Similarly, for the probability that all the particles of nitrogen are in the space B, we find

$$\left(\frac{b}{a+b}\right)^{2\times 10^{12}}$$

Hence the probability that all the oxygen is in A and all the nitrogen in B is

$$\left(\frac{a}{a+b}\right)^{2\times 10^{12}} \times \left(\frac{b}{a\times b}\right)^{8\times 10^{12}}$$

Now by hypothesis

$$\frac{a}{a+b} = \frac{2}{10}$$

and therefore

$$\frac{b}{a+b} = \frac{8}{10}$$

hence the required probability is

$$\frac{2^{26\times 10^{12}}}{10^{10^{13}}}$$

Call this $\frac{1}{N}$, and let log denote common logarithm. We have $\log N = 10^{13} - 26\times 10^{12}\times \log. 2 = (10 - 26 \log. 2)\times 10^{12} = 2173220\times 10^{6}$. This is equivalent to the result stated in the text above. The logarithm of so great a number, unless given to more than thirteen significant places, cannot indicate more than the number of places of whole numbers in the answer to the proposed question, expressed according to the Arabic notation.

The calculation of T_i when i and $n-i$ are very large numbers is practicable by Stirling's Theorem, according to which we have approximately

$$1.2\ldots i = i^{i+\frac{1}{2}}\epsilon^{-i}\sqrt{2\pi}$$

and therefore

$$\frac{n(n-1)\ldots(n-i+1)}{1.2\ \ldots\ i} = \frac{n^{n+\frac{1}{2}}}{\sqrt{2\pi}\, i^{(i+\frac{1}{2})}(n-i)^{n}}$$

Hence for the case

$$i = n\,\frac{a}{a+b}$$

which, according to the preceding formulæ, gives T_i its greatest value, we have

$$T_i = \frac{1}{\sqrt{2\pi n e f}}$$

where

$$e = \frac{a}{a+b} \text{ and } f = \frac{b}{a+b}$$

Thus, for example, let $n = 2\times 10^{12}$;

$$e = \cdot 2,\ f = \cdot 8$$

we have

$$T_i = \frac{1}{800000\sqrt{\pi}} = \frac{1}{1418000}$$

This expresses the chance of there being 4×10^{11} molecules of oxygen in A, and 16×10^{11} in B. Just half this fraction expresses the probability that the molecules of nitrogen are distributed in exactly the same proportion between A and B, because the number of molecules of nitrogen is four times greater than of oxygen.

If n denote the molecules of one gas, and n' that of the molecules of another, the probability that each shall be distributed between A and B in the exact proportion of the volume is

$$\frac{1}{2\pi e f\sqrt{n\,n'}}$$

The value for the supposed case of oxygen and nitrogen is

$$\frac{1}{2\pi\times \cdot 16\times 4\times 10^{12}} = \frac{1}{4021\times 10^{9}}$$

which is the result stated at the conclusion of the text above.

WILLIAM THOMSON

LIVINGSTONE'S WORK IN AFRICA

THE daily papers have published some extracts from a letter written from Lake Bangweolo, of the late Dr. Livingstone to Mr. H. M. Stanley, which have been kindly furnished by the enterprising proprietor of the *New York Herald*; we reproduce here so much of the letter as bears on the geographical work done by Livingstone.

"The Chambezi was crossed long ago by the Portuguese, who have thus the merit of its discovery in modern times. The similarity of names led to its being put down in maps as 'Zambesi' (eastern branch) and I rather stupidly took the error as having some sort of authority. Hence my first crossing it was as fruitless as that of the Portuguese. It took me twenty-two months to eliminate this error.

"The Cazembe who was lately killed was the first who gave me a hint that Chambezi was one of a chain of rivers and lakes which probably forms the Nile; but he did it in rather a bantering style that led me to go back to the head waters again and see that it was not the mere 'chaff' of a mighty potentate. There is Omar Island in the middle of Bangueldo, with 183° of sea horizon around. The natives, slowly drawing the hand around, said—'That is Chambezi flowing round all this space and forming Bangweolo before it winds round that headland and changes its name to Luapula.' That was the moment of discovery and not the mere crossing of a small river.

"The late Cazembe I found sensible and friendly. His empire has succumbed before a very small force of Arab slaves and Banyamwezi. Pereira, the first Portuguese who visited the Cazembe eighty years ago, said that he had 30,000 trained soldiers, sacrificed twenty human victims every day, and that the streets of his capital were watered daily. I thought that my late friend had 30,0(00), diminished by two oo's, and sacrificed five or six pots of pombe daily; but this may have been only a court scandal—the streets of his village were not made. So I was reminded of the famous couplet about the Scotch roads:—

"'If you had seen these roads before they were made,
You would lift up your hands and bless General Wade.'

"I have been the unfortunate means of demolishing two empires in Portuguese geography—the Cazembes and that of the Emperor Monomotapa. I found the last about ten days above Tette. He had too few men to make the show Cazembe did, but I learnt from some decent motherly-looking women attached to his Court Zembere (?) that he had 100 wives. I have wondered ever since and have been nearly dumfoundered with the idea of what a nuisance a man with 100 wives in England would be. It is awful to contemplate, and might be chosen as a theme for a Young Men's Debating Society. I wish someone would visit Mtesa, or Uganda, without Bombay as an interpreter. He (Bombay) is by no means a sound author. The King of Dahomey suffered eclipse after a common-sense visit, and we seldom hear any more of his atrocities. The mightiest African potentate and the most dreadful cruelties told of Africans owe a vast deal to the teller.

"You and I passed the islet Kasenge, where African mothers were said to sell their infants for a loin-cloth each. This story was made to fit into another nice little story of 'a mother bear' that refused to leave her young. A child that cuts its upper front teeth before the under is dreaded as unlucky and likely to bring death into the family. It is called an Arab child, and the first Arab who passes is asked to take it. I never saw a case, nor have the Arabs I have asked seen one either, but they have heard of its occurrence. The Kasenge story is, therefore, exactly like that of the Frenchman who asserted that the English were so fond of hanging themselves in November you might see them swinging on trees along the road. He may have seen one; I never did. English and American mothers have been guilty of deserting infants; but who would turn up the whites of his eyes and say, as our mothers at Kasenge did, these people are no better than, or not so good as, she-bears?

"This lake, so far as I have seen it, is surrounded by

an extremely flat country, though all 4,000 ft. above the level of the sea. When first discovered I was without paper, but borrowed a little from an Arab, and sent a short account home. I had so much trouble from attendants that I took only the barest necessaries. Yet no sooner was the discovery announced at the coast than the official description was forthwith sent to the Bombay Government, that 'the lake is like Nyassa, Tanganyika, and the Albert Nyanza, overhung by high mountain slopes, which slope down to great plains, which, during the rainy season, become flooded, so that caravans march for days through water knee-deep seeking for higher ground on which to pass the night.'

"The only mountain slopes are ant-hills, some of them 20ft. high. They could scarcely be called high unless thought of as being built on the top of the 4,000 ft. These statements are equally opposed to the truth, as the Cazembe town is built on the banks of the Luapula.

"People having a crochet for map-making traced every step of the Portuguese slaving expeditions to Cazembe, and built the village in latitude 8° 43′ South—that is, in deep water, near the north end of Lake Moero, and over 50 miles from Luapula. I found it in latitude 9° 37′ South, and on the banks of a lagoon or loch, having no connection with Luapula, which river, however, falls six or seven miles west of the village of Moero.

"Now it is very unpleasant for me to expose any of these misstatements and so appear contradictious. But what am I to do? I was consulted by Sir Roderick Murchison as to this present expedition, and recommended the writer of the above as a leader. Sir Roderick afterwards told me that the offer was declined unless a good salary and a good position to fall back upon were added, as Speke and Grant had, on their pay and commission. He then urged the leadership on myself as soon as the work on which I was engaged should be published. My good, kind-hearted friend added, in a sort of pathetic strain, 'You will be the real discoverer of the source of the Nile.' I don't wish to boast of my good deeds, but I need not forget them. . . ."

SOUNDINGS IN THE PACIFIC

RECENT explorations in the Pacific Ocean indicate that its bed is singularly level. The soundings of the U.S. steamer *Tuscarora*, Capt. George T. Belknap, between Cape Flattery and Oonalaska, were described in NATURE, vol. viii. p. 150. Upon the conclusion of that cruise, which included also soundings from Cape Flattery to San Francisco, a month was spent in the latter harbour, and on December 5 a survey was begun between that port and San Diego on the same coast, especially between depths of 100 and 1,500 fathoms. The latter depth or a greater one is reached precipitately along the entire coast of California, at distances of 20 to 70 miles from shore. Off the Golden Gate, in the latitude of San Francisco Bay, at a distance of 30 miles, there is 100 fathoms; at 55 miles' distance, there is a sudden descent from 400 fathoms to a depth of two miles; at 100 miles out, 2,548 fathoms failed to reach bottom.

Soundings between San Diego, California, and Honolulu, Sandwich Islands, show that this part of the Pacific is a basin with precipitous sides and a comparatively level bottom. The distance between these points, surveyed by the *Tuscarora*, is 2,240 miles. The work was accomplished between January 6 and February 3, favourable weather being experienced during almost the entire voyage.

In the first 100 miles west from San Diego, there appear to be two valleys and two peaks. The first valley is from 622 to 784 fathoms depth; the first peak 445 fathoms, the second valley 955 fathoms, the second peak 566 fathoms. Thence a precipitous fall takes place, giving in lat. 31° 43′ N., long. 119° 28′ W., at 115 miles from San Diego, a depth of 1,915 fathoms. After that there is a gentle slope with comparatively unimportant interruptions, at the rate of three feet to the mile, to the point of greatest depth, 3,054 fathoms, at a distance of about 400 miles east of Honolulu. The sharpest elevation is a rise about midway between the United States and the Sandwich Islands, in lat. 26° 30′ N., long. 127° 37′ W., the highest portion of which is 2,159 fathoms below the surface. At the next cast of the lead, the valley to the west of this elevation took 2,650 fathoms. The fall of the side of the basin east of Honolulu is even more remarkable than the descent off the American coast. Fifty miles from Honolulu, soundings gave 498 fathoms; at 40 miles farther east, in lat. 21° 43′ N., long. 156° 21′ W., the depth was 3,023 fathoms. Between the last-mentioned point and that of greatest depth a hill rises, on whose summit there are only 2,488 fathoms of water.

These soundings coincide very nearly with the determinations of the depth of the Pacific made on theoretical grounds by the United States Coast Survey in 1854. Those calculations were based on the movements of tidal waves occasioned by earthquakes in Asia. The wave that reached San Francisco had a length of 210 to 217 miles, an oscillation of 35 minutes, and a velocity of 6·0 to 6·2 miles per minute. This would give a depth of 2,200 to 2,500 fathoms. Similar data with regard to the wave that reached San Diego (having a length of 186 to 192 miles) were calculated as giving an average depth of 2,100 fathoms. The average depth of the present soundings is about 2,400 fathoms.

The bottom is generally a soft, yellowish-brown ooze, better suited in this respect, as well as in being more level, than the route surveyed toward Oonalaska, for a telegraphic cable. Other considerations of an economic character, such as prospects of connection with other telegraph lines, may also serve to overbalance the shortness of the more northern route, and there is much better prospect of fair weather for laying a cable and keeping it in repair in the lower latitudes.

Surface-temperatures rose from 59° F. near San Diego, to 74° F. near Honolulu; temperatures at 105 fathoms between the same places rose from 50° F. to 63° F. These, of course, indicate the equatorial current. At 300 fathoms the temperature was constant at 43° F. At bottom, the temperature was everywhere 35° F., except in a single instance where it was 1° colder. The uniformity of temperature below 1,600 fathoms was noticeable.

One wire has been used in all these soundings, which were made every 40 miles, and the apparatus still works excellently.

M. CHARLES SAINTE-CLAIRE DEVILLE'S WEATHER PROGNOSTICATIONS

THE prognostications delivered by M. Charles Sainte-Claire Deville, in his communication of March 2, before the French Institute, were wonderfully fulfilled, at least for Paris, the cold period having had its beginning on the 9th, and its end on the 13th, as was predicted. Public attention was all the more attracted because the cold was manifested by a heavy fall of snow, which was the first of the year. Having recently visited M. Ch. Sainte-Claire Deville, the learned physicist was kind enough to explain everything connected with his theories.

M. Ch. Sainte-Claire Deville has very often published similar prognostications which were always successful, but never in so striking a way. He has been a constant compiler of meteorological records for nearly twenty years; and being the Inspector-General of the French Meteorological Stations, as well as a member of the French Academy of Sciences, he has consequently at his command an immense number of trustworthy observations.

He has discovered that there is monthly a large thermometrical oscillation, which he calls dodecuple, from the