second circle of the still smaller and more numerous droplets that split off the ends of the rays in Fig. 9. The whole of the thirty stages described are accomplished in about one-twentieth of a second, so that the average interval between them is about one six hundredth of a second.

It should be mentioned that it is only in rare cases that the subordinate drops, seen in the last six figures, are found lying in a very complete circle after all is over, for there is generally some slight disturbing lateral velocity which causes many to mingle again with the central drop, or with each other. But even if only half or a quarter of the circle is left, it is easy to estimate how many drops, and, therefore, how many arms, there have been. It may be mentioned that sometimes the surface of the central lake of liquid, Figs. 14, 15, 16, 17, was seen to be covered with beautiful concentric ripples, not shown in the figures.

The question now naturally presents itself, Why should the drop behave in this manner? In seeking the answer it will be useful to ask ourselves another question. What should we have expected the drop to do? Well, to this I suppose most people would be inclined, arguing from analogy with a solid, to reply that it would be reasonable to expect the drop to flatten itself, and even very considerably flatten itself, and then, collecting itself together again, to rebound, perhaps as a column such as we have seen, but not to form this regular system of rays and arms and subordinate drops.

Now this argument from analogy with a solid is rather misleading, for the forces that operate in the case of a solid sphere that flattens itself and rebounds are due to the bodily elasticity which enables it not only to resist, but also to recover from any distortion of shape or shearing of its internal parts past each other. But a liquid has no power of recovering from such internal shear, and the only force that checks the spread, and ultimately causes the recovery of shape, is the surface tension, which arises from the fact that the surface layers are always in a state of extension and always endeavoring to contract. Thus we are at liberty when dealing with the motions of the drop to think of the interior liquid as not coherent, provided we furnish it with a suitable elastic skin. Where the surface skin is sharply curved outward, as it is at the sharp edge of the flattened disk, there the interior liquid will be strongly pressed back. In fact, the process of flattening and recoil is one in which energy of motion is first expended in creating fresh liquid surface, and subsequently recovered as the surface contracts. The transformation is, however, at all moments accompanied by a great loss of energy as heat. Moreover, it must be remembered that the energy expended in creating the surface of the satellite drops is not restored if these remain permanently separate. Thus the surface tension explains the recoil, and it is also closely connected with the formation of the subordinate rays and arms. To explain this it is only necessary to remind you that a liquid cylinder is an unstable configuration. As you know, any fine jet becomes beaded and breaks into drops, but it is not necessary that there should be any flow of liquid along the jet; if, for example, we could realize a rod of liquid of the shape and size of this ruler and liberate it in the air, it would not retain its cylindrical shape, but would segment or divide itself up into a row of drops regularly disposed according to a definite and very simple numerical law, viz., that the distance between the centers of contiguous drops would be equal to the circumference of the cylinder. This can be shown by calculation to be a consequence of the surface tension, and the calculation has been closely verified by experiment. If the liquid cylinder were liberated on a plate, it would still topple into a regular row of drops, but they would be further apart; this was shown by Plateau. Now imagine the cylinder bent into an annulus. It will still follow the same law, i. e., it will topple into drops just as if it were straight. This I can show you by a direct experiment. I have here a small thick disk of iron, with an accurately planed face and a handle at the back. In the face is cut a circular groove, whose cross section is a semicircle. I now lay this disk face downward on the horizontal face of the lantern condenser, and through one of two small holes bored through to the back of the disk I fill the groove with quicksilver. Now, suddenly lifting the disk from the plate, I release an annulus of liquid, which splits into the circle of very equal drops which you see projected on the screen. You will notice that the main drops have between them still smaller ones, which have come from the splitting up of the thin cylindrical necks of liquid which connected the larger drops at the last moment.

Now this tendency to segment or topple into drops, whether of a straight cylinder or of an annulus, is the key to the formation of the arms and satellites, and indeed to much that happens in all the splashes that we shall examine. Thus in Fig. 12 we have an annular rim, which in Figs. 13 and 14 is seen to topple into lobes by which the rays are united in pairs, and even the special rays that are seen in Fig. 9 owe their origin to the segmentation of the rim of the thin disk into which the liquid has spread. The proceeding is probably exactly analogous to what takes place in a sea wave that curls over in calm weather on a slightly sloping shore. Any one may notice how, as it curls over, the wave presents a long, smooth edge, from which at a given instant a multitude of jets suddenly shoot out, and at once the back of the wave, hitherto smooth, is seen to be furrowed or "combed." There can be no doubt that the cylindrical edge topples into alternate convexities and concavities; at the former the flow is helped, at the latter hindered, and thus the jets begin, and special lines of flow are determined. In precisely the same way the previously smooth circular edge of Fig. 8 topples, and determines the rays and lines of flow of Fig. 9.

TRANSFERRING GASES TO VACUUM TUBES.

By JAMES YOUNG, A.R.C.S., F.C.S., and CHARLES R. DARLING, Wh. Sc., A.R.C.S. (Ireland).

WHILE engaged in an examination of the gases evolved by certain minerals, we found it necessary to

devise a method of filling vacuum tubes, using small quantities of gas so as to recover all excess. The subjoined sketch shows the method adopted, and which we found to be more convenient than any other method we have tried.

A three-way capillary tap has one of its arms, B, bent at right angles. The tube, D, containing the gas to be admitted over mercury, and possessing a plain tap, E, is connected to B by means of a mercury joint. Both taps must be perfectly vacuum tight. The arm, C, is connected with the Sprengel or other pump, while the arm, A, is fused to the side piece of the vacuum tube, which latter is made of sufficient length to allow of convenient fusion. After joining to A, the side piece is drawn out so that it may be readily sealed off after filling. The operation is then conducted as follows: The three-way tap is turned so as to connect A and C, and pumping continued until as good a vacuum as possible is obtained. The tap, E, being closed, B and C are then connected, and the space between the two taps pumped free of air. The tap is now turned so as to connect A and B, and the tap, E, turned on, so as to admit a little of the gas into the vacuum tube. The arms, A and C, are again connected, and the excess of gas pumped out and collected over mercury at the bottom of the fall tube, all loss being thus avoided. This process is repeated two or three times to wash out the tube. The tubes may be sparked in situ, so that the pumping may be discontinued at any desired moment, and the tube sealed off.

We may mention that in a specimen of samarskite examined the residual gas obtained, after exploding with oxygen (to remove hydrogen and a hydrocarbon present), absorbing with potash, and removing excess of oxygen with alkaline pyrogallol, was found to be pure nitrogen. This was mixed with oxygen, and sparked for a considerable time over potash. There was a steady diminution of volume during the sparking; but at no period could any trace of helium be detected spectroscopically.

While sparking the tubes with a strong current, with a fairly high vacuum, we obtained brilliant mirrors of platinum deposited on the sides of the tube adja-

cent to the platinum electrodes. This was particularly the case with those containing nitrogen, and when several strands of thin platinum wire twisted together were used as electrodes. With a single piece of thick wire as electrode, only a slight blackening was obtained. With hydrogen and oxygen, using the same current, there was only a very slight deposit in all cases. In the nitrogen tubes, when the deposit attained a certain density, the current flashed across radially from the electrodes, and after a time began to eat away the mirror from the edges, redepositing a portion of it on the walls of the tube at the dark spaces. At the moment when the mirror began to conduct, a brilliant yellowish green fluorescence was observed in the glass which was scarcely visible previously. We have also noticed the phenomenon mentioned by Prof. Ramsay, viz., that with the deposition of the mirrors in nitrogen tubes the gas appears to be carried down by the platinum, a very high vacuum being in some cases obtained, which refused to allow the passage of the current.—Chem. News.

THE INTERNATIONAL GEOGRAPHICAL CONGRESS.

THE sixth International Geographical Congress was formally constituted by the Duke of York, one of the five honorary vice-presidents, in the name of the patron, the Queen, and of the vice-patron, the Prince of Wales. At 9 o'clock a. m., July 26, the delegates from governments and geographical societies assembled in the east conference hall at the Imperial Institute.

The visitors wore decorations and orders and were ranged according to their respective countries. The ceremony of presentation began as soon as the Duke of York entered the room. As the delegates were presented they filed out of the conference room and made their way to the great hall, where already a large and brilliant company had assembled. His Royal Highness delivered his address of welcome in clear and measured tones audible in every part of the great hall.

On its conclusion, Mr. Clements Markham, as president of the congress, gave a warm welcome to his fellow geographers, on whose behalf Chief Justice Daly, of New York, the doyen of the presidents of the geographical societies of the world, replied in a felicitous speech. On Saturday morning Mr. Markham delivered his presidential address.

The audience that greeted Mr. Markham when he

rose to deliver his address was brilliantly representative. Among those present were Prince Roland Bonaparte, Professor Vambéry, Dr. Neumayer, of Hamburg, Chief Justice Daly, of New York, Mr. Paul du Chaillu, Dr. Karl von den Steinen, Professor Levasseur, Senhor Luccano Cordeiro, Dr. Danckelmann, Geheimrath Hanchecorne, Professor Forel, Professor Pettersson, Mr. André, Mr. W. W. Rockhill, General Greely, Professor Libby, Colonel Haffner, Professor Yngvar Nielson, Baron Dhanis, Count Joachim Pfeil, Captain Francisco Ferreira de Amaral, Professor Wagner, Professor Rein, Professor Penck, Dr. Supan, of Gotha, Dr. Oscar Lenz, Professor H. Cordier, M. Bouget de la Grye and Count de Bizemont.

ANTARCTIC EXPLORATION.

The Arctic and the Antarctic regions between them occupied the attention of the assembled geographers for the greater part of Monday, the discussion being introduced by an admirable paper on "The Scientific Exploration of the Antarctic Regions," by Geheimrath Dr. George Neumayer, of Hamburg, certainly one of the greatest authorities in Europe on the subject. Dr. Neumayer read the first part of his paper in German and the latter portion in English. Dr. Neumayer's proposal was that the work of South Polar exploration should be made a matter of international co-operation. To the discussion that followed the reading of Dr. Neumayer's paper Dr. John Murray, of the Challenger, made a most interesting contribution. Dr. Murray has already thrown himself with characteristic zeal into the movement for inducing the British government to undertake a great Antarctic expedition.

In his address he said that with regard to the condition of the Antarctic regions the indications were rather those of a real continent than of a chain of volcanic islands. During the voyage of the Challenger they brought up a considerable quantity of deposits now forming at the bottom of this area, and they found all sorts of rocks, such as were found in traveling over the European continent. He believed the Norwegian gentleman who had quite recently landed at Cape Adair, and was the first man, perhaps, who had put his foot upon the earth of the Antarctic continent, had brought home some cryptogamic organisms, which, it was believed, were very much the same as those Sir Joseph Hooker found years ago. He commented further upon the important meteorological questions that remained to be settled by investigation of these regions. If Sir James Clark Ross was able to penetrate the part of the Antarctic region to the west of Victoria Island on two successive occasions in a ship without steam, and if a small steamship had been able to penetrate into the same place, he thought possibly the indications were that the winds blew from the south so as to free that region from ice and made it clear almost every season. Remarking on some of the results achieved by the Challenger expedition in the Antarctic seas, Dr. Murray said that the amount of life found in this Antarctic region to the south of latitude 40° was very much more abundant than in any other part of the world. It was not at all impossible that one of the great secrets of oceanic circulation was to be found by investigation of these regions. Certainly one of the greatest pieces of scientific and oceanographical work yet to be done on the surface of the globe awaited their efforts in the Antarctic regions. If the civilized nations of the world were to spend their wealth in the highest and best manner, then he thought that they should give their sympathy toward the completion of this great piece of scientific work before the close of the present century. (Cheers.) He thought the exploration should be undertaken by the navies of the world. It could not be done by private enterprise, unless they could get two or three millionaires each to subscribe a million. (Laughter.) We ought to lead in the matter, and if we made the start, he had no doubt some of the other civilized nations would follow. (Cheers.) His idea was that in the first instance ships should make a preliminary survey of the ice. After that he did not think there would be much risk in landing a certain number of men from these naval expeditions and establishing observatories, which might be carried on for two winters, communication being held with the explorers during the summer. He hoped that the first step taken by the congress in regard to this matter would be to appoint a small committee to draw up a resolution on the subject to be passed by the congress as a whole.

Sir Joseph Hooker lent the weight of his great name to the demand for a new South Polar expedition, an expedition which, as Dr. Murray insisted, was beyond the capacity of private individuals or corporations, and to be successful must be national or international in its character, backed up by the resources of the treasury and the ships of the Royal Navy. As a practical outcome of the discussion a committee was appointed to frame a resolution to be submitted to the congress before it disperses.

THE NORTH POLE BALLOON PROJECT.

To the Arctic regions several papers were devoted. Admiral A. H. Markham introduced the subject in an essay giving a general survey of the present state of our knowledge of the Arctic regions. General Greely's paper "On the Scope and Value of Arctic Exploration" dealt with the results which had been attained, both from a commercial and from a scientific point of view, by polar exploration in the past, and he paid generous testimony to the great part which British sailors and explorers had taken in the work. It was, however, in Herr S. A. André's promised explanation of his project for reaching the North Pole by the aid of a balloon that the keenest interest centered.

The problem of reaching the pole, he said, or generally speaking, to make a journey across the Arctic deserts, was not a purely scientific, but a technical problem. The results to be achieved were, of course, of prime importance to science, whereas it belonged to the engineer to devise the means by which the desired end was to be accomplished. Herr André then stated as follows the requirements for a successful balloon expedition to the North Pole:

1. The balloon should be of sufficient carrying power to enable it to carry three persons, together with all necessary instruments for making observations, provisions, etc., for four months, and ballast, all estimated to weigh about 3,000 kg.

* See Worthington on the "Spontaneous Segmentation of a Liquid Annulus," Proc. Roy. Soc., No. 200, p. 49 (1879).