In East and South Africa are found *A. mossambica*, *A. bengalensis*, and *A. bicolor*, the range of all of which extends to the South Pacific. Of these, *A. mossambica*, ranging from the Cape to Zanzibar and the Seychelles, comes nearest to the European species, from which it differs by the broader bands of teeth. Strange to say, however, there are no eels in tropical West Africa, this being accounted for by "Dr. J. Schmidt, of the Danish Fishery Commission, who, with the aid of Danish hydrographers, has ascertained that the water of the great depths of the inter-tropical Atlantic is for the greater part between 4° and 5° C., nowhere reaching the temperature ascertained to be the minimum (7° at a depth of 1000 metres) required for the breeding of the eel in the North Atlantic. Therefore the reason why eels are absent from some of the warmest regions of the world, such as West Africa and tropical South America, is that the deep sea to which they would have to resort for breeding is too cold, an extraordinary fact when we bear in mind that, outside the period of reproduction and of larval life, the European eel can accommodate itself to such varied climatic conditions as obtain between the Arctic circle and Nubia. The suitable conditions for breeding are only to be found in the North Atlantic, the Mediterranean, and the Indian Ocean; in consequence eels are only found in those parts of Africa (North, East, South) which are within the migratory powers of the fish."

In this connection may be quoted a paragraph recently published in the daily Press, that, in order, apparently, to preserve the supply for home waters, "Denmark intends to stop the migration of eels from the Baltic to the outer ocean by placing a barrier of submerged electric lights between the island of Faröe and the Fyen coast. Eels, which migrate in the dark, will not, it is believed, cross this barrier."

An article on the migration of fishes, including eels, by Mr. V. Franz, appears in the aforesaid issue of *Himmel und Erde*.

A summary of reports relative to eel-fry, drawn up by Mr. A. B. E. Hillas, is published in No. ii. of Irish Fisheries Investigations for 1909 (1911); while No. vi. of the same for 1910 is devoted to an account, by Messrs. Holt and Byrne, of the fishes of the genus Scopelus from the Irish Atlantic slope.

PAPERS ON PLANT PHYSIOLOGY.

THE action of radium compounds on plants is discussed by Prof. H. Molisch in a short article published in the *Sitzungsberichte der kaiserlichen Akademie der Wissenschaften*, Vienna (vol. cxx., part v.). Experiments showed that sufficient light is emitted by strong preparations to produce heliotropic curvature in the case of very susceptible plants such as the oat and the common vetch. With regard to the action of the α, β, and γ rays, it was found that longitudinal growth is diminished and that the periods of spontaneous nutation are shortened, but they induce no form of tropism.

Prof. J. v. Wiesner contributes to the *Sitzungsberichte der kaiserlichen Akademie der Wissenschaften*, Vienna (vol. cxx., part iii.), a paper, supplementary to his book, discussing further investigations as to the light-regulated position of leaves and the amount of light utilised by plants (Lichtgenuss). In the same publication experiments are described by Dr. F. Weber which were intended to throw light on the dormant condition of trees and shrubs. Following up the warm-bath method of forcing proposed by Molisch, which showed that individual branches can be separately resuscitated, the effect of injecting water into branches was tried, and also of the mere insertion of the injection syringe. In the case of lilac and the broad-leaved lime, water injection caused the buds to open three weeks earlier than normal buds, while mere pricking produced a similar result, though not quite so pronounced.

With reference to experiments designed to investigate the effect of growing plants in air enriched with carbon dioxide, Dr. F. F. Blackman communicates a note to *The Gardener's Chronicle* (December 2, 1911) in which he presents an apt illustration of the operations of "limiting factors." When plants are placed in air which contains more than the normal amount of carbon dioxide, if either the light or the temperature is low, the plant may not respond to the increased supply of carbon dioxide, because assimilation is as great as the amount of light or degree of heat will allow; the light or temperature may act as a limiting factor. If the light is increased, then plant assimilation may also increase until another limiting factor comes into operation. Therefore in experiments dealing with assimilation, growth-rate, or other physiological processes it is necessary to consider whether the results expected from improvements of any one condition may not be prevented by the limitation imposed by another factor.

An account of cotton investigations in Egypt, by Mr. W. L. Balls, published in *The Cairo Scientific Journal* (vol. v., No. 60), deals with several interesting problems in general plant physiology. The conclusions, based on the study of the root system of the cotton plant, deserve close attention. While examining the effect of temperature upon growth, it was observed that growth of the tap root amounted to half a metre in twenty-four days at a mean temperature of 25° C. Considerable importance is attached to checks imposed upon root growth, whether by interference of other roots or rise of the water-table. It is argued, and experiments are cited in proof, that a premature rise of the water-table, as in 1909, must cause untimely shedding of bolls, flowers, and buds. Reference is also made to the previously noted "sunshine effect," *i.e.* the complete arrest of main-stem growth during the hottest months whenever the sun shines directly on the plant.

A contribution to the subject of saltmarsh and estuarine vegetation, which deals with the distribution of halophytic plants as controlled by the salinity of the subsoil water, is presented by Dr. J. W. Harshberger in the Proceedings of the American Philosophical Society, Philadelphia (vol. i., No. 201). A combined hydrometer and thermometer was used for determining the water density at various stations, where the assemblage of plants was also noted. From the readings taken, maximum and minimum densities were obtained for each plant. Thus *Spartina stricta*, var. *maritima*, which showed the widest range of accommodation, was found growing in water containing as little as 2 and as much as 4 per cent. of salt. For *Spartina patens* and *Salicornia herbacea* a similar maximum, but a higher minimum, are recorded. *Distichlis spicata*, *Limonium carolinianum*, and *Juncus Gerardi*, which follow next in order, have a much narrower range. A remarkably low maximum is recorded for *Suaeda maritima*.

In connection with the condition of apples appropriately known as "bitter pit," which has supplied fungologists and others with a puzzling problem, an explanation ascribing the cause to poisonous effects produced by arsenical sprays has been put forward in the Proceedings of the Royal Society of Victoria (vol. xxiv., part i.) by Dr. Jean White; the arguments are rational, and if substantiated will lead to a more careful consideration of spray effects. The author had had the opportunity of making a few trials with sprayed and unsprayed trees which bear out the explanation, but the opinion is expressed reservedly and published in order to induce fruit-growers to put the theory to test.

A PHOTOGRAPHIC STUDY OF VORTEX RINGS IN LIQUIDS.

THOUGH the laws of vortex motion have been extensively examined by the ablest mathematicians, comparatively few experiments appear to have been made to study the nature of these motions in air and liquids beyond some experiments made about 1867 by Prof. P. G. Tait, who examined the properties of smoke rings in air. In an extended experimental investigation of this subject the present writer found that very beautiful vortex motions may be easily produced in such high-density fluids as water and oils which have free surfaces and small viscosity. The study consisted in examining the various properties of single and double rings, both visually and with the aid of the camera.

A tank was constructed which would permit the rings to be observed from the two sides, the top, and one end. This tank was made with sides of plate glass. It was 151 cm. long, 59·5 cm. high, and 12 cm. wide. For the production of the rings a cylindrical metal can was pro-

vided. The diameter of the can was 7·7 cm., and its axial length 6·6 cm. One end of this was provided with a flexible diaphragm of phosphor bronze, which could be struck suddenly by the plunger of an electromagnet. The other end of the can could be closed with metal discs, which were provided with one or more holes of various shapes and dimensions. For the production of a single ring one hole in the centre of a disc was used 1 cm. in diameter, and for the production of double rings two holes, one above the other, each 0·85 cm., were employed. We shall hereafter call this can the "gun."

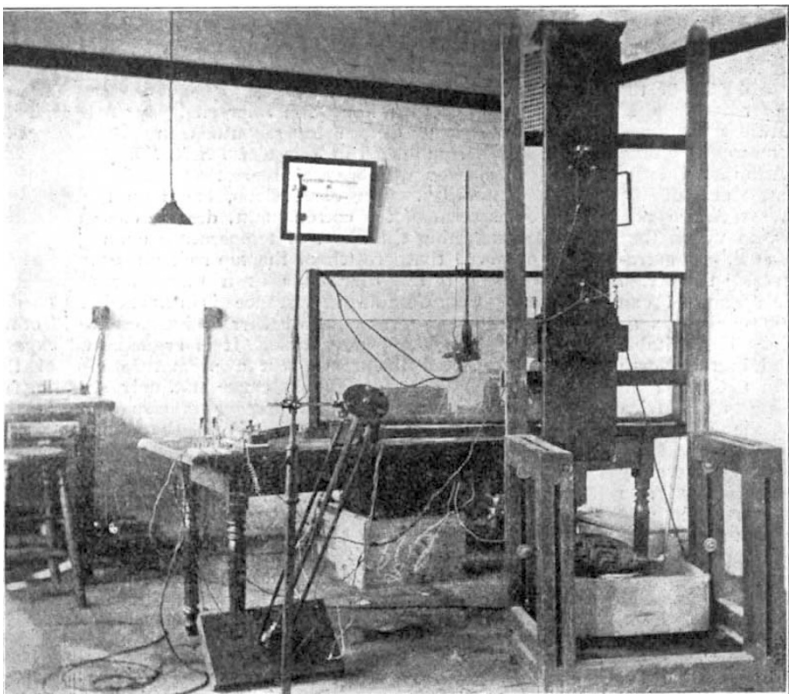

FIG. 1.—Apparatus for the production and photography of vortex rings.

To make the rings visible, and at the same time provide for keeping the water clear so that the tank would not have to be repeatedly refilled, it was necessary to fill the can with highly coloured water, the colouring of which would entirely disappear when the ring broke up and dissipated. Among other colouring materials tried in the experiments, that which was most used was phenol phthaline. The water in the can was made strongly alkaline, and the water in the tank was made slightly acid. Thus the projected rings were of a deep red colour, and entirely disappeared upon breaking up. An illustration is here reproduced (Fig. 1) of the entire outfit above described, together with the plate drop and other devices employed in the photographing of the rings.

Experiments preliminary to the photographic work revealed the following properties of these rings. The motion through the water is rapid, being about 2 metres per second. The rings move in a straight path with a gradually diminishing speed, and always maintain their plane perpendicular to their line of motion. When the water of the tank contains suspended particles of slightly greater density than water, a ring will pass through and among them without incorporating and carrying any of the particles along with it. When a piece of chiffon cloth is stretched over a frame and is held in the path of a ring, the ring will be found to pass easily through it without being broken up or much disturbed in its motion. When a piece of tissue paper similarly stretched on a frame is held in the path of the ring, the ring will break through it, though it is in turn broken up by the impact. If a light watch-chain hangs in the water and is fairly struck by a ring it is bent into a decided curve by the force of the blow. The kinetic energy of these rings is thus seen to be considerable. When two rings are made to approach from opposite ends of the tank, they will on impacting be broken up and dissipated if they meet fairly, but if their line of approach

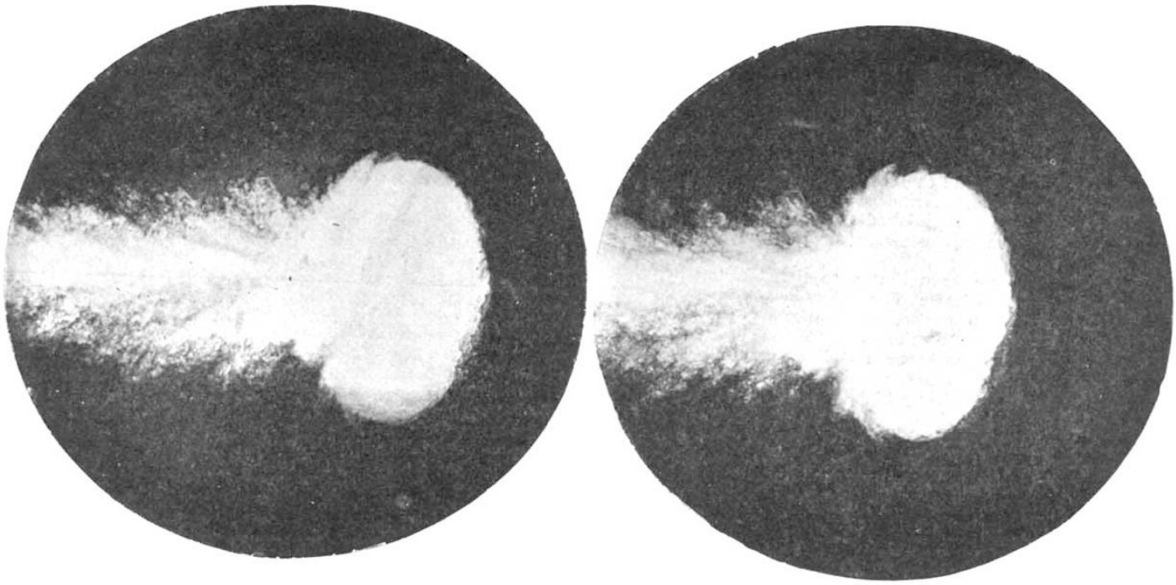

FIG. 2.—Stereoscopic photographs of a vortex ring just issuing from the gun.

is such that they might be expected to touch on their edges, upon a close approach they bend out of a straight course and pass one another without an encounter.

When a ring is aimed to approach the surface of the water, it is upon reaching the surface reflected in a very beautiful manner. As the surface of the water is approached the upper edge of the ring gains velocity over the lower edge, the plane of the ring tilting in such a manner as to maintain itself always at right angles to the line of motion of the ring. If the angle between the surface of the water and the line of approach of the ring to the surface be as much as 22°, the ring is still reflected. If this angle is much exceeded the ring bursts through the surface with a spurt of water.

Refraction was also observed. The lower half of the tank was filled with a dense salt solution, and the upper half with pure water. The ring in passing from the upper to the lower layer, with a slight angle from the horizontal, was deviated from its straight path. The laws of both reflection and refraction were proved to be, approximately at least, those of light.

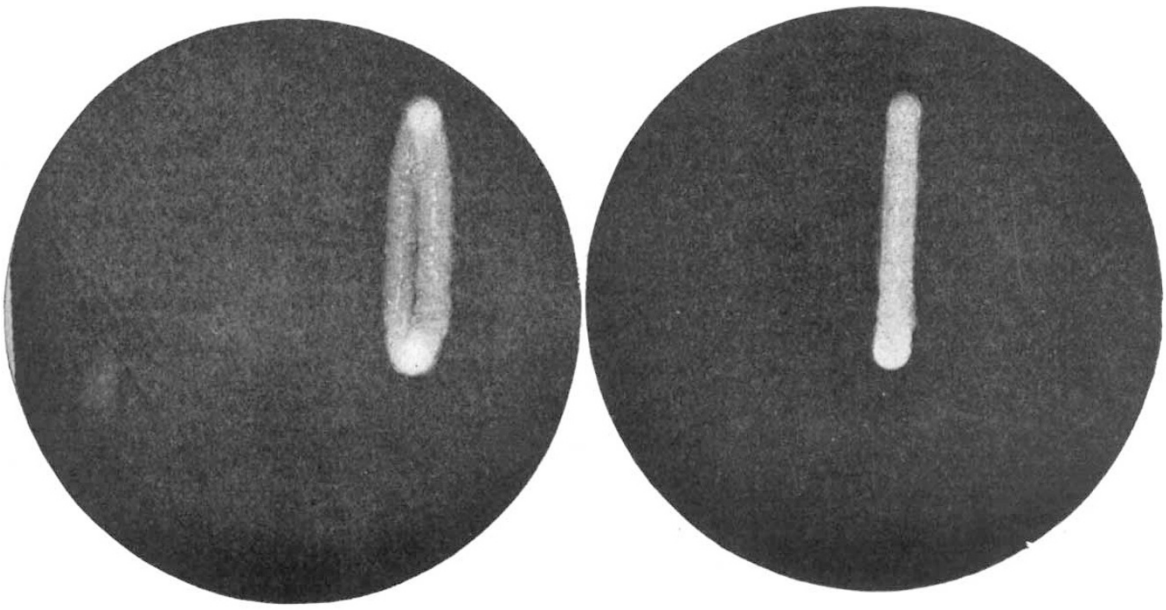

FIG. 3.—Stereoscopic view of a fully-formed vortex ring.

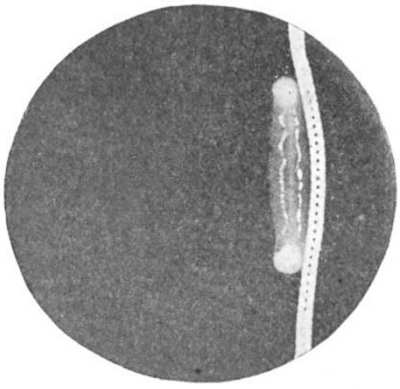

FIG. 4.—Vortex ring about to strike a watch-chain after progressing about half a metre from the gun.

Rings ejected from a very exactly circular hole are themselves circular, and advance through the water with no other motion visible than that of progression. If, on the other hand, the hole is elliptical, they have a vibratory motion in their own plane. The vibrations are such that the vortex changes from an ellipse with its major axis vertical to an ellipse with this axis horizontal. The vibrations are almost too rapid to be followed distinctly with the eye, but make an interesting sight when the ring is observed from the end of the tank as it approaches the eye.

The most scientifically interesting property of water rings may be observed when the end of the gun is provided with two holes, one above the other. In the experiments tried, the two holes, each 0·85 cm. in diameter, were placed with their centres separated 2·55 cm. The two rings, which issue simultaneously from the two holes, begin to attract each other the moment they leave the gun, and at a distance from the gun of about 6 to 8 cm. they come together with great suddenness, uniting to form a single ring of approximately twice the circumference of one of them. The rings so formed proceed with the same velocity as a single ring until broken up by impact with the end or side of the tank. This ring possesses vibratory motions that are remarkable. Unlike the single ring, which issues from an elliptical hole with vibrations in one plane only, a ring which is formed by the union of two rings has a very complicated vibratory motion in planes both normal and parallel to the direction of forward motion of the rings. These motions will be better understood by a study of the photographic views.

If the surface of the water in the tank be covered with a layer of kerosene oil from 5 to 10 cm. deep, an interesting phenomenon may be observed, which is rendered more apparent when the oil is coloured a deep red with a dye known to the trade as Soudan III. When the gun is filled with uncoloured water, and is located a few centimetres below the surface of the oil, and an invisible ring is projected at a suitable angle with the surface of the oil, it enters the oil, and is instantly converted into an oil ring which proceeds to the upper surface of the oil; it is there reflected and re-enters the water as a visible oil ring, which proceeds with only slightly diminished velocity for a metre or more through the water. After the ring breaks up the oil rises to the surface of the water, and after the surface has been quitted another ring may be produced, and the process may be continued indefinitely. As the water is uncoloured, the illusion is produced of red oil rings issuing from the oil without any apparent agency for their production.

Experiments were conducted which demonstrated that in the case of two liquids of different densities—at least if these two liquids are not miscible—it is possible to project

a ring of the less dense liquid through the liquid of greater density, but it is not possible to project a vortex ring of the liquid of greater density through the liquid of less density. Thus a ring of kerosene oil can be projected through water, but a ring of carbon tetrachloride cannot. By projecting rings of liquid paraffin through hot water, and thence into an underneath stratum of cold water, very pretty solid rings of paraffin were obtained and preserved.

The problem of photographing these rings was one of peculiar difficulty. The rapidity of their motions made it necessary to make exposures which would be of the order of only one twenty-five-thousandth of a second. Of course, no mechanical shutter could be constructed to give so brief an exposure. An electric spark method, an optical arrangement, and a timing device were finally devised which gave excellent results and fully exposed plates. The majority of the pictures were obtained with a stereoscopic camera, and the double views which were obtained, when examined, as they should be, with a stereoscope, reveal the mechanism of the rings in a much finer manner than can be obtained from single views. The electrical spark device employed was very similar to the primary spark used in the sending station for wireless telegraphy. The stereoptic device required that two sparks, separated in space by a distance equivalent to that between the lenses of the stereoscopic camera, should be simultaneously produced. A very special form of double spark-gap was constructed so that the sparks took place between amalgamated zinc terminals and the clean, bright surface of mercury.

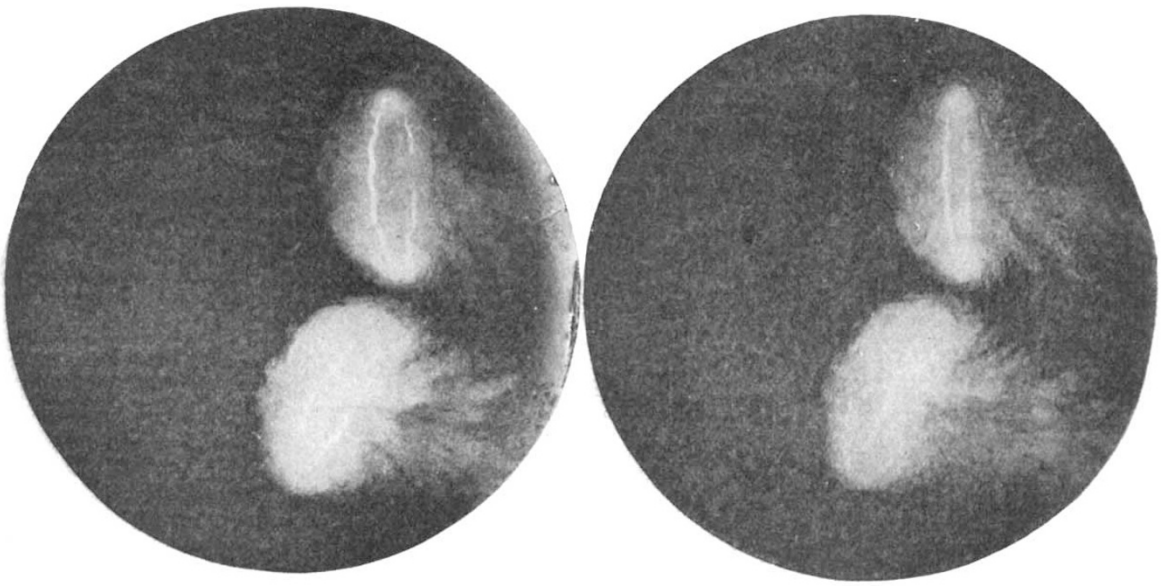

FIG. 5.—Stereoscopic view of two vortex rings produced simultaneously.

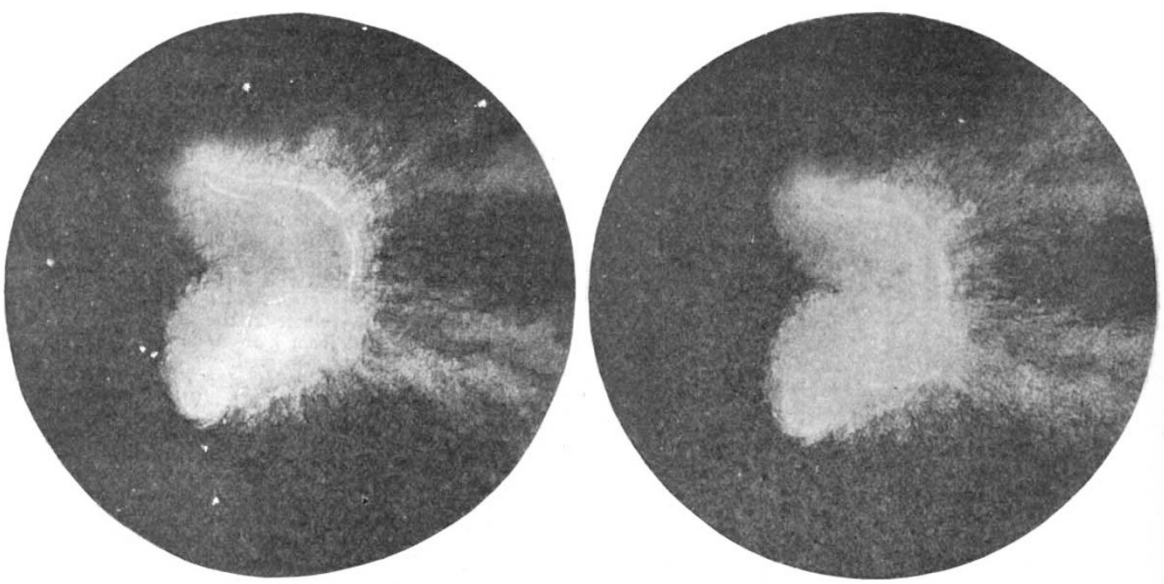

FIG. 6.—Stereoscopic view of two vortex rings uniting.

At the moment when the ring was photographed it appeared before the brilliantly illuminated surface of a plano-convex lens $12\frac{1}{2}$ cm. in diameter. The ring as seen in the camera thus appeared as a dark object against a brilliantly illuminated background. The alternating

current used produced a succession of sparks, each lasting a less time, perhaps, than the fifty-thousandth of a second,

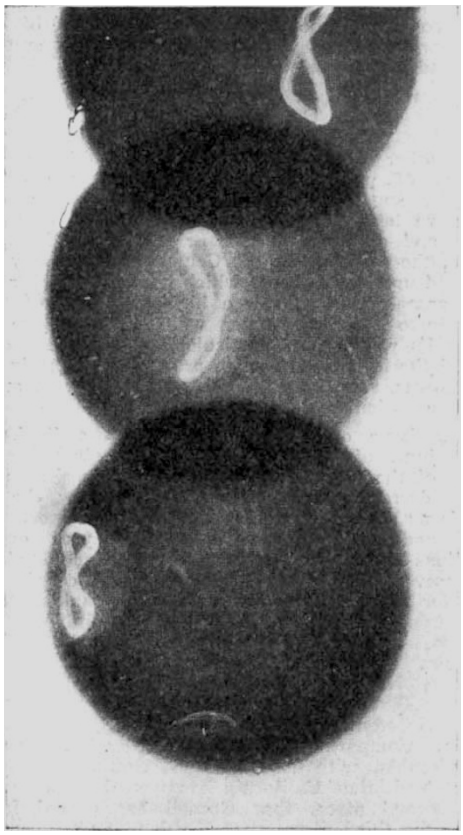

FIG. 7.—Three photographs, separated by about one-fiftieth of a second, of a vibrating vortex ring formed by the union of two rings.

one, and only one, spark occurring at each alternation of the primary current, or about eighty per second.

at the back of the camera, the arrival of the ring in the field of view, and the occurrence of a spark, or, more precisely, of a brilliant flash of light. The timing was all done by a falling weight, which made suitably timed electrical contacts, one of which operated an electromagnet to release the plate, and another the electromagnet of the vortex ring gun.

When a single ring first issues from the gun it is not recognisable as a ring, but is surrounded by an ellipsoid of coloured water, and is followed by a trail of colour. This is shown in the stereoscopic view in Fig. 2. As the ring progresses, the colouring of this ellipsoid, in which the ring is embedded, and the colouring of the trail, grows paler and paler until the ring in the interior of the ellipsoid alone is visible, and has the appearance shown in the steroscopic view in Fig. 3. Fig. 4, which is of special interest on account of the fortunate timing, shows a ring which has already progressed half a metre or more, and is just about to strike a silver watch-chain which hangs suspended in the water. It should be noted that the chain has begun to bend before an actual impact has occurred. This, together with the other views, demonstrates that the ring is at all times surrounded with an ellipsoid of water which moves with the ring, and in its early stages is visible as shown in Fig. 2. Water being a viscous fluid, the material of this ellipsoid is gradually being drained off and left behind as the trail, but also being as continuously replenished with clear water, until it is invisible except by its effects, which are made manifest in Fig. 4.

The stereoscopic view in Fig. 5 shows two rings which have just issued simultaneously from two holes in the gun. They are perhaps 5 or 6 cm. from the gun, and are already seen to be approaching each other under the influence of their mutual attraction. In the stereoscopic view in Fig. 6 two single rings have just united. A careful study of this picture in a stereoscope will show just what has taken place. Already the conditions are fully established for the subsequent complicated vibratory motions of this type of ring. The single view in Fig. 7 shows another ring at a later stage, also made up of two separate rings, as it appears in three successive stages separated by intervals of about one-fiftieth of a second. Here is plainly seen the four types of motion possessed by liquid vortices formed by the union of two single rings. First, there is a rotation about the vortex filament; secondly, the forward motion of the vortex as a whole; thirdly, the motion of oscillation of the extremities of the vertical diameter of the vortex in a vertical plane lying parallel to the direction of forward motion; and, fourthly, a motion of oscillation of the extremities of the horizontal diameter of the vortex in a

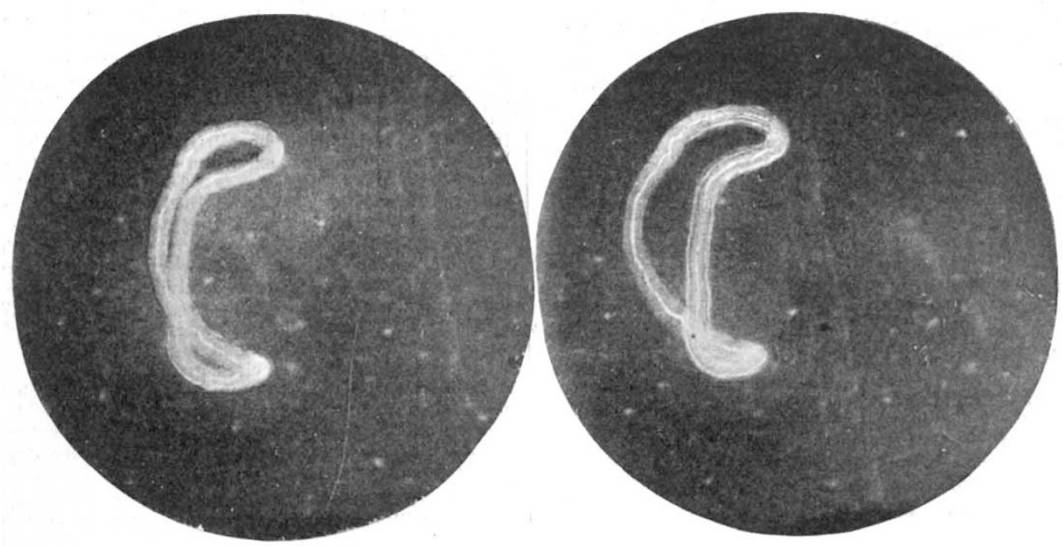

FIG. 8.—Stereoscopic view of a vibratory ring in one phase of its motion.

Three events were made, by the timing device, to occur simultaneously; they were the arrival of the falling plate

horizontal plane. These four motions, except the second, are too rapid to be observed satisfactorily with the eye.

A slightly enlarged stereoscopic view of one of these vibratory rings in one phase of its motions is shown in Fig. 8. In this view, as also in Figs. 3 and 4, note the line of particles lying in the filimentary axis of the ring. These particles probably consist of materials less dense than water which have been gathered up by the ring in its progress through the water, not entirely free from suspended matter, and swept into the axis and carried along with the ring.

The results of the research above outlined were first described in the September and October numbers (1911) of the Journal of the Franklin Institute. In the original paper are given other photographs than those reproduced here, and the apparatus is described in sufficient detail to enable one to reproduce it. The electric circuits and other devices employed in taking the pictures are fully described, and physical explanations of the vortex motions observed are given. It is there shown that most, if not all, of the observed motions of liquid vortices may be approximately explained by employing the principle first laid down by Bernoulli, that since the sum of the potential and kinetic energies in a liquid is constant, it results that where the velocity of the fluid is high the hydrostatic pressure is diminished. The attraction and final union of two rings is supposed to be explained by this principle.

It is hoped that this experimental study of actual vortex motions in fluids having viscosity will throw light upon and constitute a proper basis for mathematical investigations regarding ideal fluids.

EDWIN F. NORTHRUP.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

CAMBRIDGE.—The governing body of Gonville and Caius College has resolved to place in the hands of the University Association for transference to the university the sum of 500*l.*, to be invested for the maintenance of buildings. It hopes that the sum will be added to the fund now being collected for the maintenance of the new buildings for physiology and experimental psychology.

Dr. Macalister, professor of anatomy, and Dr. Haddon have been nominated to represent the university at the International Congress of Americanists to be held in London in May next, and Prof. Burkitt has been chosen to represent the university at an International Congress on the History of Religion to be held at Leyden in September next.

FOUR Gresham lectures on "Sleeping Sickness" will be delivered on February 13, 14, 15, and 16 by Dr. F. M. Sandwith, Gresham professor of physic. The lectures, which will be delivered at the City of London School, Victoria Embankment, E.C., are free to the public, and will begin each evening at six o'clock.

IT is announced in *The Times* that Dr. Francis, honorary secretary of the Education Fund for Europeans and Eurasians in India, has been promised by an anonymous donor a lakh of rupees (about 6600*l.*) if four lakhs more are raised in India. Between 80,000*l.* and 90,000*l.* of the 250,000*l.* needed has already been raised in this country, and it is hoped that the recent impetus given to native education in India will also direct attention to the urgent need of those whom the fund will benefit.

THE Goldsmiths' Company has made the following grants to the Senate of the University of London:—for the building fund of King's College for Women, 10,000*l.*; for the endowment fund of Bedford College for Women, 5000*l.*; for the building and equipment fund of the chemical department of University College, Gower Street, 1000*l.* The company has also made a grant of 1000*l.* to the National Physical Laboratory at Teddington for the equipment of the metallurgical department at that institution.

THE Education Committee of the London County Council has published some interesting particulars as to the number and ages of pupils in London secondary schools receiving financial aid from the Council. During the year ended on March 31 last there were in such schools 14,036 pupils—9369 boys and 4667 girls. Of this total there were 112 boys and 31 girls above eighteen years of age; 618 boys and 402 girls between sixteen and eighteen years; and 2820 boys and 1435 girls between fourteen and sixteen years. That is to say, less than half of the pupils in these secondary schools, which include many of the best in London, are above fourteen years of age, and 941, it may be added, are below ten years of age.

THE Central Bureau for the Employment of Women, of 5 Prince's Street, Cavendish Square, London, W., has published a pamphlet entitled "Openings for University Women other than Teaching." The booklet contains a summary of professions suitable for women of higher education, suggestions on more recent spheres of remunerative labour, and a comparative table of university degrees and diplomas in the British Isles. Miss M. G. Spencer, the secretary of the Central Bureau, may be congratulated upon the success which has followed her attempt in the pamphlet to provide a bird's-eye view of the field now open to educated women who desire to take part in the world's work. The particulars as to courses of training, and the information as to probable salaries in various appointments, should be of assistance to parents arranging for the education of their girls.

IN the issue of *Science* for January 5 Prof. Rudolf Tombo, jun., of Columbia University, gives his annual analysis of the registration statistics of American universities. A decrease in the total enrolment for the current session was noticeable at Chicago, Missouri, Northwestern, Texas, and Yale Universities. This year only four institutions exhibit an increase of above 200 students, as against seven in 1910 and eleven in 1909. According to the figures for 1910, twenty-seven universities ranked as follows as regards number of students:—Columbia, Chicago, Michigan, Harvard, Pennsylvania, Cornell, Minnesota, California, Wisconsin, Illinois, New York University, Nebraska, Northwestern, Yale, Syracuse, Ohio State, Missouri, Texas, Kansas, Indiana, Tulane, Iowa, Stanford, Princeton, Western Reserve, Johns Hopkins, Virginia. Comparing this with the order for 1911, we find that Columbia, with 8642 students, continues to maintain its long lead, that California has passed from the eighth to the second place, that Cornell has passed from the sixth to the third place, that Michigan and Harvard have each dropped down one place, Pennsylvania two places, and Chicago four, and that Wisconsin and Illinois have advanced a place.

THE Birmingham Education Committee has decided to recommend the City Council to make a grant annually to the University equal to the net produce of a penny rate, which is estimated to realise about 16,000*l.* It has also recommended that the University should offer annually fifteen major scholarships entitling the holders to a remission of fees, together with a maintenance grant in case of necessity of not more than 30*l.* per annum, and should appoint certain additional lecturers. It may be noted that as a consequence of the grant of an extra halfpenny rate (making a penny rate in all) made by the City Council last year, before the extension of the city boundaries, twelve city scholarships were offered for competition, the successful candidates being entitled to maintenance grants of an annual value not exceeding 30*l.* each if their circumstances were such as to render pecuniary aid of this kind desirable. Nine of these scholarships have been awarded, and six of the holders are receiving maintenance grants (five at 30*l.* per annum and one at 25*l.*). The Workers' Educational Association has hitherto received valuable support from the University, and members of the University staff have given their services gratuitously. The Birmingham Education Committee now suggests that such services should receive formal recognition, and presumably appropriate remuneration, which the increase in value of the grant in consequence of the enlargement of the city should render possible.

IT is expected that the Rice Institute at Houston, Texas, U.S.A., will be opened for the reception of students next autumn. The institute is described as being "of liberal and technical learning founded by William Marsh Rice, and dedicated by him to the advancement of Letters, Science, and Art." An artistically illustrated prospectus of this latest American institute has reached us, which shows