vacuum was fairly high. The resistance, however, was low. The experiment was not really a successful one, for there arose some trouble from either small leakages or vapour pressures. The next form was Fig. 7. This gave really bright flashes on a sensitive screen, and the resistance was low. Still another form is that of Fig. 8. The anode now is a hollow cylinder with one end open. The total area of this anode is considerably greater than that of Fig. 3, but the latter gave much the more powerful radiation. It appears, therefore, that both the size and the shape of the anode have an important influence on the radiating power of the apparatus.

The form which gave the most powerful radiation was that of Fig. 3. This sent a powerful radiation through 3 feet of solid timber. The rays on emerging were received on a fluorescent screen made of about fifteen shillings' worth of potassium-platino-cyanide, and the area of which was 36 square inches. This screen was considerably affected by the rays after having traversed the 3 feet of timber, and gave sufficient light to see very small objects in. But the hand, when placed between the screen and the timber, cast no shadow whatever.

The next observation on the power of the radiation was to take the screen to a distance of 30 feet from the source. At this distance the bones of the hand could be seen, but not the flesh. Even the bones cast no deep and sharp shadows at this distance, not owing to lack of fluorescence—for the screen was really bright—but owing probably to the turbidity of the intervening 30 feet of air.

The source was afterwards placed in position at one end of the laboratory, and the screen taken to the opposite end, or rather to the end of the corridor leading to the laboratory—a distance of 62 feet from the source. Even here the screen fluoresced with some energy, but the hand was observed to cast no perceptible shadow. When this apparatus was working, there was no place within the large room where the screen did not fluoresce, the rays passing through masses of timber and tables with surprising penetration.

This experimental tube, however, with its rubber joints and ebonite insulation, is not a lasting concern. Although a good vacuum can be maintained for hours together when not in work, it will not last more than half an hour or so when in continuous use, after which more pumping is necessary. The current evidently produces some change in the rubber and ebonite, disengaging a gas which slowly destroys the vacuum.

In the final instrument the joints are of mercury, and the insulation of porcelain. The joints are first ground and polished, and then flooded with mercury. Except the porcelain, the entire apparatus can be made in the lathe, which is a great consideration. A longitudinal section of the instrument is given in Fig. 9. At the end of the porcelain is an arrangement for focusing, which can be manipulated while the instrument is working, so that a point source can be obtained definitely and easily by trial. This figure, which is reproduced from an early picture, has a spherical anode. This should be replaced by a circular plate resembling the anode of Fig. 3.

This last form of instrument, though designed in the middle of May, has not yet been built, owing to the delay in manufacturing the various parts. The parts are easily enough made, but manufacturers seldom care to attend to single articles except at their own convenience.

In conclusion it may be stated, though it is unnecessary to do so, that the instrument just described owes its existence to the teaching of Prof. Lodge. BENJAMIN DAVIES.

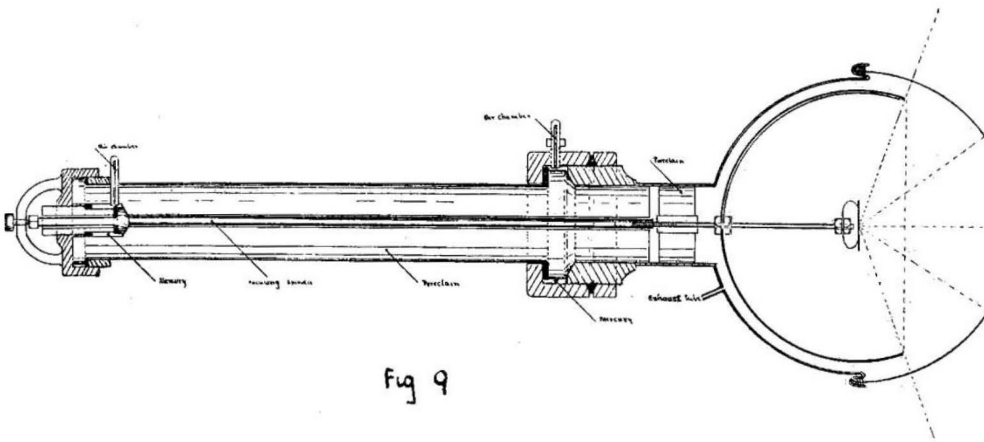

Fig 9

THE ROBOROVSKY EXPEDITION.

ROBOROVSKY and Kozloff, the two explorers who accompanied Prjevalsky in his last journeys, and for two years continued his work of exploration of Central Asia, are now back at St. Petersburg; and they have returned literally loaded with zoological, botanical, and geological collections, together with the results of meteorological observations and extensive surveys, as well as of numerous astronomical determinations. The chief interest of the collections will certainly be centred round the specimens of the wild horse (*Equus Przewalskii*) and wild camel which they have secured, as well as in the great numbers of new species of plants and insects which have been systematically collected by M. Kurilovitch, who stayed at well-chosen stations, while Roborovsky and Kozloff, mostly accompanied by one man only, made the most adventurous "excursions"—that is, journeys three and four hundred miles long—into the unknown highlands of the Nan-Shan. Great privations were endured by the two explorers during these journeys, which were made without guides, during the winter, when the thermometer stood at $-25°$ to $-35°$ C., and fearful snow-storms blew away the tent, while the sand borne by the wind sharply stung the travellers' frozen faces. These privations, of which the Russian travellers speak so light-heartedly, seem, however, to have ruined the health of the chief of the expedition, Roborovsky. And when the expedition made its last journey into the highlands which separate the Nan-Shan highlands from the valley of the Yellow River, Roborovsky, who had already endured pleurisy and erysipelas, was laid down with a stroke of paralysis, which deprived him of the use of all the right part of his body; while the Tangut robbers, who people these mountains, gathered in bands round the small encampment. The expedition was already at the western foot of the high snow-clad chain of peaks of the Alma-machin, which rise on the left bank of the famous bending of the Yellow River; a few days' journey only separated them from the yellow waters of the Hoang-ho; but in such conditions they were compelled to return—the Tanguts immediately taking advantage of the retreat to attack the caravan. They were only repulsed, Roborovsky writes, after "a great loss in men and horses."

Notwithstanding this failure, even the purely geographical results of the expedition, to say nothing of its scientific collections, are very important. From Lake Issyk-Kul the small party proceeded eastwards, exploring the highlands and the plateau of Yulduz, to Karashar, near Lake Denghiz, or Bagrach-Kul, and thence to Turfan and the oasis of Hami. Having now to cross the great desert of the Hashun Gobi, before reaching the Nan-Shans, Roborovsky and Kozloff took two different routes: the eastern route, Hami to Sa-chou, and the western route, from Kurla to Lob-nor, and thence eastwards to Sa-chou, along the northern foot of the great border ridge, the Altyn-tagh. Two excursions made, for 150 miles, into the interior of the desert gave an insight into its physical features, flora and fauna. Moreover, before crossing the Gobi, the expedition explored in detail the remarkable Lukchun depression (in the south-east of Turfan), which was discovered by the brothers Grum-Grzimailo, and proved to be some 150 feet below the level of the ocean, although it is surrounded on all sides by high plateaus. Roborovsky established there a meteorological station, at which the barometer was observed for two consecutive years, and, accordingly, it may now be taken as certain that the surface of this depression is really from 150 to 300 feet below the sea-level.

Spending nearly one year in the Nan-shan highlands, the expedition has covered them with a whole network of surveys; so that when these surveys, as well as Obrucheff's researches are taken into account (as they are in a preliminary map appended to the *Izvestia* of the Russian Geographical Society), we see this region, almost entirely unknown three years ago, better explored now than many parts of Siberia. Where one ridge only was formerly drawn, we find on the new map a series of parallel ridges all running W.N.W. to E.S.E., intersected by high valleys, and attaining by their snow-clad peaks the heights of from 14,000 to 16,000 feet in the chains of Humboldt, Ritter, Da-sue-shan, and Alexander III.'s. The beginnings also have been made of a careful exploration of the Altyn-tagh, which was formerly known through Prjevalsky's and Littledale's journeys along its outer border.

It is pleasant to add that Roborovsky's health has much improved during the return journey, and that, on arriving in Russian Turkestan after a two years' absence, he could report "all well." The account of this journey will add several more important volumes to the scientific literature of Central Asia.

EVAPORATION.[1]

THE quantities of water added to the atmosphere daily by evaporation from the oceans and the continents constitute a fundamental consideration in meteorology; the quantities evaporated from cultivated fields, forests, and other forms of vegetation are equally important in agriculture, but as yet we have confessedly attained to only a very imperfect knowledge of this subject. Meteorologists have generally observed the amount evaporated from a small surface of water exposed either in the open air and sunshine, or else within such a shelter as is used for the open-air thermometer; lately a disc of moist paper has been substituted for the surface of water, as in the Piche evaporometer. Agriculturists, on the other hand, have made use of the lysimeter, which consists of a deep metallic box buried in the earth and having its open upper side flush with the surface of the ground. This box is filled with soil in which plants may or may not be growing, according to the object of the investigator. Record is kept of the amount of water or rain that is added to the lysimeter box from day to day, and also of the amount of water that drains from the bottom of the box. The difference between the two is adopted as the natural evaporation from the soil. The soil in the box may be kept very wet, to imitate a morass, or very dry to imitate a desert; the fineness of the soil may vary from coarse gravel to the finest silt.

If we desire the actual amount evaporated into the atmosphere, we must do more than record the results of the above forms of apparatus. The evaporating surface of water in the shaded thermometer shelter will indeed give up its moisture in proportion to the temperature of the water and to the velocity and dryness of the wind at its surface; but these three important factors have values so different out of doors from those within the shelter, that such records can, at the best, only give us a crude idea of the actual evaporation from surfaces in the open air. A great evaporation within the shelter, caused by a strong, hot, dry wind, may be accompanied by but little evaporation from the surrounding country if the latter be a desert of rock and gravel.

On the other hand, by means of the lysimeter, one may indeed determine directly the evaporation from soil of any character exposed to the natural outdoor conditions; but there then remains the difficult task of determining how much soil of each respective kind really occurs in the surrounding territory. In order, therefore, to determine the actual evaporation from land surfaces, one must observe a large number of lysimeters, and make an extensive minute survey of the country. The calculations incident to this latter method are very laborious.

The ordinary psychrometric observations give the dew-point or quantity of moisture in a small unit volume of air at any moment. If in the course of the day this quantity increases, we are not thereby warranted in concluding that the increase is due to a local evaporation; it may have been brought from a distance by the wind, or it may even have come down from the clouds as rain. If observations of dew-point are carefully made on all sides of a large field, over which a gentle wind is blowing, and if it should appear that there is a little more moisture in the air on the leeward side than on the windward side, one might conclude, provisionally, that this increase represented the quantity of moisture thrown by evaporation into the air as it gently moved over the surface of the field. But even this conclusion must be modified indefinitely by the consideration that in blowing across the field the wind does not move horizontally, but in a series of rolls and whirls by which the lower air in which we are observing becomes mixed with upper air, about whose moisture we know little or nothing.

In the midst of all these uncertainties it seems almost hopeless to attempt anything like an accurate determination of the moisture actually added to the atmosphere by evaporation from any extensive region of land or water; the question is far more complex than the determination of the evaporation from a reservoir of water, which latter problem is often attacked by the hydraulic engineers. Including the earth and its atmosphere in one comprehensive view, we may certainly say that the total annual evaporation from snow and ice, fresh water and salt water, must average the same as the total annual precipitation. We may even make an annual average for each continent, and say that the evaporation from the land plus the water that flows away in the rivers must equal the rainfall, and as the river discharge is frequently well known, we may, by subtraction, infer the evaporation. For the oceanic surface, on the other hand, the evaporation must equal the rainfall plus the river discharge from the continents.

The latest contribution to our knowledge of evaporation from land surfaces is published by Prof. E. Wollny, of Munich, at page 486, vol. xviii., of his "Forschungen." As the result of three years' continuous observations of five lysimeters and a neighbouring evaporometer, he concludes:

(1) That the quantity of moisture evaporated from the soil into the atmosphere is considerably smaller than that evaporated from a free surface of water.

(2) That the evaporation is smallest from naked sand, and largest from naked clay, whereas naked turf and humus or vegetable mould have a medium value.

(3) That the evaporation is increased to a considerable extent by covering the ground with living plants.

As the result of a minute analysis of the complex relations between the evaporation and the meteorological elements, on the one hand, and the physical features of the soil, on the other, Dr. Wollny further concludes as follows:

(4) Evaporation is a process that depends both upon the meteorological conditions and on the quantity of moisture contained by the substratum of soil.

(5) Among the external circumstances temperature is of the greatest importance, inasmuch as, in general, evaporation increases and diminishes with it; but this effect is modified according as the remaining factors come into play, and in proportion to the quantity of water supplied by the substratum.

(6) The influence of higher temperature is diminished, more or less, by higher relative humidity, greater cloudiness, feebler motion of the wind, and a diminished quantity of moisture within the soil, whereas its influence increases under opposite conditions. On the other hand, low temperatures can bring about greater effects than high temperatures if the air is dry, or the cloudiness small, or the wind very strong, or if a greater quantity of water is present within the evaporating substance.

(7) For the evaporation of a free surface of water, or for earth that is completely saturated with water, the important elements are—first the temperature, next the relative humidity

[1] Prof. Cleveland Abbe, in the U.S. *Monthly Weather Review*.