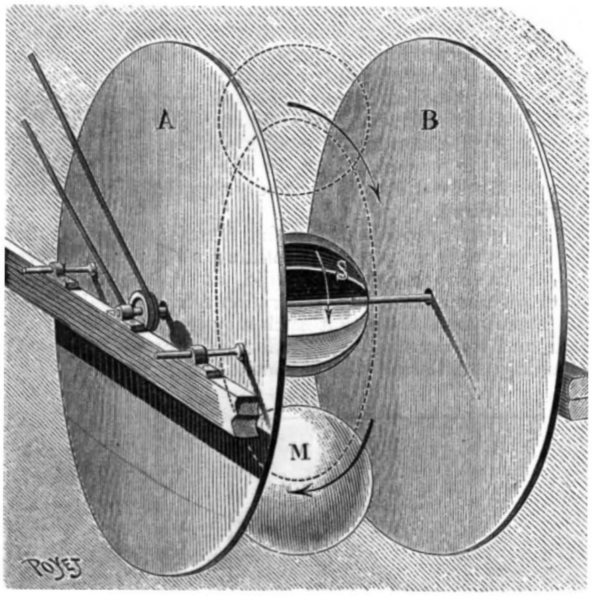

FIG. 5.

and suggestive, and if he can ultimately succeed in imitating the conditions of Nature more closely, we shall doubtless have an end of the theoretical polemics which have hitherto retarded rather than aided the progress of our knowledge of aërial motions and their causes.

E. DOUGLAS ARCHIBALD.

TIMBER, AND SOME OF ITS DISEASES.[1]

VII.

IF we pass through a forest of oaks, beeches, pines, and other trees, it requires but a glance to see that various natural processes are at work to reduce the number of branches as the trees become older. Every tree bears more buds than develop into twigs and branches, for not only do some of the buds at a very early date divert the food-supplies from others, and thus starve them off, but they are also exposed to the attacks of insects, squirrels, &c., and to dangers arising from inclement weather, and from being struck by falling trees and branches, &c., and many are thus destroyed. Such causes alone will account in part for the irregularity of a tree, especially of a Conifer, in which the buds may be developed so regularly that if all came to maturity the tree would be symmetrical. But that this is not the whole of the case, can be easily seen, and is of course well known to every gardener and forester.

If we remove a small branch of several years' growth from an oak, for instance, it will be noticed that on the twigs last formed there is a bud at the axil of every leaf; but on examining the parts developed two or three years previously it is easy to convince ourselves of the existence of certain small scars, above the nearly obliterated leaf-scars, and to see that if a small twig projected from each of these scars the symmetry of the branching might be completed. Now it is certain that buds or twigs were formed at these places, and we know from careful observations that they have been naturally thrown off by a process analogous to the shedding of the leaves; in other words, the oak sheds some of its young branches naturally every year. And many other trees do the same; for instance, the black poplar, the Scotch pine, *Dammara*, &c.; in some ees, indeed, and notably in the so-called swamp cypress *Taxodium distichum*) of North America, the habit is so ronounced that it sheds most of its young branches very year.

But apart from these less obvious causes for the suppression of branches, we notice in the forest that the ajority of the trees have lost their lower branches at a uch later date, and that in many cases the remains of e proximal parts of the dead branches are sticking out om the trunk like unsightly wooden horns. Some of these ranches may have been broken off by the fall of neighbourg trees or large limbs; others may have been broken by e weight of snow accumulating during the winter; others, gain, may have been broken by hand, or by heavy wind; nd yet others have died off, in the first place because the ver-bearing shade of the surrounding trees cut off the ccess of light to their leaves, and secondly because the ow of nutritive materials to them ceased, being diverted

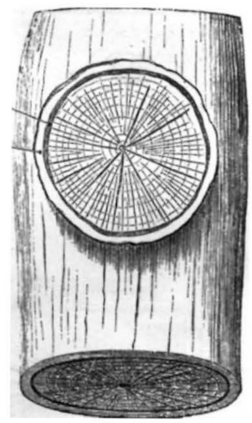

FIG. 21.—Portion of a tree from which a branch has been cut off close to the stem. *C*, the cambium of the branch; *B*, the cortex.

into more profitable channels by the flourishing, growing parts of the crown of leaves exposed to sunlight and air above.

The point I wish to insist upon here is that in these cases of branch-breaking, however brought about, open wounds are left exposed to all the vicissitudes of the forest atmosphere; if we compare the remnant of such a broken branch and the scar left after the natural shedding of a branch or leaf, the latter will be found covered with an impervious layer of cork, a tissue which keeps out damp, fungus-spores, &c., effectually.

It is, in fact—as a matter of observation and experiment —these open wounds which expose the standing timber to so many dangers from the attacks of parasitic fungi; and it will be instructive to look a little more closely into the matter as bearing on the question of the removal of large branches from trees.

If a fairly large branch of a tree, such as the oak, is cut off close to the trunk, a surface of wood is exposed, surrounded by a thin ring of cambium and bark (as in Figs. 21 and 22). We have already seen what the functions of the cambium are, and it will be observed that the cut edge of the cambium (*C*) is suddenly placed under different conditions from the usual ones; the chief change, and the only one we need notice at present, is that the cambium in the neighbourhood of the cut surface is released

[1] Continued from vol. xxxvii. p. 516.

from the compressing influence of the cortex and bark, and owing to this release of pressure it begins to grow out at the edges into a cushion or "callus," as shown in Figs. 23 and 24. A very similar "callus" is formed in the operation of multiplying plants by "cuttings," so well

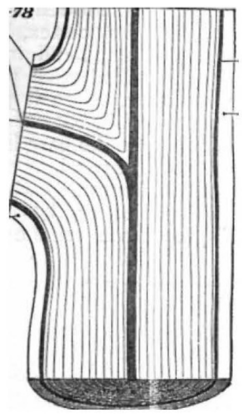

FIG. 22.—The same in longitudinal section. *P*, the pith of stem and branch; on either side of this are the twelve annual zones of wood produced during the years 1867–78, as marked. The cambium, *C*, separates these from the cortex, *B*.

known to all: the cambium at the cut surface of the "slip" or "cutting," is released from the pressure of the cortex, and begins to grow out more rapidly in the directions of less pressure, and forms the callus.

Now this callus (Fig. 23, *Cal*) is in all cases something more

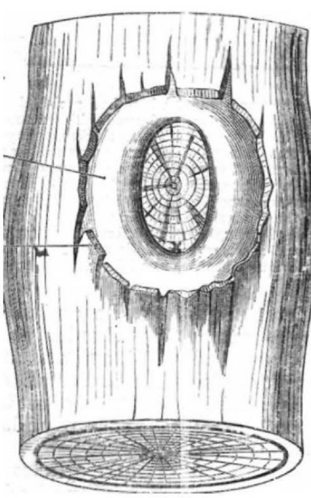

FIG. 23.—The same piece of stem four years later. The cushion-like development, *Cal*, resulting from the overgrowth of the cambium and cortical tissues of the cut branch, has extended some distance from the edges, and is covering in the exposed wood. *B* is the dead outer corky tissue, incapable of growth, and partially cracked under the pressures exerted by the thickening of the stem. The latter is somewhat swollen transversely, owing to the release of pressure in this region enabling the cambium to develop a little more actively here; the quicker growth of the occluding cushion in the horizontal direction is due to the same cause.

than mere cambium—or rather, as the cambium extends by cell-divisions from the cut edge of the wound, its outer parts develop into cortex, and its inner parts into wood, as in the normal case. The consequence is that we have in the callus, slowly creeping out from the margins of the wound, new layers of wood and cortex with cambium between them (Fig. 24); and it will be noticed that each year the layer of wood extends a little further over the surface of the wound, and towards the centre of the cut branch; and in course of time, provided the wound is not too large, and the tree is full of vigour, the margins of the callus will meet near the middle, and what was the exposed cut surface of the branch will be buried beneath layers of wood and cortex, between which lies the cambium, now once more continuous over the whole trunk of the tree (Figs. 25 and 26).

It is not here to the purpose to enter into the very interesting histological questions connected with this callus-formation, or with the mechanical relations of the various parts one to another. It is sufficient for our present object to point out that this process of covering up, or *occlusion*, as I propose to term it, requires some time for its completion. For the sake of illustration, I have numbered the various phases in the diagram, with the years during which the annual rings have been formed; and it

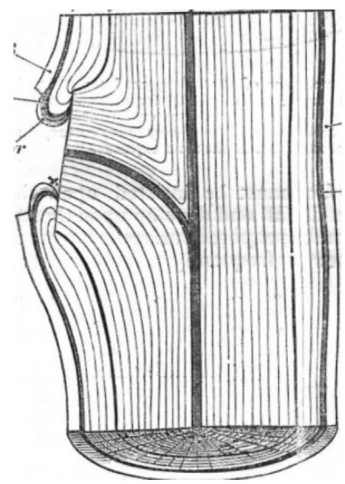

FIG. 24.—The same in longitudinal section: *P*, *B*, and *C* as before. The four new layers of wood formed during 1879–82 are artificially separated from the preceding by a stronger line. On the left side of the figure it will be noticed that the cambium (and therefore the wood developed from it) projected a little further over the cut end of the branch each year, carrying the cortical layers (*Cor*) with it. At ×, in both figures, there is necessarily a depression in which rain-water, &c., is apt to lodge, and this is a particularly dangerous place, since fungus-spores may here settle and develop.

will be seen at a glance that, in the case selected, it required seven years to cover up the surface of the cut branch (cf. Figs. 21–26). During these seven years more or less of the cut surface was exposed (Fig. 24) to all the exigencies of the forest, and it will easily be understood that abundant opportunities were thus afforded for the spores of fungi to fall on the naked wood, and for moisture to condense and penetrate into the interior; moreover, in the ledge formed at × in Figs. 23 and 24, by the lower part of the callus, as it slowly creeps up, there will always be water in wet weather; and a sodden condition of the wood at this part is insured. All this is, of course, peculiarly adapted for the germination of spores; and, since the water will soak out nutritive materials, nothing could be more favourable for the growth and development of the mycelium of a fungus. These circumstances, favourable as they are for the fungi, are usually rendered even more so in practice, because the sawyers often allow such a branch to fall, and tear and crush the cambium and cortex at the lower edge of the wound. These and other details must be passed over, however, and our attention be confined to the fact that here are ample chances for the spores of parasitic and other fungi to fall on a surface admirably suited for their development.

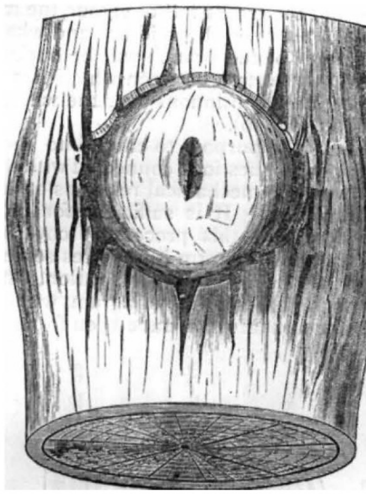

FIG. 25.—The same piece of stem six years later still: the surface of the cut branch has now been covered in for some time, and only a boss-like projection marks where the previous cut surface was. This projection is protected by cork layers, like ordinary outer cortex, the old outer cortex cracking more and more as the stem expands.

The further fact must be insisted upon that numerous fungus-spores do fall and develop upon these wounds, and that by the time the exposed surface is covered in (as in Fig. 25) the timber is frequently already rotten, usually for

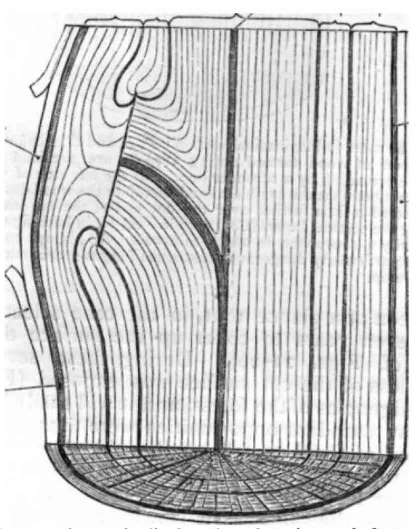

FIG. 26.—The same in longitudinal section: lettering as before. Six new layers of wood have been developed, and the cut end of the branch was completely occluded before the last three were formed—*i.e.* at the end of 1885. After that the cambium became once more continuous round the whole stem, and, beyond a slight protuberance over the occluded wound and the ragged edges of the dead corky outer layers, *B*, there are no signs of a breach.

some distance down. In the event of fungi, such as have been described above—parasites and wound-parasites—gaining a hold on such wounds, the ravages of the mycelium will continue after the occlusion is complete, and I have seen scores of trees, apparently sound and whole, the interior of which is a mere mass of rottenness: when a heavy gale at length blows them down, such trees are found to be mere hollow shells, the ravages of the mycelium having extended from the point of entry into every part of the older timber.

In a state of nature the processes above referred to do not go on so smoothly and easily as just described, and it will be profitable to glance at such a case as the following.

A fairly strong branch dies off, from any cause whatever—*e.g.* from being overshadowed by other trees. All its tissues dry up, and its cortex, &c., are rapidly destroyed by saprophytic fungi, and in a short time we find only a hard, dry, branched stick projecting from the tree. At the extreme base, where it joins the tree, the tissues do not at once perish, but for a length of from half an inch to an inch or so the base is still nourished by the trunk. After a time, the wind, or a falling branch, or the weight of accumulated snow, &c., breaks off the dead branch, leaving the projecting basal portion: if the branch broke off quite close to the stem, the wound

FIG. 27.—Base of a strong branch which had perished naturally twenty-four years previously to the stage figured. The branch decayed, and the base was gradually occluded by the thickening layers of the stem: the fall of the rotting branch did not occur till six years ago, however, as can be determined from the layers at *e* and *f*, which then began to turn inwards over the stump. Meanwhile, the base had become hollow and full of rotten wood, *g*. It is interesting to note how slight the growth is on the lower side of the branch base, *i*, as compared with that at *h* above: the line numbered 24 refers to the annual zones in each case. As seen at *b* and *d*, the rotting of the wood passes backwards, and may invade the previously healthy wood for some distance. (After Hartig.)

would, or at least might, soon be occluded; but, as it is, the projecting piece not only takes longer to close in, but it tends to rot very badly (Fig. 27), and at the best forms a bad "knot" or hole in the timber when sawn up. Of course what has already been stated of cut branches applies here: the wounds are always sources of danger so long as they are exposed.

It is beyond the scope of these articles to set forth the *pros* and *cons* as to the advisability of adopting any proposed treatment on a large scale: the simple question of cost will always have to be decided by those concerned. But whether it is practicable or not on a large scale, there is no question as to the desirability of adopting some such treatment as the following to preserve valuable trees and timber from the ravages of these wound-parasites. Branches which break off should be cut close down to the stem, if possible in winter, and the clean cut made so that no tearing or crushing of the cambium and cortex occur; the surface should then be painted with a thorough coating of tar, and the wound left to be occluded. If the cutting is accomplished in spring or summer, trouble will be caused by the tar not sticking to the damp surface. Although this is not an absolute safeguard against the attacks of fungi—simply because the germinal tubes from spores can find their way through small cracks at the margin of the wound, &c.—still it reduces the danger to a minimum, and it is certain that valuable old trees have been preserved in this way.

Before passing to treat of the chief diseases known to start from such wounds as the above, it should be remarked that it is not inevitable that the exposed surface becomes attacked by fungi capable of entering the timber. It happens not unfrequently that a good closure is effected over the cut base of a small branch in a few years, and that the timber of the base is sound everywhere but at the surface: this happy result may sometimes be attained in pines and other Conifers, for instance, by the exudation of resin or its infiltration into the wood; but in rarer cases it occurs even in non-resinous trees, and recent investigations go to show that the wood formed in these healing processes possesses the properties of true heart-wood. At the same time there is always danger, as stated, and we will now proceed to give a brief account of the chief classes of diseases to which such wounds render the tree liable.

The first and most common action is the decay which sets in on the exposure of the wood surface to the alternate wetting and drying in contact with the atmosphere: it is known that wood oxidizes under such circumstances, and we may be sure that wounds are no exception to this rule. The surface of the wood gradually turns brown, and the structure of the timber is destroyed as the process extends.

The difficulty always arises in Nature, however, that mould-fungi and bacteria of various kinds soon co-operate in and hurry these processes, and it is impossible to say how much of the decay is due to merely physical and chemical actions, and how much to the fermentative action of these organisms. We ought not to shut our eyes to this rich field for investigation, although for the present purpose it suffices to recognize that the combined action of the wet, the oxygen of the air, and the fermenting action of the moulds and bacteria, &c., soon converts the outer parts of the wood into a mixture of acid substances resembling the humus of black leaf-mould.

Now as the rain soaks into this, it dissolves and carries down into the wood below certain bodies which are poisonous in their action on the living parts of the timber, and a great deal of damage may be caused by this means alone. But this is not all: as soon as the decaying surface of the wound provides these mixtures of decomposed organic matter, it becomes a suitable soil for the development of fungi which are not parasitic—*i.e.* which cannot live on and in the normal and living parts of the tree—but which can and do thrive on partially decomposed wood. The spores of such fungi are particularly abundant, and most of the holes found in trees are due to their action. They follow up the poisonous action of the juices referred to above, living on the dead tissues; and it will be intelligible that the drainage from their action aids the poisonous action as it soaks into the trunk. It is quite a common event to see a short stump, projecting from the trunk of a beech, for instance, the edges of the stump neatly rounded over by the action of a callus which was unable to close up in the middle, and to find that the hollow extends from the stump into the heart of the trunk for several feet or even yards. The hollow is lined by the decayed humus-like remains of the timber, caused by the action of such saprophytes as I have referred to. Similar phenomena occur in wounded or broken roots, and need not be described at length after what has been stated.

But, in addition to such decay as this, it is found that if the spores of true wound-parasites alight on the damp surface of the cut or broken branch, their mycelium can extend comparatively rapidly into the still healthy and living tissues, bringing about the destructive influences described in Articles III. and IV., and then it matters not whether the wound closes over quickly or slowly—the tree is doomed. H. MARSHALL WARD.

(*To be continued.*)

HERVÉ MANGON.

IN the current number of *La Nature* there is an interesting article, by M. Gaston Tissandier, on Charles François Hervé Mangon, whose death we announced last week. The following are the essential facts noted by M. Tissandier.

Hervé Mangon was born in Paris on July 31, 1821, and was trained by his father, a military surgeon, who devoted himself almost entirely to the education of his son. At the age of nineteen the young man entered l'École Polytechnique, and two years later l'École des Ponts et Chaussées. He afterwards acted as engineer for several railways, but his chief interest at that time was in science as applied to agriculture.

In 1850 he published his "Études sur les Irrigations de la Campine Belge," and on the "Travaux Analogues de la Sologne." This work attracted great attention, and brought about important improvements in the French laws relating to agriculture. Drainage was then scarcely known, even by name, in France. In 1851, M. Hervé Mangon published a work on the subject, which was considered so valuable that he received from the Academy of Sciences the decennial prize for the most useful work on agriculture issued during the previous ten years. His practical instructions on drainage, of a little later date, were widely circulated, and it is estimated that the results of his researches have led to an increase, in the French revenue, of fourteen millions of francs yearly. Irrigation, manures, chemical refuse, and everything by which land might be fertilized, were made by him subjects of prolonged and careful study. He visited the principal agricultural works and irrigations in France, Belgium, Scotland, Spain, and Algiers, and summed the knowledge thus acquired in his "Traité de Génie Rural."

These researches were followed by meteorological studies, in which he took the deepest interest. He invented or improved many meteorological instruments, and on his estate at Brécourt in Normandy he organized a model meteorological station, provided with the latest scientific improvements. Towards the end of his career he played a most important part in the reorganization of the French meteorological service, and he became the President of the Meteorological Council. He contributed also to the organization of the scientific mission to Cape Horn, and to many other enterprises useful to science.

As a Professor, he created at the École des Ponts et Chaussées the course on "Hydraulique Agricole" (1849); at the Conservatoire des Arts et Métiers the course on "Travaux Agricoles et de Génie Rural" (1864); and at the new Institut National the course on "Génie Rural" (1876), a science of which he may be considered one of the founders. He lectured with ease, and his expositions were always clear and methodical.

He possessed an extraordinary power of work. He rose early, carried on his own correspondence, and did all his literary work without assistance. His personal tastes were simple, and the activity of his body seemed to keep pace with that of his mind. He welcomed fellow-workers cordially, and readily offered them counsel and help, his disposition being one of rare generosity. He was skilful in working in wood and metal, and always kept in his library a quantity of apparatus made by himself. With this he was constantly experimenting, sometimes even getting up during the night to carry on some research of special interest.