meteorological services is that of observing from an aeroplane. This method is expensive and is restricted to those days when it is possible for an aeroplane to fly. In consequence, efforts are now being made to develop wireless methods.

Mr. L. H. G. Dines, of Kew Observatory, described the meteorograph in greater detail, and showed a number of specimen records obtained by its use. On account of the lightness of the instrument, it can be sent up with any other instruments used for the investigation of conditions in the upper air.

Prof. K. O. Lange, of Blue Hill Observatory, Harvard University, described a wireless transmitter which has been developed at Blue Hill, for use on balloons in conjunction with a receiver at the ground. The transmitter sends out waves of constant frequency, and the aim of the designer of the instrument is to replace the measures of the meteorological elements by time intervals. The meteorological instruments are an aneroid, a bimetallic thermometer and a hygrometer. Each of these instruments is equipped with a pen arm, and these pen arms, together with a fixed pen, slide over a small cylinder on which is wound a fine platinum wire in the form of a helix. The helix and the pens are wired to the transmitter, and the cylinder on which the helix is wound is rotated by a clockwork which makes two revolutions per minute. The contacts of the fixed pen with the helix bring the transmitter into action at regular intervals of ½ minute, while the pens attached to the meteorological instruments bring the transmitter into action at times which are determined by the readings of these instruments. The signals being recorded on the drum of a chronograph, the lags between the records given by the moveable pens and the fixed pen are readily estimated and converted into the readings of the corresponding meteorological element.

The instrument shown by Prof. Lange is extremely compact, being contained in a small wooden box, the external dimensions of which do not exceed 8 in. × 4 in. × 3 in. This method is now being adopted at some of the upper air stations in the United States, instead of the aeroplane ascents which have hitherto provided the data required for weather forecasting. It is likely that the same or similar instruments will be in general use in many parts of the world within a few years, in view of the saving of money, combined with the enormously increased frequency of observations, which will be obtained when this method supplants the aeroplane. The use of such instruments will open up the possibility of obtaining observations of the conditions in the central part of depressions and in other conditions when it is impossible for an aeroplane to make an ascent, as in rain or fog.

Prof. F. A. Paneth, in continuing the discussion, explained the methods by which he and Mr. Dines had obtained samples of air at high levels in the atmosphere, and showed some of the results of analysing these samples. The most interesting result so far obtained is the apparent increase in the proportion of helium present in air at levels of 25 km. and upward, indicating a tendency for the component gases of the atmosphere to separate out according to their molecular weights at such levels in the atmosphere. Further observations will be required before this can be accepted as conclusively proved. Prof. Paneth emphasized the importance of analysing samples of air from high levels for their water-vapour content. In view of the fact that nearly all the radiation and absorption of long-wave radiation in the atmosphere are produced by water vapour, it is of the greatest interest to meteorologists to know how much water vapour actually is present at high levels in the atmosphere. D. B.

The Percy Sladen Expedition to Lake Titicaca*

By H. C. Gilson, Leader of the Expedition

SINCE April 14, the day after the arrival of the main body at Puno, the Expedition has been established in a hacienda (Camjata) on the peninsula of Capachica, which bounds the north side of Puno Bay (see Fig. 1). The first fortnight was spent settling in, arranging laboratory accommodation, and transporting all our numerous cases of apparatus and equipment out from Puno, a four-hour trip by motor launch. During this time a good deal of miscellaneous collecting was done in the ponds and streams of the peninsula, but it was not until the beginning of May that work on the lake could be started in earnest. Since then routine hydrographical and chemical observations

* See also the article by Prof. J. Stanley Gardiner in NATURE of Feb. 27, 1937, p. 353.

have been made at a station about four miles out from the anchorage, besides numerous trips farther afield. An intensive faunistic and ecological study has been made of the anchorage and neighbouring bays, also supplemented by expeditions to other shores of the lake.

The hydrography of the lake is somewhat complicated, and no certain conclusions as to the water movements can be drawn from our work as yet. It can be seen from Fig. 2, which shows temperature profiles for the same station at different dates, that during the two and a half months of our observations there has been a steady loss of heat from the lake as a whole. At the same time the thermocline has moved down from 60 metres to 100 metres and its temperature difference has decreased. The causes of these two changes are presumably to be found in the considerable radiation which occurs during the nights, which are almost always clear at this season, and in mixing by the wind. The latter has not been strong, averaging 9·4 m.p.h. in May, 8·8 m.p.h. in June, and 9·5 m.p.h. in the first half of July, but higher velocities have probably been reached for short periods in July than in the preceding months.

The lake water is distinctly alkaline, the *p*H varying from about 8·5 in the surface layers to 7·75 at the bottom. It has a comparatively high content of solutes, the chloride alone ranging from 245 to 250 parts per million. The alkali reserve shows small variations about 0·0023 *N*, being generally rather lower in the illuminated zone. Of the nutrient salts, silicate ranges from 300 mgm. to 800 mgm. Si per cubic metre in the photosynthetic zone, and rises to 2,000 mgm. Si in the depths; phosphate shows a similar reduction in the surface layers where it never exceeds 15 mgm. P/m.^{3}, but depletion by the plankton is by no means complete, as we have never found this figure to be less than 7; in deep water it rises to about 25. Dissolved oxygen approaches saturation above the thermocline, frequently showing a maximum at 5 or 10 metres, as is commonly found in the sea. Below the thermocline the concentration is lower but never falls below 45 per cent of saturation, which suggests that there must be complete circulation at some time of the year. An experiment with raw plankton gave the 'compensation point' at 13 metres, but the true level is probably somewhat lower.

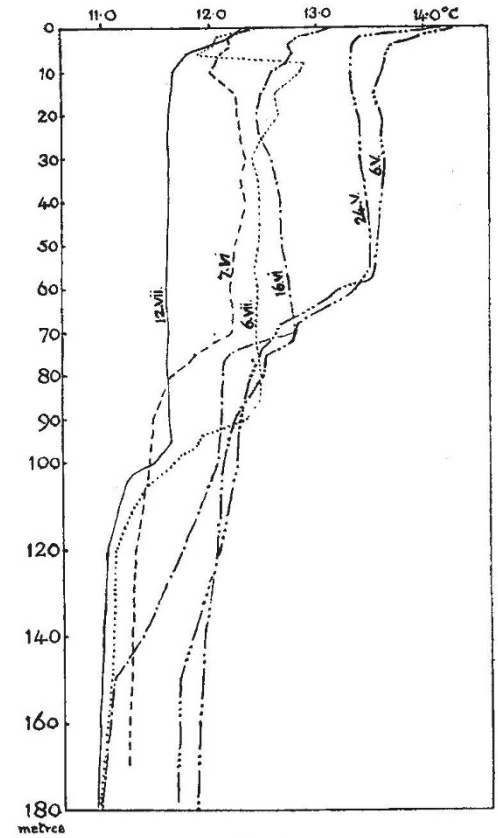

Fig. 2.

TEMPERATURE PROFILES AT A STATION IN LAKE TITICACA.

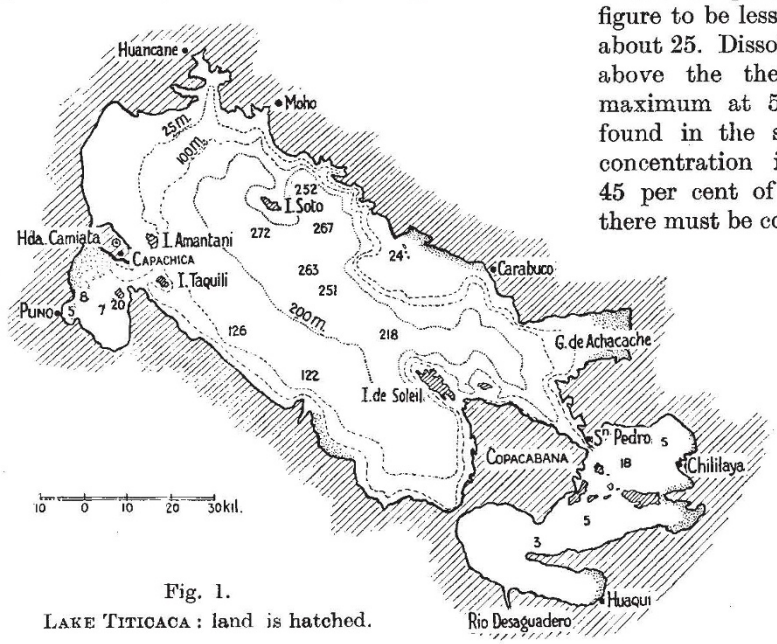

Fig. 1.

LAKE TITICACA: land is hatched.

Plankton is abundant, the principal plankton animal being a species of *Diaptomus*. Early in the season a daphnid was also present in considerable numbers, but later gave place to a small chydorid. Several species of rotifer are also common. The dominant phytoplankton forms

are a diatom and a colonial green alga resembling *Dictyosphærium*. The latter is abundant at all depths down to 50 metres; the diatom is found alive down to 15 metres, but below this there are only dead shells. The less common forms show an interesting vertical distribution. Thus from 10 to 20 metres *Lagerheimia* sp. (Chlorococcales) and *Chlamydomonas* sp. occur; from 20 to 30 metres *Oocystis* sp. (Chlorococcales) is found and *Peridinium* sp. in small numbers; from 30 to 40 metres the *Peridinium* is common with *Staurastrum* sp. (Desmidiaceæ); from 40 to 50 metres there is little alive except the *Dictyosphærium* and *Peridinium*.

Round the shores the rooted vegetation varies considerably with depth, exposure and type of bottom. In all sheltered places where the depth is between 1 and 4 metres, such as the major part of Puno Bay, there is a thick growth of "tortora" (*Scirpus riparius*). Underneath this and elsewhere is a mixed smaller vegetation which shows a marked zonation with depth. Thus in moderate shelter from 0·2 to 0·5 metre *Zannichellia* sp. is dominant; from 0·5 to 8 metres there is a mixed vegetation of *Potamogeton*, *Elodea* and *Myriophyllum*; from 8 to 13·5 metres *Chara* sp. is dominant; from 13·5 to 17 metres this is replaced by a moss. With greater exposure the zones tend to be shifted downwards, perhaps owing to the harder bottom and consequently clearer water found there.

The fauna of the lake is rich in individuals, but species are not numerous. No Isopoda, Neuroptera, Plecoptera, Hydrometridæ or Gerridæ have been found.

In the "tortora" swamp occur *Notonecta* and the water beetles *Agabus* and *Trophisternus*. The same species of these genera are also present in ponds near the lake. In the belt of low-growing weeds which fringes the shores down to a depth of about 10 metres, the most abundant animals are several species of *Hyalella* (Amphipoda) and *Littoridina* (Mollusca). Besides these, Turbellaria, Oligochæta, *Platytaphius* (a ramshorn snail), *Ancylus* (a freshwater limpet), *Pisidium*, *Sphærium*, leeches, water mites, Corixidæ and the larvæ of caddis flies, Chironomidæ and dryopid beetles are usually found. A green sponge is common, growing on plant stems. A similar fauna is present in the shallow lagoons near the north end of the lake.

On bare stony bottoms *Hyalella* is dominant, as many as 1,500 having been counted to the square foot. Below the 10-metre line the bottom is usually muddy and contains *Platytaphius* and *Hyalella* (different species from those in the weed), *Pisidium*, leeches, chironomid larvæ and sponges.

There are in the lake a number of species of *Orestias* (a Cyprinoid fish), a large catfish, and an aquatic frog (*Cyclorhamphus*). The catfish is also found in the larger rivers which run into the lake, and in these it is fished commercially.

In the smaller streams near the lake and the headwaters of the rivers are numerous beetles, larvæ of dragonflies and mayflies, *Planorbis*, *Sphærium* and *Hyalella*. The same species of *Planorbis* has been found near Cuzco in the Amazon basin; and the same, or a closely related, species of *Hyalella* as far down as Quillobamba

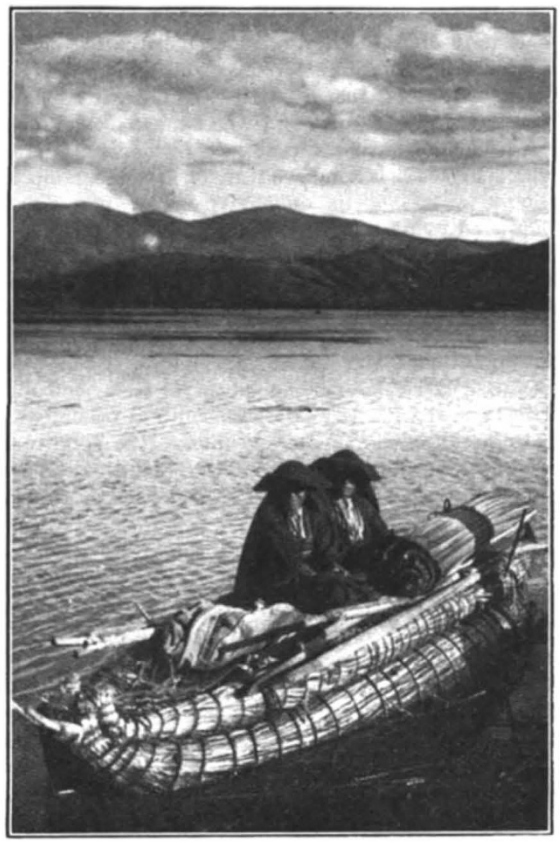

Fig. 3.

NATIVE BOAT WITH WOMEN WEARING A TYPE OF HAT COMMON IN COUNTRY DISTRICTS NEAR LAKE TITICACA.

(3,600 feet) in the Amazon basin, as well as at San Antonio (15,500 feet) in the Pacific drainage area. In some of the temporary ponds near our base a species of *Estheria* (Conchostraca) was abundant until they dried up.

Besides the field work, the results of which are very briefly summarized above, a good deal of laboratory work has also been done. Hinton has worked out the life-histories of nearly all the important insects, besides making extensive collections of the terrestrial insect fauna. Collections have also been made of many of the birds and their parasites.

I am much indebted to all my colleagues for their wholehearted co-operation in all the work of the Expedition and for much of the information contained in this article. We are also indebted to Señor Carlos Landaeta B. for allowing us to use the Hacienda Camjata as our base, and to the officials of the Peruvian Corporation in Puno and Arequipa for arranging our food supplies and helping us in innumerable other ways. We gratefully acknowledge the help thus afforded the Expedition.

Obituary Notices

Prof. Frank Morley

FRANK MORLEY, professor emeritus of mathematics at Johns Hopkins University, died at Baltimore on October 17. He was born in 1860 at Woodbridge in Suffolk, and was educated at Woodbridge School until he went into residence at Cambridge in 1879, having won an open scholarship at King's College. His university career was sorely hampered by illness. He did not graduate until 1884, a year later than the normal date, eighth in the list when G. B. Mathews was senior wrangler and A. N. Whitehead fifth. Ill-health beyond all doubt had prevented him from doing himself justice, but the disappointment was keen. In middle life he was loth to speak of his student days, yet the friendships then formed with Lowes Dickinson and others were lasting. It is saddening to contrast the conditions of sixty years ago with the encouragement and the opportunities that are offered to a clever boy to-day.

For three years after leaving Cambridge, Morley was a master at Bath College. Then, by the good offices of Dr. Rendel Harris, Morley (whose parents were Quakers) became professor at the Quaker College of Haverford, Pa. From then onwards his home was in America. The hardships of his earlier years were behind him; his health no longer caused him anxiety, though he was always cautious; he married, feeling that his position was assured, and lived in Haverford for twelve years, years of great happiness, during which his powers and his reputation steadily increased. His closest mathematical associations were with two Cambridge professors at the neighbouring college of Bryn Mawr, Charlotte Scott from Girton College, one of the foremost of the younger geometers, and James Harkness of Trinity College, who collaborated with him in his first book, a treatise on the theory of functions published in 1893, and reissued six years later in a shortened and much improved form as an introduction to that subject.

In 1900, Frank Morley accepted the professorship of mathematics at Johns Hopkins University, Baltimore; this he held until he reached the age of retirement nearly thirty years later. His election to this famous chair, always associated in Britain with the name of J. J. Sylvester, was an honour that could scarcely be surpassed. Other honours were bestowed upon him as the years passed by; they will not be catalogued here. He filled his high office and performed its duties with dignity and distinction.

At Johns Hopkins the work was more onerous and the responsibilities were greater than at Haverford; it is not unreasonable to feel regret that Morley's output of original papers was thereby lessened, for it is in these that his most characteristic work is to be found. As a boy and a young man Morley had shown exceptional promise as a chess-player; throughout his life he could grasp the possibilities of a position at chess or of a hand at cards with astonishing ease and certainty. He had something of the same power in discussing a geometrical configuration, for he proved, not once but many times, that he could penetrate more deeply into its inner significance than the rest of us.

There can be no doubt that the life Prof. Morley loved best was the quiet life of the student, a simple home life with friends near at hand. His elevation to the prominence of the professorship at Johns Hopkins University was a well-deserved honour, but whether it added to his happiness is doubtful. He never allowed himself to lose touch with England; it was his habit to come in alternate years, but after his retirement in 1928 he came every year; always if possible making a stay at both Woodbridge and Cambridge. A few years ago he was stricken with a serious illness while at sea on the way to England, and never wholly recovered his strength. This year he had a heart attack at sea while returning to America, and died peacefully soon after reaching his home at Baltimore.

Prof. Morley leaves a widow and three sons, all of whom were Rhodes scholars at Oxford.

HERBERT W. RICHMOND.

Prof. H. Jacobi

THE death is reported of Prof. Hermann Jacobi, emeritus professor of Sanskrit in the University of Bonn, which took place at Bonn on October 20 at the age of eighty-seven years.

Jacobi's early researches relating to Indian culture and religion dealt with the then little understood cult of Jainism. When quite a young man he accompanied Dr. Buhler, who was a member of the Bombay Educational Service, to Jaisalmer and other centres of Jain learning. He then made a profound study of the cult; and in consequence it was he who was mainly instrumental in securing the recognition in Europe and America of Jainism as an important religious system quite independent of Buddhism, of