meter, the time occupied in passing from the upper to the lower well being thus found, and giving the rate of flow of the water.

Further details of observations of underground flow as carried out by this method are given in paper No. 112, by Homer Hamlin, with numerous illustrations of the apparatus used.

Stove-pipe Wells.—In the same report is a paper by Charles S. Slichter on the method of sinking stove-pipe wells. These consist of a riveted sheet steel starter from 15 feet to 25 feet long, made of two or three thicknesses of sheet steel with a forged steel shoe at the lower end. The rest of the casing consists of two thicknesses of sheet steel made into riveted lengths of 2 feet, one set of sections being made just so much smaller than the other as to permit them to telescope together. Each outside section overlaps the inside section 1 foot. This casing is sunk, length by length, by hydraulic jacks, which press on the upper sections by means of a suitable head. After the well has been sunk to the required depth, a cutting knife is lowered into the well and vertical slits are cut in the casing opposite such water-bearing strata as may have been met with; a well 500 feet deep may have 400 feet of screen if circumstances justify it. The perforator is handled with 3-inch pipe. By raising slowly on the line with hydraulic jacks, cuts are made from three-eighths to three-fourths of an inch wide, and from 6 to 12 inches long.

The well casings vary in diameter from 17 inches to 14 inches, and are sunk to depths from 500 feet to 1400 feet, the yield of water varying from 300,000 to 3,000,000 gallons in twenty-four hours. The cost of a 12-inch 500 feet well is about 140*l.* for labour and 100*l.* for materials, the drillers being paid 1*l.* and the labourers 10*s.* a day. The soil where these wells are in use consists of mountain débris, clay, gravel, sand, and boulder.

Pollution of Streams by Waste from Factories.—Paper No. 103 contains a review of the laws in operation in the different States of America for the prevention of pollution of inland waters. The broad legal principles under which anti-pollution statutes become operative are explained, and important Court decisions are quoted to show the authority upon which certain deductions in the report are founded.

In paper No. 133 the special stream pollution arising from the refuse water from the "straw board" factories is dealt with. In Indiana, Ohio, and Illinois there are several large factories engaged in making pasteboard from rye, wheat, and oat straw. For this process 40,000 gallons of water are required to wash 1 ton of straw, and 3200 lb. of straw and 560 lb. of lime are required to make 2000 lb. of board. In an ordinary factory 2,000,000 gallons of water are used daily, which carries with it 19 tons of straw waste and 10 tons of lime. This waste generally runs into a neighbouring stream, and is the cause of a serious amount of pollution. The report of the Government Commissioner for Fisheries states that the pollution of the streams in Indiana by the refuse from the strawboard mills, oil mills, and pulp mills is greater than from any other source. The refuse from these covers the spawning beds and prevents the eggs from hatching, while it penetrates the gills of the living fish and either kills or drives them away from the streams.

The remedy is by chemical precipitation of the waste products, but it is contended that the small profit on the manufacture of strawboard does not permit of the application of the process required.

Another source of water pollution dealt with in this report arises from the overflow from the oil wells in Indiana. Around the city of Marion there are no less than seventy-five oil wells in a few square miles of territory. Upwards of 300 surface and rock wells in this area are suffering contamination from this source. The strata in this district consists of sand and gravel for about 50 feet, then clay for about 80 feet, and below this limestone. The water supply of the town and neighbourhood is derived from water in the limestone, and there is a constant flow of underground water. Oil occurs near the top of the formation. Beneath the oil is salt water. In order to form a reservoir for the oil the limestone is entered some distance, and the most successful wells are those which are drilled deep enough to allow a large amount of oil to collect, so as to be above the upper level of the brine. These oil wells are generally 1000 feet deep, the oil rising to within 600 feet or 700 feet of the surface. When the well is bored it is "shot" with nitroglycerin, which breaks up the limestone and forms fissures and small cavities which act as reservoirs into which the oil flows. The surface effect of the shooting is the violent ejection of salt water and oil, often to the extent of thousands of gallons. The oil and salt water then sink into the soil where it is porous, and finally reach the surface zone of underground flow, where they partake of the general movement of the water toward the main line of underground drainage, and cause its pollution. The brine and oil pumped from these oil wells is discharged into a settling tank. The oil, owing to its lighter specific gravity, settles at the top and is drawn off, the brine being discharged into any neighbouring creek or stream, or is allowed to sink slowly into the ground, in either case becoming a serious source of pollution to the water supply of the neighbourhood.

Paper No. 121 relates to the pollution of Lake Champlain, by M. O. Leighton. The report was made in consequence of complaints made to the Government that the water of the lake has been rendered unfit for domestic consumption; that the usefulness of the lake for watering cattle has been destroyed; and that the refuse poured into it is destructive to fish life. The cause of pollution is due to the waste discharged into it from the pulp mills situated on its banks. The analysis of the water and other details are interesting to those who have to deal with the making of pulp and similar industries.

Paper No. 122 is entitled "Relation of the Law to Underground Waters," by D. W. Johnson, and contains an outline of the main features of the laws respecting underground waters with the object of giving to the owner of such waters some idea of his rights and obligations concerning them. Such legal decisions as serve to show the relation of the law to the problems which are essentially geological in character are referred to. Underground waters are defined and classified. Although this paper refers to United States practice, there is a great deal of information that would be of service to water engineers in this country. We shall refer more fully to this paper in a future number.

THE PERCY SLADEN EXPEDITION IN H.M.S. "SEALARK" TO THE INDIAN OCEAN.

I HAVE just received the following interesting communication from Mr. Stanley Gardiner. It was written from Port Victoria, Seychelles, under date October 28, and is the fourth report of his expedition which he has sent home. Mr. Gardiner is expected home early in the New Year. For his earlier reports, see NATURE, August 10, October 5, and November 9. A. SEDGWICK.

Cambridge, December 1.

During the ten days that the *Sealark* left us at Coetivy while she was coaling in the Seychelles, we as thoroughly as possible collected the animals and plants of both the land and reef. The island was higher than any we had up to that time visited, having wind-blown sand ridges and hills up to 80 feet above sea-level, arising on a flat coral reef. Although situated only about 130 miles to the south of the Seychelles Islands, the land fauna and flora are almost the same as on the islands of the Chagos Archipelago, being scarcely richer in either. The plants, of course, in the main necessarily govern the fauna, and it would appear to us that they are in their turn governed rather by the nature of the soil—coral and coral sand—than by their proximity to continental land. On the other hand, the reefs of Coetivy showed in every group of marine animals a more varied fauna than those of the Chagos, while very nearly all the species of the latter seemed to be present. The reef on the eastern, or seaward, face of the island was of a rather different character from any we had as yet seen (or from any I have seen in the Pacific), being covered with a grass-like weed, locally termed "varech." There was also on the same part a

considerable variety of other algæ, but the edge and outer slope were, as elsewhere, covered by corals and nullipores. The reef, however, to the west, where there is a flat extending out for some miles with about 16 fathoms of water, closely resembled similarly situated reefs in the Chagos, but the greater variety of its organisms was equally marked, though individual species were much less common.

Leaving Coetivy on September 25, we proceeded to a point about midway between Madagascar and Farquhar Atoll, both to ascertain the depth and the compass variation. The latter was almost the same as at Mauritius, situated 9 degrees to the south, while the depth, 1856 fathoms, precludes the idea of any close connection between the two localities. Farquhar, which we then visited, was (as, indeed, were all the reefs we subsequently saw) remarkable for its almost completely covered "varech" reefs, both rim and lagoon. Its land attains a height of more than 70 feet, and is clearly of the same formation as that of Coetivy; it shows no trace of elevation, and it has not been formed, as has been stated, by submarine deposits. The section of the reef also showed the outer slope to be quite similar to that of other atolls.

From Farquhar we proceeded to sound between the chain of islands that extends between Madagascar and the Seychelles, and which would appear to indicate a line of former connection. Between Farquhar and Providence, 32 miles, we found 890 fathoms, and between the latter and Alphonse-François, 155 miles, 2170 fathoms, while there were already soundings of 952 fathoms between Alphonse and the Amirante Group, 46 miles, and of 1150 fathoms between the latter and the Seychelles, 32 miles. As the depth on either side is only about 2300 fathoms, any connecting ridge is comparatively low and of doubtful importance.

Providence was particularly interesting, being simply a great reef, 28 miles long by 7 miles broad to the 100-fathom lines. Off it we took twelve dredgings, obtaining a rich fauna down to about 100 fathoms, below which the bottom was exceedingly barren of life. From one dredging at 744 fathoms, 3 miles to the west of the reef, we obtained about 5 cwt. of stones, the largest about 2 feet in diameter. We have here no means of properly ascertaining their nature, but similar rock has not, so far as we are aware, been hitherto described off any coral reef. It is almost entirely insoluble in acids, and is largely formed of different crystals, organic deposits practically not entering into its composition. Some masses looked like solidified ash or clay, while others *appeared* rather like volcanic bombs. All were more or less coated with manganese, but we do not know its thickness, preferring to keep the specimens intact for proper examination on our return to England. However, it is clear that the existence of this rock in such a position will have to be carefully considered in connection both with the formation of Providence Reef and with the existence of any former land connection between the Seychelles plateau and Madagascar.

Pierre Island, 17 miles to the west of Providence Reef, and with a depth of 1088 fathoms between, is peculiar in having no fringing reef. It is simply an elevated coral island, reaching to a height at present of about 30 feet, surrounded by overhanging cliffs, so that landing is extremely difficult. Its rock is entirely coral.

Alphonse and François are sandbanks on the rims of two reefs, scarcely 2 miles apart. Both reefs are of atoll formation, the lagoon of Alphonse (not shown in any chart) being 3 to 8 fathoms deep and of considerable size.

The Amirante Islands are likewise sandbanks, no parts of any being more than 10 feet above the high-tide level. The hills represented in the separate enlarged plans of D'Arros, St. Joseph, and Desroches do not exist, and probably owe their presence thereon to the imagination of the draughtsman.[1] Desroches is really an atoll by itself, lying 10 miles to the east, and being separated by a channel 874 fathoms deep. The rest of the islands and reefs lie on a bank about 50 miles long by 20 miles broad, with an average depth of about 30 fathoms. Eleven separate reefs reach the surface, of which St. Joseph alone has a lagoon, being really a small atoll with about 4 fathoms of water in the centre. With the exception of Eagle, D'Arros, and Bertant, all the reefs lie on the edge of the bank, but its edge is in most places covered by at least 8 to 10 fathoms of water. Its slope is steeper than is customary off coral reefs, no possible dredging ground existing between 60 and 500 fathoms.

All the islands of the Amirante Group, with the exception of Marie-Louise and Eagle, are now planted for cocoanut oil, but the indigenous vegetation still remains in places. The land plants and animals are almost the same as at Coetivy and in the Chagos, the additions due to the

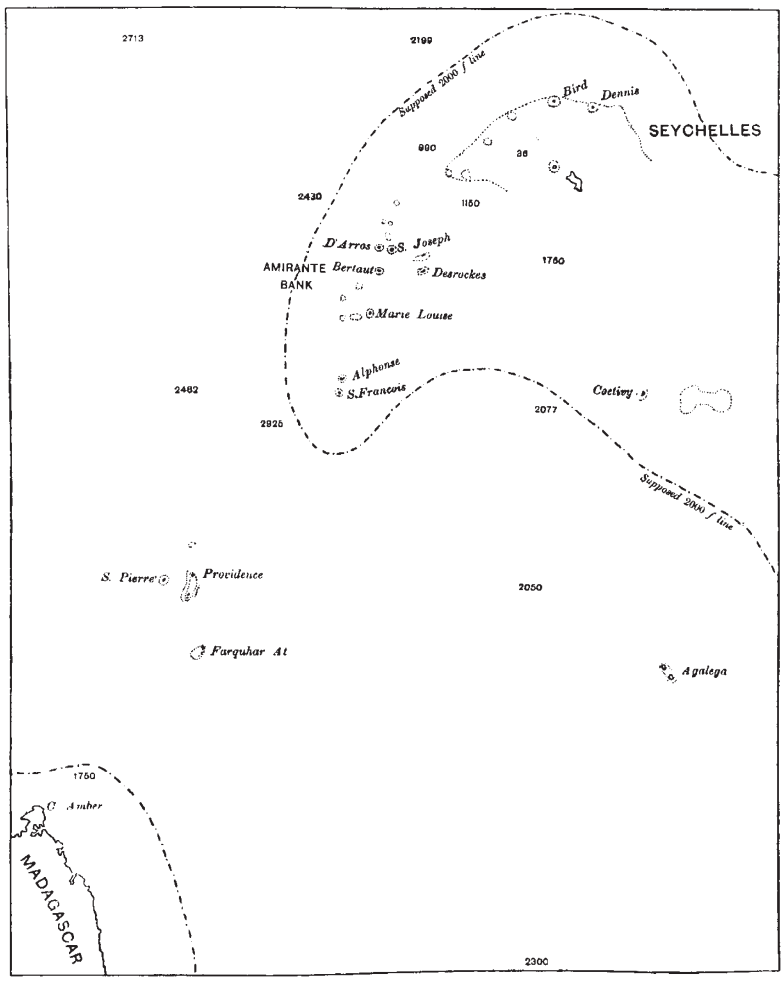

FIG. 1.—Chart of the Indian Ocean between Madagascar and the Seychelles.

[1] If we had had any idea of this earlier, we should have probably visited Cosmoledo and perhaps Aldabra.

proximity of Africa and the Seychelles being relatively few. The marine fauna and flora was markedly richer than even at Coetivy.

Of other work, we have taken about sixty dredgings off the islands we visited down to more than 800 fathoms, and tow-nettings at various depths to more than 1000 fathoms. We have consequently rich collections, but obviously no estimate of them can be at present formed. We have also serial temperatures in a series of positions, and water samples have been taken throughout down to various depths. Magnetic observations have also been secured at intervals along the line between Madagascar and the Seychelles.

As we are now leaving H.M.S. *Sealark*, I would like to express our great indebtedness to Commander Boyle T. Somerville and every officer and man on board for their great kindness and most cheerfully rendered assistance to Mr. Forster Cooper and myself. Nothing has seemed too great or intricate or small for them to undertake, from a complicated survey to the repair of delicate instruments or dredges. The weather throughout the voyage—the season chosen was governed by considerations relating to hurricanes—has been, generally speaking, most unsuitable and unpleasant, but work has nevertheless gone on almost continuously. All regular survey work, sections across the islands, soundings, magnetic, tidal and temperature observations, &c., have been done by Commander Somerville and his officers. Mr. Beer, the artificer engineer in charge, and his staff have been indefatigable in eking out the coal, on which our movements necessarily depended to a large degree, and in effecting the not inconsiderable repairs connected with such a long cruise away from regular ports. The artificers (carpenter, blacksmith, and armourer) have never failed over the varied and unusual work which they have at times been called upon to undertake, and, finally, every individual hand has been splendid in giving of his very best to assist the expedition to success.

J. STANLEY GARDINER.

FORESTRY IN BELGIUM.

THE Royal English Arboricultural Society paid a visit to the Belgian forests on August 12–22. The Belgians, like ourselves and all other European countries, except Scandinavia, Russia, Austria, and some of the smaller States near the Black Sea, have insufficient woodlands to supply the timber that is necessary for their requirements. In 1840, Belgium imported 187,920*l.* worth of timber, but in 1893 the imports were valued at 4,677,880*l.*, together with about 1,200,000*l.* of wood-pulp and other articles manufactured out of wood, such as matches, gun-stocks, masts, furniture, bark, &c. The annual exports of wood from Belgium are now valued at 600,000*l.* only, so that there is an annual deficit of timber production in the country amounting to more than 5,000,000*l.*

The Belgian Government is dealing with this deficit in the most statesmanlike manner, by using all available means for increasing the production of timber, by improving the management of the existing woodlands, and by planting their waste-lands.

The areas of woodlands in Belgium, according to the agricultural statistics of 1895, are as follows:—

Nature of proprietor	Area in acres
State	62,600
Communes	395,455
Public establishments	17,380
Private owners	828,300
Total	1,303,735

The area of forests in Belgium is therefore about one-sixth of the total area of the country.

The small area of the Belgian State forests is chiefly due to the fact that, between 1815 and 1830, when the country was united to Holland, the Government sold all the State forests, and the present area of State forests has been bought back from private owners through the wise policy of the first king, Leopold I.; this has been continued recently by the present Government, which purchases suitable private woodlands whenever they are for sale.

In 1850 there were the following areas of waste-land in Belgium; I have not been able to obtain more recent figures:—

	Acres
State	17,140
Communal	145,267
Private	423,322
Total	585,729

Since 1897 the State has been acquiring waste-lands and re-planting them, 212,960*l.* having been so invested up to date, and land to the extent of 15,317 acres having been acquired and planted.

The State has no power of compelling communes to plant their waste-lands, but important subsidies are granted by the State to encourage them to do so. The Forest Department also organises annual sylvicultural conferences with the object of inducing communes and private owners to utilise their waste lands. This has been so successfully managed, that in the province of Luxemburg, where there were in 1847 126,000 acres of waste-land, by the end of 1887 only 42,000 acres of waste remained in the province, the balance having been converted into 49,000 acres of arable land and pastures and 35,000 acres of woods.

In the space of this short article it is impossible to do more than give a mere sketch of the interesting woodlands recently visited by the Royal English Arboricultural Society in Belgium. It would interest British municipalities, such as those of Liverpool and Leeds, that are engaged in planting the catchment areas of their waterworks, to see the immense tract of woods that cover the catchment area of the Gileppe, a stream rising in the Ardennes and feeding a large reservoir, constructed between 1869 and 1898, to supply water for the population that carries on the extensive woollen industry in Verviers and the other hamlets lower down. The planting with spruce of the Hautes Faynes, or peat district of the Hertogenwald, at altitudes between 1600 and 2160 feet, which is being carried on at the rate of 1000 acres annually, is a vast and highly original work, the rapidity and excellence of which merit careful study.

Plantations of Austrian pine on the very dry and hot Devonian limestone rocks, near Rochefort, supply valuable wood as pit-timber, and afford shelter and increased moisture to the neighbouring farms. The domain of Mirwart, belonging to an Antwerp family named von der Becke, and managed by Dr. Schlich, where millions of spruce and other trees have been planted to replace 32,000*l.* worth of inferior timber that was cut out between 1892–1902, was also visited. Here, forty acres of Scots pine, now thirty years old, has already yielded in thinnings, since 1891, 11*l.* per acre net, while in another eight years, when the whole will be felled as pit-timber, it will yield 64*l.* per acre, or a total return, including thinnings, of 75*l.* per acre.

The domain of Chenoy, belonging to Mr. Boël, contains magnificent beech, oak, and ash standards over coppice. The underwood is sold as pit-timber. Oak trees containing 100 to 140 cubic feet (solid measure) are not uncommon, and some of the ash standards are quite as large. These trees sell standing at 2*s.* and 2*s.* 6*d.* per cubic foot. Abeles (*Populus alba*) up to 80 feet in height are not uncommon, and sell at 9*d.* per cubic foot. It is a curious feature of these woods that whenever the aspect is south or west, the poor Tertiary sandy soil (Bruxillien), from which the fertile superficial loam has been washed, will yield only pines or birch, while immediately the aspect changes to north or east, and the loam remains *in situ* over the sand, splendid broad-leaved woods are produced. In the valleys, Silurian rock crops out from below the sand, all the usual intermediate strata being absent. There we saw a considerable area of Scots pine wood, about forty years old, the trees of which are being pulled up by their roots by a machine, "La