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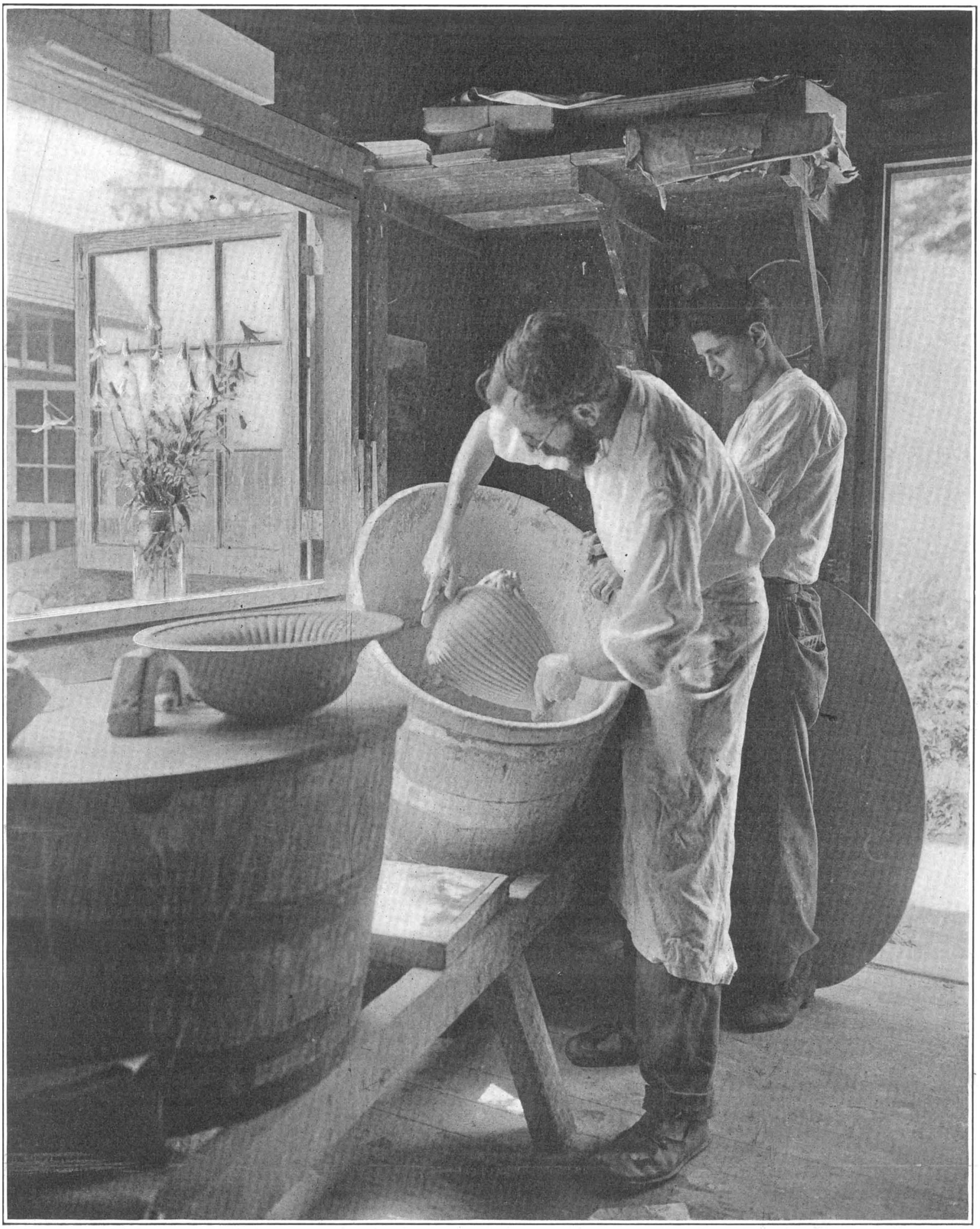

Dipping fine porcelains into the glazing solution.

ARTISTIC POTTERY MADE IN AMERICA.—[See page 296.]

The Principle of Relativity*

A Survey of Theories Concerning a Matter of Importance to Many Sciences

MAN in a philosophical mood readily concedes that everything is relative. The boy who, by performing jumping exercises on a moving stairway, manages to remain at the same level, feels that it may require hard work to keep relatively at rest. How the astronomer can correctly predict the moment of an eclipse, though the earth rotates and revolves round the sun, and the moon describes its orbit subject to complex perturbations, is a matter of wonder to most people. That such problems concern the principle of relativity is an old story, of course. Within the last decade, however, that expression has assumed a definite meaning, and the reader who wishes to inquire into it is at once confronted not only by pages of abstruse mathematical deductions, which he expected to have to face, and by four-dimensional co-ordinates, but also by references to Newtonian mechanics, the Lorentz contraction, the Michelson-Morley experiment, non-Euclidian geometry, etc., the immediate relevancy of some of which he hardly understands. Though the principle creeps up in many scientific memoirs, the literature on the subject speaks of the electrodynamics of moving systems rather than of relativity.

The term "principle of relativity" first occurs, we believe, in the philosophical writings of William Hamilton, the metaphysician of Glasgow and Edinburgh, who died in 1856—not to be confounded with his contemporary, the great Dublin mathematician, William Rowan Hamilton. According to Hamilton, relativity is a general condition of the thinkable, and quantity has three phases: Time (protensive), space (extensive), degree (intensive). The modern conception of relativity confines itself to movements in space and time. Prof. A. Einstein, now of Berlin, whose "Electrodynamics of Moving Bodies" (*Annalen der Physik*, 1905) initiated the present relativity movement, is in these, as in other fundamental investigations (e. g., the quantum theory), associated with his colleague, Prof. M. Planck. To have clearly laid down the inseparability and formal equivalence of time and space in physical research is the merit of the late Hermann Minkowski, a brilliant young mathematician of Göttingen, who died in 1909, before some of his best work was published. If we add the names of Dr. M. Born and of Mr. E. Cunningham, of Cambridge, we have almost exhausted the list of the chief workers on relativity, apart from mathematicians like Grossman, Civita-Levi, Poincaré, Ricci, who have developed new mathematical lines of attack, and physicists like J. Laub, who reviewed the experimental basis of the theory, beginning with Bradley's determination of the aberration of light.

"Philosophically the motion of a body is unintelligible except in reference to some other body. Yet in dynamics the first thing done is to specify the motion of a body without reference to the other body (Larmor)." When formulating his laws of motion, Newton postulated an absolute frame of reference for the position of a point, and it seems possible to choose a frame such that Newton's laws accurately describe the motions of material systems. The position of a point is commonly referred to an orthogonal system of axes X Y Z; an event is said to happen t time-units after another. Newton's laws show invariance in two respects: The form of the equations remains unchanged, (1) for zero time when the orientation of the system of co-ordinates is changed, that is, when the system is turned about its origin; transformations of this group are considered to establish the fundamental character of space (Minkowski). The forms of the equation allow (2) of imparting uniform translation to the system, when the co-ordinates x, y, z pass into $x - a\,t$, $y - \beta\,t$, $z - \gamma\,t$. "Transformations of this second group are rather shirked, because we can never decide in physical phenomena whether the space, considered to be at rest, was not in a uniform motion. Thus the two groups remain separated. But all our observations are bound to space and time. Nobody ever saw a place except at some definite time, nobody ever noticed a time except at some place. Three-dimensional geometry must give way to four-dimensional physics; we should discuss, not places or events, but point-events. If we were able to trace the dx, dy, dz, dt of any point through space and time, we should have the 'life or world-line' of the point, and the universe would be resolved into world-lines (Minkowski)." To mark the inseparability of space and time, scientists sometimes designate the axes x_1, x_2, x_3, x_4 instead of X, Y. Z. T.

*Engineering.

In formulating the principle of relativity Einstein demanded that the laws of motion should be framed independently of the system of reference—provided, in the first instance, that the various systems of reference are to one another in uniform (not in accelerated) motion. This provision was first stipulated lest the problems become too complex. Recently the general laws of motion have been expressed by equations which remain co-variant for all transformations, and Einstein distinguishes in this sense the "general" principle of relativity—dealing also, e. g., with gravitational problems—from the first "special" principle. Why do the Lorentz contraction, the electromagnetic theory, etc., at once enter into the problem? The electromagnetic theory of Maxwell and Hertz seemed to promise, in the all-pervading æther, an ultimate system of reference relative to which velocities might be specified. Different scientists advocate different æthers, and in most systems of electrodynamics and optics the mobility of the æther plays an important part. The æther may (1) be free and in absolute rest, not influenced by moving bodies; (2) it may adhere to matter and be carried away with it; (3) it may partake of both these properties. In his "Theory of Electric and Optical Phenomena of Bodies in Motion," H. A. Lorentz (Leiden, 1895), with many other scientists, assumed the æther to be at rest. It seemed possible then to establish a case of absolute motion, a velocity of the earth with regard to the æther. Attempts to establish that motion had been made before that time, notably by Michelson and Morley since 1886, but they had as completely failed to give evidence of such a velocity as dynamical science had failed to give evidence of an absolute velocity of a material body in space. Now Lorentz proved (in the paper mentioned) that the looked-for influence of the motion of the earth on optical phenomena should, indeed, *not* have been observed if, in his formula, the term v/c (v velocity of the earth, c velocity of light) were alone considered, but that a second-order effect v^2/c^2 should have been observed. But Michelson and Morley did not find either when determining the velocity of light in the direction of the motion of the earth and in the opposite direction.

To help over the difficulty the late G. F. Fitz-Gerald and Lorentz suggested that a body in motion would be contracted, in the direction of the motion, in the ratio $1 : \sqrt{1 - v^2/c^2}$. The suggestion looked arbitrary and to be made merely to save a theory: "However extraordinary this hypothesis may appear, it is by no means gratuitous, if we assume that the intramolecular forces act through the mediation of the æther in a manner similar to that which we know to be the case in electric and magnetic forces. Form and dimensions of a body are determined by these forces, but, of course, the elongation or contraction is extraordinarily small; it would increase or shorten the diameter of the earth [roughly 8,000 miles] by about 6½ centimeters (Lorentz)." The belief in this remarkable property of the electromagnetic field (Voigt, Larmor) has been much strengthened since, and it forms, in fact, the mathematical foundation for the principle of relativity. Yet the contraction remains startling. It signifies that the dimensions of a body change with the velocity assigned to it; measurements of the time interval between two events at the same point would similarly be affected. In addition to the first-order Doppler effect (due to the motion of the source of light in the line of sight) a second-order effect (at right angles to the motion) should be observable, and search for it has been made by Laub. On the other hand, Einstein has shown that, when the "local time" of Lorentz is simply defined as time, the contraction appears as a necessary consequence of the relativity principle. But he has to modify his conception of the æther; his electromagnetic fields are not conditions of matter, but things of independent existence, akin to ponderable matter and having inertia like it.

Mere equations of free space cannot lead to any tangible results. Man is concerned with material phenomena, and the observation of the propagation of light is only possible when light meets matter. The most widely accepted theory of matter is the electronic theory; thus we come to the material point—the electron. Examining the experiments of Kaufmann and Bucherer on the variability of the acceleration of β rays of different velocities in the same field, Einstein discovered indeed a slight but systematic deviation of the experimental from the theoretical curve, which was one of the reasons inducing him to generalize the relativity theory.

A uniform translation is not the only one which might be concealed in an electromagnetic field. Acceleration of one system with regard to another might also be concealed, though the magnetic effect produced by a rotating sphere would, e. g., be observable by an instrument carried round with the sphere. Such considerations lead to modifications of the meaning of mass, momentum, kinetic energy and of the nature of gravitation. According to Einstein, the inertia and internal energy of a system are of the same kind; the mass m would correspond to the energy mc^2 (c = velocity of light), and the astounding energy of radioactivity would only represent a small fraction of this store of energy; a radiation confined within a closed space would possess, not only inertia, but also weight. The mathematics of these relations can be understood only by the mathematician. But we may say a few more words concerning measurements of length and time and the constant vacuum velocity c of light which these considerations involve.

The principle of relativity can, from known phenomena in a given system, furnish information as to the corresponding phenomena in the same system supposed to be as a whole in uniform translation. But the principle does not tell us the influence of system A on system B, when B is moving relative to A, from a knowledge of that influence when the two systems are at rest. That fact is associated with the already mentioned fact that events appearing simultaneous to one observer are not necessarily simultaneous to another.

On the ordinary view the specified points of a system at rest are at a definite distance apart, independent of orientation in space; events are equally independent of orientation in time. The theory of relativity does not accept that. Requiring some method of setting two clocks relatively to one another, it assumes that the clocks could be so set, that the velocity of propagation of light *in vacuo*—measured by means of these two clocks—is everywhere equal to a constant c. Let the points A and B, relatively at rest, be provided with clocks at distance r, and let t be the time of the clock A when a ray of light reaches A in the direction A B (through vacuum), and let t be similarly defined, then $r/(t_B - t_A)$ is always to be equal to c. This principle of the velocity of light is by no means self-evident. Einstein considers that it has experimentally been demonstrated. We shall revert to this statement. A clock at point P, which has the gravitation potential ϕ with regard to the origin of the system, will run at a rate by $(1 + \phi/c^2)$ quicker than the clock at the origin. One of Einstein's similia is the following: Let K be a Galilean system of reference (i. e., a system relative to which a mass at sufficient distance would move uniformly in a rectilinear path), and let K_1 be another, rotating at uniform rate about the common Z axis of the two systems. Let a circle be described about the common origin with unit radius in the plane X Y; it will also be a circle in X_1 Y_1. Now measure the ratio; circumference to diameter, with a rule at rest respectively to K; in the first case the ratio will be π, in the second case it will be greater than π. We recognize this when we consider that (judging from K) the circumference rule (but not the radially-applied rule) will have undergone a Lorentz contraction. With regard to K_1, Euclidean geometry will not be applicable, and the path of a ray of light cannot be straight (but must be curved), since the light is to be propagated at a uniform rate in a rectilinear path with regard to K. Nor can we introduce into K_1 a clock of the same nature as the K clock and at rest with respect to K. To understand this, imagine a clock or watch W at the origin, and another W_1 on the circumference of the circle and looked at from K; watch W_1 will appear to lag behind W because it is being carried round; the observer will think that the rate of motion of a clock depends upon the position in space. Thus space and time cannot be so defined that differences of space and time can directly be measured with the aid of the unit rule and standard clock. Let, further, K be a system at rest, K_1 a system at uniform acceleration with regard to K; outside K_1, B be a body having uniform acceleration with regard to K_1. Can the observer, moving with K_1, know that he is in accelerated motion? Einstein answers, "No." For the behavior of B could also be explained by the following argument: The system K_1 is not accelerated, but there is a gravitational field in K_1, which imparts acceleration to B.

As regards gravitation—which has the remarkable property of imparting the same acceleration to all bodies—the theory of relativity concludes that the Newtonian law cannot be exact, but that it can be made exact in many various ways. "If gravitation is to be included in an electromagnetic scheme of matter, it must be propagated through the æther with the velocity of light. If, on the other hand, gravitation has nothing with the electromagnetic properties of matter, we shall hardly expect it to conform to the principle of relativity. Just as the Newtonian mechanics break down in the light of the electrical theory, so the latter may become only an approximation, if gravitation is concerned with more remote and yet undiscovered properties" (Cunningham).

Carried to its furthest extent, the principle of relativity would appear to declare that the phenomena do not lead us to any knowledge of a permanent and unique frame of reference relative to which the motions of bodies can be determined. It is a question of particular interest whether experiment can say anything concerning gravitation from the relativity standpoint. W. de Sitter (Leiden) has examined two modifications of the relativity laws (due to Poincaré) with respect to planetary orbits. Neither of the two modifications leads to any observable periodic or secular change in the orbits, except possibly in the case of Mercury, where the observed effect might, however, be ascribed to other causes. According to Einstein and the late Schwartzschild (Berlin Academy, 1916), the elliptical orbit of a planet would undergo a slow rotation in the direction of the orbit motion, amounting to 43 seconds of arc per century for Mercury—which figure, they consider, would be in excellent agreement with Leverrier's residual movement of the perihelion of Mercury, for which the attraction of the other planets would not account. De Sitter has further established the constancy of the velocity of light c by observations of binary stars. Ritz had asserted that when the source of light had a velocity u of its own, the light should be propagated at the rate $(c+u)$. Edwin Freundlich questions the validity of this proof and method; he likewise rejects the direct suggestion of Ritz, yet he considers that there might be an effect of some function of u. On the other hand, Einstein calculates that a ray of light passing the sun would be bent through 1.7 seconds of arc, and a ray passing Jupiter would undergo a bending of 0.02 second.

The corrections of physical data, so far due to the principle of relativity, may appear small and insignificant. For the advance of exact science the delineation in clear mathematical terms of what had remained hazy generality or metaphysical speculation is of paramount importance.

Invisible Comets*

Derelicts of the Sky That Long Ago Vanished from Sight

By William H. Pickering

The nucleus of a comet may be defined as that portion of a meteor swarm which gives out sufficient gas to become electrically luminous. Often there is no nucleus, only a general illumination. It does not necessarily include the whole swarm, since swarms are often elongated, and comets' heads are usually spherical. The escaping gases, certainly in the case of large comets, often reach far beyond the limits of the swarm. Sometimes the swarm has two or more nuclei, and sometimes several swarms follow along in nearly the same orbit.

A meteor swarm, on the other hand, may be defined as a comet which strikes the earth. Fortunately, within historic times these swarms have all been invisible until they entered our atmosphere, otherwise they would doubtless have occasioned great and general distress and alarm. In the Harvard Bulletin 608, Prof. Perrine records the appearance on May 4 of this year of a bright object, which between 9h and 10h moved 10 degrees toward the sun's place. He suggests that it may possibly have been a comet. If so, it must have been a very small one, and situated very near the earth. In *Popular Astronomy*, 1909, 17, 330, it is shown that we probably strike the head of a luminous comet once in about every 2,000,000 years. It is possible that collisions occur rather more frequently than that, but since it is probable that life has existed upon this earth for at least 100,000,000 years, and perhaps longer, it would seem that we must have been in collision with fully 50 luminous comets during that interval, with evidently no very serious results in consequence, hitherto. On the page above referred to in the tenth line, by a typographical error one zero was omitted, and the number should have read 1,000,000,000.

Many short period comets have ceased to be luminous during the past century, sometimes lighting up again temporarily after a long series of years. Unless shifted into another orbit, and driven out of the solar system altogether, these innumerable invisible comets, like derelicts at sea, must still be pursuing their way among us unannounced, and gradually disintegrating. Whether their returns to perihelion exceed those of the visible comets 10, 100 or 1,000 times, we have no means of knowing, but astronomically speaking, collisions with them cannot be rare.

The heads of the smaller comets that we usually see are in general of about the size of the planet Jupiter, but there seems to be no theoretical lower limit, and it is possible that the meteor swarms themselves are sometimes only a few miles in diameter. The latest instance of this sort is that of the brilliant meteoric display which became visible in western Canada on the night of February 9, 1913, and was traced across Canada and some of the Northern States, past Bermuda, and was last seen off the South American coast, in longitude 33 deg. 30 min. W. latitude—3 deg. 20 min. S., a total course of some 6,000 miles. (*Journ.* B. A. A., 1916, 26, 275.) This delay must have been due to a graze with a very small swarm, moving in a direct orbit, which had passed perihelion, and which reached its descending node at the earth's orbit a little too late for a direct collision. Nevertheless, it had a few of its outlying members dragged down into our atmosphere to a sufficient depth to become self-luminous, and to be ultimately destroyed and captured. Different members were constantly being dragged in along the whole route. If the main mass escaped, as seems probable from Prof. Chant's account of the phenomenon (*Journ.*, Royal Astron. Soc. of Canada, 1913, 7, 157, 444), its period of revolution will have been materially shortened, and other returns will occur in the future at intervals, upon the same night of the year. That the display was of such small dimensions, only 3 or 4 miles in width, would imply a very minute swarm. That none of the meteors reached the earth's surface confirms the computed value of their high velocity, and the fact that they have not since been seen, shows that they were, and are still, if not destroyed, revolving about the Sun, and not about the earth as a primary.

It is recorded in Chambers' Astronomy 616, that at Cairo in August, 1029, "many stars passed, with a great noise, and brilliant light." If this report is correct, the phenomenon observed must have been similar to that above recorded, and described so fully by Professor Chant. The loud noise heard in both cases differentiates them clearly from an ordinary Perseid, or even the finest Leonid display. These showers are silent because their orbits are retrograde, and the individual meteors are therefore burned up in the upper layers of the earth's atmosphere. In no other early record of meteoric showers is there mention of any noise being heard. It is unfortunate that we have no record of the direction of motion of the Egyptian meteors, but it is probable that like the Canadian display their orbit was direct.

Another small swarm of meteors which struck the earth very recently was the Leonid shower which fell on the night of November 14, 1901. The first relatively modern observation of the Leonid display was made in 1698. As pointed out in *Popular Astronomy*, 1899, 7, 523, since that date it has appeared with considerable regularity in multiples of 34 years. Its next appearance was 101 years later in 1799. Its finest modern appearance was in 1833. It appeared next in England in 1866, and in the States in 1867 and 1868. There is evidence that the last was the finest shower of the three, but these observations are little known outside of the Eastern States. Taking 1867 as the mean date, the next year on which a shower should have been expected, adding another 34 years, was 1901, not 1899 as assumed by Messrs Stoney and Downing, and in 1901 a small but fine shower appeared, as we shall presently see. Since in their investigation these computers used an erroneous period, placing the shower fully two years out of the way, some doubt may well be felt as to whether their conclusion that, owing to perturbations when passing near Jupiter, the meteoric orbit now lies 100,000 miles inside that of the earth at the node, is justified.

The great shower of 1799 was observed throughout the whole extent of the American continent, and was even seen in Greenland, but since then the areas have been much more restricted, that of 1833 reaching only from the Great Lakes to somewhat north of the equator, and the more recent showers covered still smaller areas. Since the whole earth must pass through the geometrical plane of the meteoric orbit within a few minutes of time, it is singular that in the same longitude a shower should not, with clear skies, be equally visible throughout a great range of latitude. Yet such is by no means the case, and hitherto no satisfactory explanation of it has been offered.

In 1866 Dawes with a single assistant counted the meteors at the rate of 1,200 per hour, which for a single observer would mean perhaps 800 in that period. In 1901 with perfectly clear skies in Cambridge, in latitude +42 degrees, we counted the meteors at the rate of 60 per hour for a single individual, yet on the steamer Admiral Dewey, latitude +26 degrees, in the same longitude as Cambridge, and at the same time, they appeared at the rate of over 420 per hour. At Trinidad, B. W. I., the rate was 290; at Fort Worth, Texas, 420; Sonora, Mexico, countless; Tuscon, Arizona, 225; Claremont, California, 800 for four observers, or presumably 400 for one. At the Lowe Observatory, California, the rate was 300. The shower does not appear to have been quite as pronounced as that of 1866 in England, but even in Cambridge the rate was twice that of any previous year. Most of the stations where many meteors were observed were near latitude +30 degrees. Six observers were at work in Cambridge, but 60 an hour was the best rate that anyone secured. Other northern observers obtained similar results. The next important display should occur in 1935.

*Popular Astronomy.

Perfected Electric Motor Blast Fans

The theory and construction practice as regards motor-driven air blowers or exhaust fans lies in close connection with what has already been worked out for steam turbines, so that the new type evolved at the Swiss Oerlikon works had the benefit of the extensive turbine engineering practice at this well-known establishment; and again, the electric motors built at the works can be coupled so as to make a most practical and compact outfit for blowing or exhaust purposes. For exhaust work it is only required to run the fan backwards. Considering the question of modern blast fans on the present approved designs, these blowers can be classed as low, medium and high pressure, and the latter class also includes air compressors, that is a fan is termed a compressor when the pressure is above the atmosphere. The underlying principles are the same for all the blast fans, that is, an outer case or shell holds a wheel which draws in the air through an axial opening at the side of the case and sends it out by a radial or tangential opening of the familiar kind. Pressure and output depend on the design and size of the rotating wheel, and also the speed. Wheels can be single or double, etc., and can work in parallel so as to add their outputs, *i.e.*, the volumes of air delivered at the same pressure, or in series to add their pressures for a given output. The smaller types of fan deliver 100 cubic feet per minute, and find their best use for forge fires, drying ovens or sand blasts, and require only 0.8 horse-power in the motor. A larger combination rated at 1.5 horse-power serves very well for the portable drying ovens used in foundry work, and here the fan and motor set is mounted on a truck. Still larger sets are now employed for blasts in coke furnaces or for the suction of gases in chemical works, for zinc processes, in sugar plants, also for cupola ovens and copper smelting ovens, and quite a variety of other work.

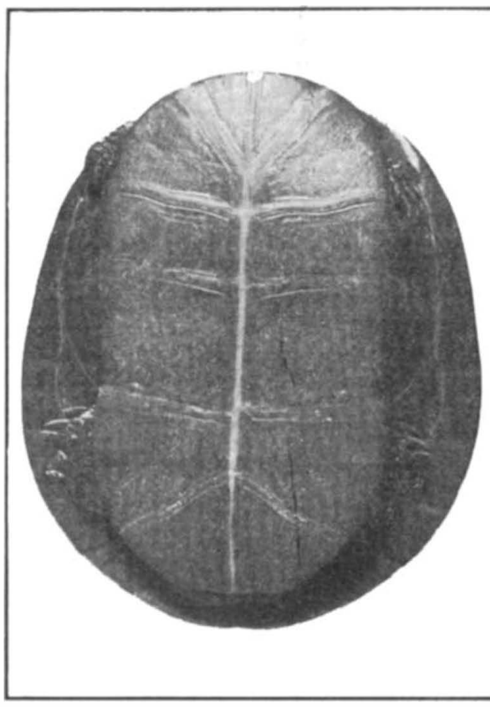

Fig. 1.

Fig. 2.

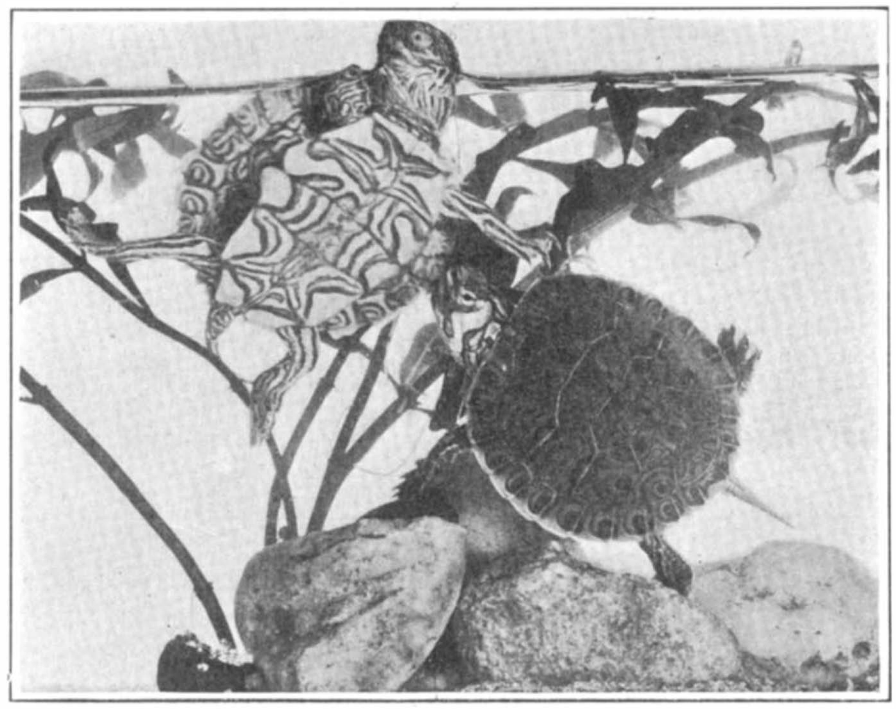

Fig. 4.

Fig. 1.—Ventral aspect of a subadult specimen of the Pond Turtle (*Chrysemys picta*). Fig. 2.—Ventral aspect of a young specimen of the Pond Turtle (*Chrysemys picta*). Age not definitely known, though probably of the second summer or somewhat older. Both figures natural size, and photographed from life by the author. Fig. 4.—Young turtles of the fir t year. Upper one, *Malachlemys geographica;* lower one, *Chrysemys scripta.* Natural size; photographed from life in the water by the author.

Certain American Turtles

A Preliminary Study of Individual Variation in Their Markings

By Dr. R. W. Shufeldt

Within the last year I have paid considerable attention to some of the characters of the chelonians of the eastern part of the United States, with the view of noting such variations as occurred among them in the matter of color markings, general form, and, in a few instances, habits. Most of my observations have been made upon the young, though the adults were by no means neglected. Apart from the few specimens of the Painted Pond Turtle (*Chrysemys picta*), taken by me near my home in Washington, the majority of the specimens have been kindly loaned me by Mr. Edward S. Schmid, proprietor of the pet establishment at 712 Twelfth Street, of this city. Every spring Mr. Schmid receives hundreds of young turtles, which are transported to all parts of the country for aquaria and ponds. The principal species examined by me at his place have been the Painted Pond Turtle mentioned above, the Spotted Pond Turtle (*Chlemys guttatus*), the Snapping Turtle (*Chelydra serpentina*), the Mud Turtle (*Kinosternon pennsylvanicum*), the Musk Turtle (*Aromochelys odorata*), with many scores of the young of the southern species *Chrysemys elegans, C. scripta* and *Malachlemys geographica.*

In all of these turtles the *outline* of the carapace and, to a lesser degree, the outline of the plastron, changes in figure at different stages of the animal's growth. Such species as the Painted and the Spotted Pond turtles have the carapacian outline nearly circular when young, to include the early subadult period; but as these particular chelonians advance toward maturity, this outline becomes more or less elliptical. In some specimens the ellipse is quite true, while in others the anterior minor axis is shorter than the posterior one, as here shown in an individual of the first-named species (Fig. 1). Fig. 2 shows the circular outline of the carapace in the young of this species of the second summer or somewhat older. Observe that the plastronic outline in both of these specimens is a blunt, rather elongate ellipse.

These Painted Turtles grow to be much larger than the individual shown in Fig. 1, while there are specimens before me not half the size of Fig. 2. As a rule, the exposed surface of the plastron in this species, when fully adult, is of a rich yellow, though it is sometimes of a coral red, which appears to be sufficiently constant to have a subspecies made of the form exhibiting it—*C. p. rubiventris.* Sometimes the yellow is blotched with a pale tan; and often in both old and young the entire plastron is of a deep, rich, chocolate shade, blotched with yellow or buff. Recently I have examined a young individual of this species, of about the same size as the one shown in Fig. 2, where the plastron bears a more or less complicated figure, such as we frequently see in *Malachlemys geographica.* (See Fig. 6.) This interesting specimen was kindly loaned me by Mr. J. A. Phillips, of Washington, who still has it in his possession. Of the hundreds of turtles of this species, both young and old, that I have examined and compared, this is the first and only specimen I have met with so marked.

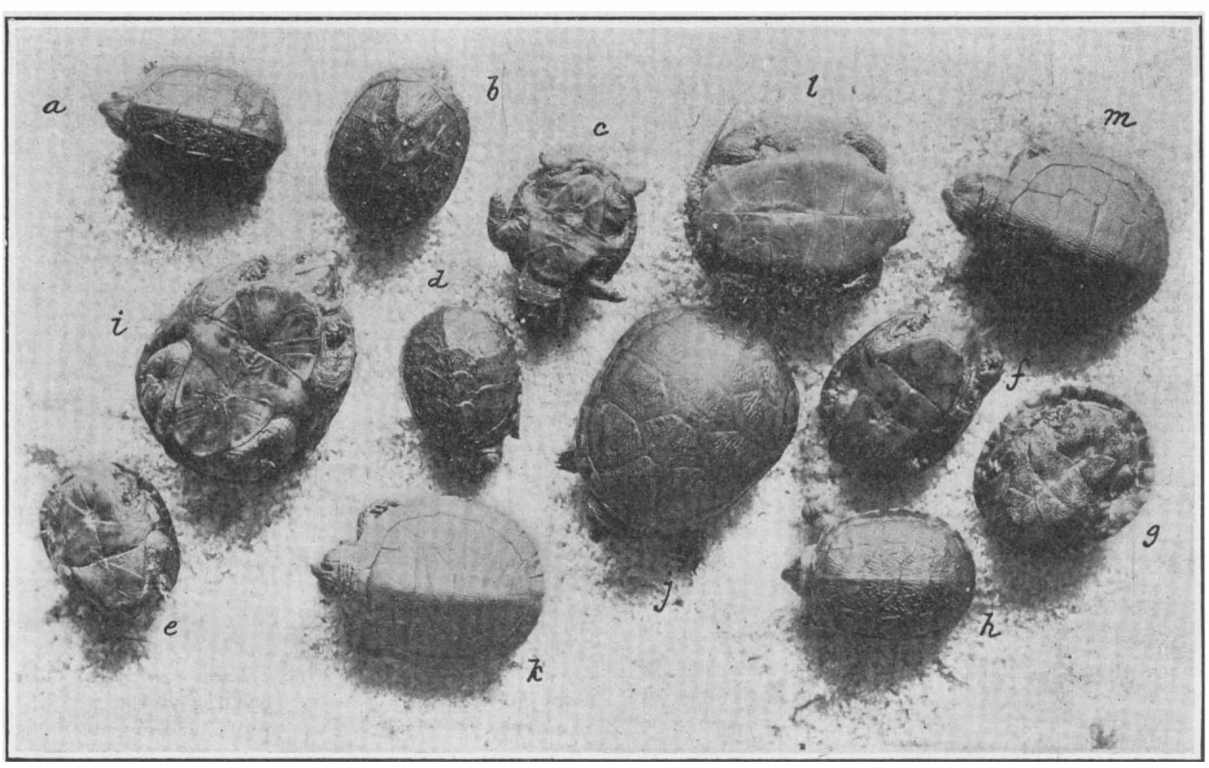

Fig. 3.

Fig. 3.—Superior and inferior aspects of several species of young turtles of the first part of the first year of their lives. *a-k,* the very young of the Mud Turtle (*Cinosternon pennsylvanicum;* *i,* seen from below; and *j,* from above, where the specimen just begins to gain the external characters of the adult. *k-m,* the young of the Elegant Pond Turtle (*Chrysemys elegans*). Photographed from life by the author. (Four fifths of natural size.)

This change in the form of the shell of fresh water turtles, as they pass from the young stages to maturity, is, in my opinion, of the same character as seen in those changes in the form and size of the head of the young of our own species, between the times of foetal and adolescent periods of life. It is a well known fact that the head of the young child is very much larger in proportion to its body in the infant than in the adult of man. No such discrepancy is ever seen in the case of chelonians, in so far as I have studied them, unless it be to some slight extent true of the common snapping turtle (*Chelydra serpentina*). Sometimes the tails of young pond turtles of several species are much longer in proportion to the rest of the body than they are when the animals have attained maturity; but such disproportion of parts must be accounted for in some other way than attempting to explain it away as a condition that just happens to be so. Occasionally we meet with specimens of adult Pond Turtles (*C. picta*) in which the claws of all the feet are conspicuously long and slender. My wife collected a specimen of this species, in April, 1916, near the Georgetown Canal, which exemplified this peculiar character in a very marked degree. Why it should be present in one adult individual and not in many others of the same species at hand—some of which are much larger and older—is a difficult matter to give a correct reason for; it surely is not to be explained by simply pro-

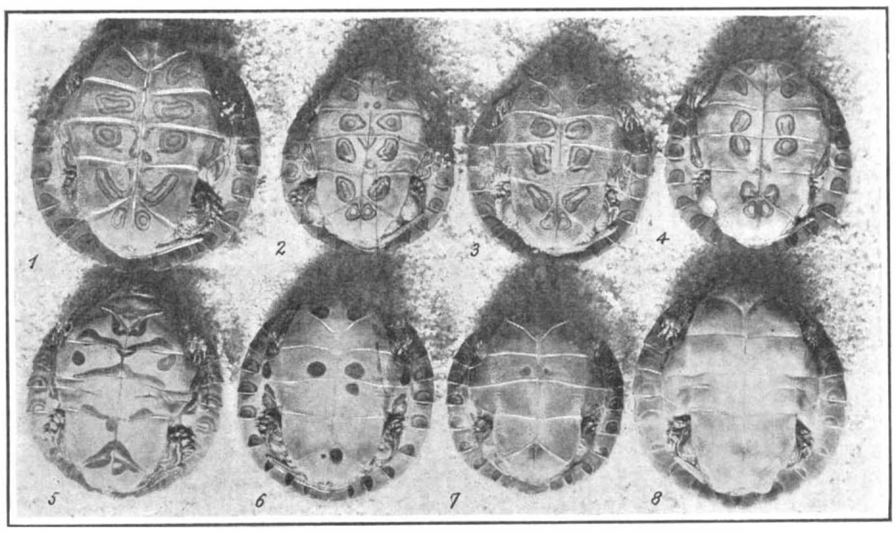

Fig. 5.

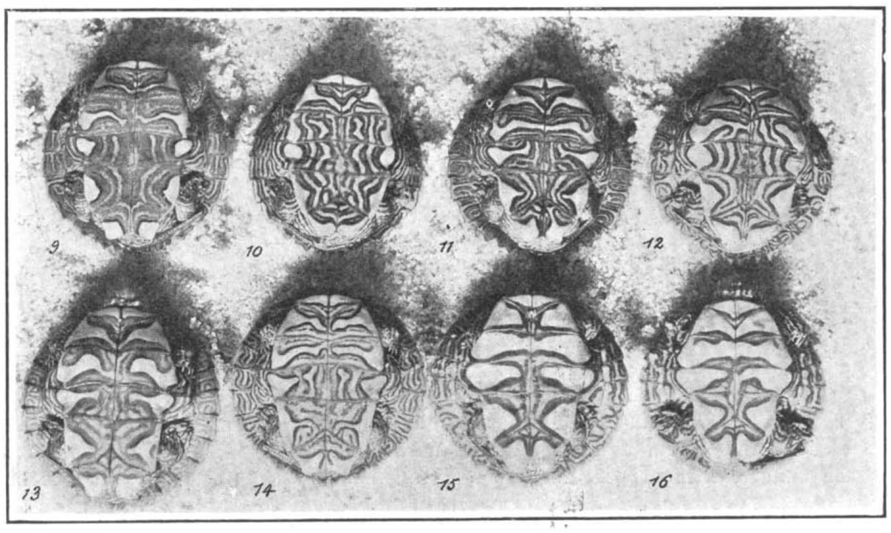

Fig. 6.

Fig. 5.—Ventral views of the young of *Chrysemys elegans,* showing the variations in the markings on the plastron and inferior marginal scutes; photographed from life by the author. In Fig. 5 we have the ventral view of a young specimen of *Chrysemys scripta,* here introduced in the series with *C. elegans,* in order to show the combination of the markings of the latter and *M. geographica.* Fig. 6.—Ventral views of the young of the Geographic Turtle (*Malachlemys geographica*), showing the variations in the markings on the plastron and the inferior marginal scutes. Photographed from life by the author. These illustrations are about seven tenths natural size.

nouncing it to be a "freak," which is so often made a cloak to cover our ignorance in such matters.

In addition to these remarkable variations in the form of the shell in the turtles above described, we also are to note similar departures from any type pattern of coloration and markings, as we find them to exist in the head, limbs, and tail of all these different species. This I shall not enter upon especially, as I desire to devote the remaining few paragraphs of my article to noticing the curious variations of the markings to be found on the ventral aspect of the plastrons in the young of *Chrysemys elegans, C. scripta,* and *Malachlemys geographica.* (Figs. 5 and 6.) These are very remarkable, and have heretofore never been published in series as shown in the present article—certainly not from photographs made direct from the living specimens. Personally I have not, as yet, had the opportunity to study these species in their natural habitat in nature; I sincerely regret this—especially with respect to the adult turtles of all three species. To the best of my knowledge, they all occur in the same waters in the swamps of the Carolinas and Georgia, and probably elsewhere in adjoining regions of their several ranges. Whether they ever interbreed and produce hybrids, I am not at this time able to state; it would be an interesting fact to know, however, particularly as to what extent it would modify or alter the markings of the progeny in any particular species.

I am much indebted to Dr. Leonard Stejneger, of the U. S. Museum, for assisting me in the matter of identifying the young of the turtles from the Southern States, here shown in Figs. 4, 5 and 6; it is not always an easy thing to do, owing to the scant literature upon this subject, and to the meagre descriptions published on the external characters and markings of the young.

In the case of these young chelonians, whether there is an evolution of their markings in the course of progress; or whether these markings possess any sexual significance; or, finally, if they have any value as secondary sexual characters, will, without doubt, require much further research than I have given the matter up to date. The present article pretends to be nothing more than an introduction to the subject, especially along the lines of evolution.

From a study of Fig. 5 it will be observed that in the case of *Chrysemys elegans,* the rich yellow plastron may be quite immaculate and entirely devoid of spots, while semi-markings or rather semi-patterns are found upon the ventral marginal scutes. (8). These latter persist in 7, while small black spots appear on the *gular, pectoral* and *anal* scutes—the last merging into one. These are larger in 6, while an additional spot occurs on the *left abdominal* scute, and those on the anals are separated, the right one being very small. This brief observation would simply go to show that in the appearance of these spots, if they appear in any particular specimen at all, they show up *first* on the *gulars* (anteriorly), then medianly, and finally on the posteriorly situated scutes—possibly on the anals first. These spots are plain and uniform in color, being only occasionally paler or grayish. In following this series from 4 to 1 (Fig. 5), we are to note that these *spots* have changed from dots to ocellated, leopard-like markings, which exhibit an infinite amount of variation, though, as a rule, they are in two rows, a spot being on each scute of the yellow plastron, with sometimes *median* markings of a less definite character (1 and 2). These spots may be nearly round, or they may be pear-shaped, elongate or of irregular outline; but they are *never* alike on any two specimens. In other words, their variations are practically infinite, and this likewise applies to the markings on the nether surface of the marginal scutes. In the case of these latter, it may require two consecutive scutes to accommodate the *completed* marking (see 1), while in other specimens it may be imperfect, disjointed, or, finally, partially suppressed—all of which is curious and very interesting when we come to consider the basic reasons for it all, and how the variations are really brought about. In the case of these markings as we find them in *Malachlemys geographica,* they are far more complicated, both these we find on the plastron as well as on the marginal scutes. These patterns are so well shown in Fig. 6 that they will need no especial descriptions from me here, though I may say that the ground-color of the plastron is usually of a greenish yellow, while the markings are blackish, grayish, and sometimes, in part, a very pale gray. What I have said in regard to these markings in *Chrysemys elegans* also applies to the present species.

In *Chrysemys scripta* (5 of Fig. 5) we find a *combination* of the pattern markings of the plastron and marginal scutes of the young, as I have described them for *C. elegans* and *M. geographica;* for we not only have the *geographical pattern,* but likewise the plain, solid spot and the concentric or ocellated one.

In the case of the specimen shown in 5 of Fig. 5, it is interesting to note that these patterns on the plastron of the young of this turtle (possibly in others) may likewise, as in the case of the patterns on the marginal scutes, be disjointed or broken, the disconnected parts not matching on the scute of the opposite side. This condition is well shown in the *anal scutes* of 5 of Fig. 5. It is very difficult to account for this, and it points to a certain *independence of production* with respect to the marking in *some cases,* which is quite extraordinary; for, as a rule, the matching is quite perfect, which may be seen in 9, 10 and 11, and in many other specimens I have examined while preparing this article.

Growth of Crystals Under Pressure

In 1853 Jean Lavalle stated that growing crystals exerted a linear pressure. Kopp, on the other hand, could not observe that a crystal had the power of raising itself by growing on the face on which it rested. Discordant observations were made by others. In 1905 G. F. Becker and A. L. Day described experiments according to which a crystal growing in a saturated solution at a constant temperature could raise a load of 1 kg., placed on the top of the crystal, through a height of several tenths of a millimeter; attempts to determine the linear force exerted per square centimeter failed, because the area of contact with the glass plate on which the crystal rested could not be measured. The experimental detail given was meagre, and, repeating the experiments in 1913, as far as possible under the same conditions, with the greatest care, W. Bruhns and W. Mecklenburg did not confirm the observation. Only the unloaded crystals grew. Late in 1914 Mr. Stephen Taber (*American Journal of Science,* xli, pages 532-556, June, 1916) took up the problem, mainly for the sake of its geological importance, apparently. He grew crystals of alum and other salts on glass plates, supported in dishes kept in desiccators; any load applied was put on a small glass plate resting on the top of the crystal; this had been done by his predecessors. But he had loaded crystals in one dish, unloaded ones in another, and loaded and unloaded crystals in a third dish. Under these conditions he observed that a loaded crystal did raise its load, but only when there was no unloaded crystal near it; Bruhns had had a loaded and an unloaded crystal next to one another, and, Taber suggests, had failed for this reason. When two crystals, similarly placed in the same saturated solution, are subjected to unequal pressures, the system is, he argues, in unstable equilibrium. Thus the solution may become supersaturated (and would hence crystallize) with respect to one crystal, while at the same time tending to dissolve a crystal which is under greater pressure. Pressure tends to increase solubility of salt when there is contraction in volume, and most crystals dissolve in water with contraction, *i. e.,* the sum of the volumes of the water and of the salt is larger generally than the volume of the solution. But every big crystal, we thought, is only an agglomeration of small crystals, and we do not see why a big crystal should not be regarded as a unit in one respect, but as a unit with regard to a crystal next to it. Taber admits that some of his observations are not satisfactorily explained. Whenever a crystal grew in height, he found afterwards that a cavity had formed on its lower face (on which is was lying) even when that face had been quite plane, and there might also be a cavity on the top. In one case the lower cavity had a height of 0.54 millimeter, the upper a height (or depth) of 0.06 millimeter, and the whole crystal grew by 0.6 millimeter in 15 hours; thus the total increase in height nearly balanced the total decrease in the cavities. In another case a crystal, 3 millimeters thick, of potassium sulphate, placed between two glass plates which were pressed together by the two rubber bands, completely dissolved in a few weeks in its own saturated solution. When a crystal grew in height, a kind of footstep, terraced often, was formed at its base, and that footstep grew only on its rim. The point is probably that there is a film of solution between the crystal and the glass plate on which it rests. That film is under the pressure of the crystal weight and becomes further supersaturated by capillary forces and absorption. In the experiments, supersaturation of the whole solution was produced by slow evaporation or by cooling. Crystals of copper sulphate growing through porous clay walls or within thin glass bulbs (partly filled with crystal fragments and sand to start the crystallization) crushed the clay or smashed the bulb in a week or so; the sulphate in the cracks was fibrous, resembling asbestos fibers in serpentine; this asbestos, Taber suggests, may have been formed in a similar way. We all know that freezing water will burst pipes, and if salts contract when dissolving in water, the solutions should expand when crystallizing. We also remember that powdered substances combine and react with one another when highly compressed (Spring and others), and all these phenomena involve the little understood molecular forces.—*Engineering.*

A serious problem that is confronting road engineers is to provide against the damage done by heavy trucks, driven at high speed.

Latent Life—II*

Its Nature and Its Relations to Certain Theories of Contemporary Biology

By Paul Becquerel, Sc. D.

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VII.—THE INFLUENCE OF LOW TEMPERATURES.

The influence of low temperatures on seeds and on spores of bacteria has been studied for thirty years by a number of investigators, chief among whom are Raoul Pictet, Casimir de Candolle, Brown and Escombe, Dyer, and MacFadyen. These scientists have proved that seeds and spores in their state of natural desiccation endure, without perishing, temperatures as low as 190 to 250 degrees below zero. I myself in attempting to ascertain the influence of the state of hydration, of decortication, and of gaseous reserves of the seed, have obtained analogous results. The investigators above mentioned, believing that physical and chemical phenomena are completely suppressed by low temperatures, have thought that the latent life of seeds and germs plunged into liquid air or hydrogen must be a completely suspended life. But this opinion should be accepted with some reserve. Certain chemical reactions may still take place at low temperatures. Have not Dewar and Moisson shown that solid fluorine in contact with liquid hydrogen is combined explosively at 250 deg. Cent. below zero? On the other hand, Svante Arrhenius[7] does not now admit the suppression of chemical reactions at that temperature. He considers that the chemical reactions especially connected with the loss of the germinative power of seeds must be much retarded by cold. Upon the basis of the experiments of Nyman and Madsen, in which the spores of anthrax are shown to develop twice as rapidly when the temperature is increased 10 degrees, the eminent Swedish physicist formulated an ingenious hypothesis according to which the retardation of life should be twice as great if the temperature is lowered 10 deg. Cent. According to this rule the germinative power of spores would diminish no more during 3,000,000 years at 220 degrees below zero than during a single day at 10 degrees above zero.

If we accept this calculation and apply it to macrobiotic seeds which live a hundred years at a temperature of 10 degrees, their latent life, provided it could be kept at a temperature of 220 degrees below zero, could be prolonged for two hundred billions of years. This is a number which surpasses any which is conceded for the duration of life on the surface of the earth, and even for the period of the evolution of our Solar System.

If the physical and chemical phenomena of life are thus retarded, we concede that we could not detect it experimentally.

But since in all the experiments with low temperatures upon which Arrhenius relies, it is a matter of germs in the state of natural desiccation, containing consequently from 5 to 12 per cent of their weight of water, it is interesting to ask what would happen if we were to experiment with dried seeds placed in the most complete vacuum and submitted at the same time to the lowest temperatures. With this in view, with the valuable co-operation of the learned physicist of Leyden, M. Kammerlingh Onnes, who very kindly placed at my disposal the resources of his excellent cryogen or refrigerating laboratory, there were submitted for three weeks to the temperature of liquid air and then for seventy-seven hours to that of liquid hydrogen at 250 degrees below zero, decorticated seeds previously dried, of lucerne, mustard, and wheat, and spores of Mucor, Rhizopus, and Aspergillus, and of various bacteria enclosed in sealed tubes in which the most complete vacuum possible had been secured.[8]

All these seeds at the end of one year, and the spores after two years in the vacuum, showed a high percentage of germination.

In this particular case in which the cell was deprived of water and gas, in which its diastases were desiccated, and the protoplasm lost its state of colloid solution, at least while they were under the simultaneous influence of desiccation and low temperatures, one can hardly say that latent life is relaxed life.

Life without water, without air, without gaseous exchanges, without colloid molecules, in suspension in a liquid, appears to me paradoxical. The vital phenomena of assimilation and of protoplasmic disassimilation being rendered temporarily impossible, I believe that the real latent life such as Claude Bernard conceived it, that is to say, the suspension of life, under these particular conditions has been realized.

VIII.—THE PHYSIOLOGICAL CONSEQUENCES OF THE SUSPENSION OF LIFE.

If that is the case, the law of the continuity of vital phenomena is dealt a severe blow. In fact, the phenomena of life, which since their appearance on earth have been transmitted without interruption from generation to generation during millions of centuries, with only occasional retardation in the germs, have now for the first time, under the influence of exceptional conditions, been interrupted in certain cells, without injury to their power of resuscitation. Moreover, these facts demonstrate that one cannot confound an organism wholly inert during latent life with a dead organism. Although on examination a dried seed and a dead seed appear identical, there is a great difference between them. The protoplasm of the dead seed has undergone an irrevertible chemical modification, such that if it be placed in conditions favorable for its development, none of the physical and chemical phenomena of assimilation and disassimilation can longer be produced.

On the contrary, the protoplasm of the seed in latent life, under the combined action of the vacuum, desiccation, and cold has received only a physical modification which has in no way altered its chemical composition. It is a revertible modification which it has undergone, since if there be restored to it water, gases, and the proper temperature, its substances again take on their properties and all the physico-chemical phenomena of its vital activity reappear. The experimental proof of the interruption of life without destroying its power of resuscitation and without leaving any mark to make one suspect the existence of a limit to its prolongation in the case of both seeds and spores, is, moreover, a good argument against certain neovitalistic theories. It demonstrates the actuality of the strong persistence of vital phenomena and exposes the unstableness of the basis of the definition of life accepted and promulgated by such scientists as Grasset, Bundge, Reinke, and Lodge.[9]

According to the definition of this last author, in his little work, "La Vie et la Matière," life is a particular force, "a special directive power issuing from a world in which physics and chemistry have no part, a world impossible for us to know through our senses."

But after the results of all my experiments, which confirm the ingenious views of Claude Bernard, it can no longer be affirmed that life is a principle or a mysterious directive force escaping the influence of natural phenomena.

Life is nothing more than the extremely complex physico-chemical functioning of protoplasmic organisms produced by their incessant relations, their continual exchanges of elemental matters, and the different forms of energy.

IX.—THE BIOLOGICAL IMPORTANCE OF LATENT LIFE.

This study of latent life not only brings us preciseness as to the nature of life and of death, but it touches also on the biological problems concerning the dissemination and conservation of life.

In fact, this peculiar property of latent life confers on all organisms that possess it the power to traverse time and space. It is to be noted that the seeds which preserve their germinative power the longest are almost always heavy ones, which cannot be transported by the wind, and which, if buried, must wait during a long time conditions favorable to their germination and growth. Most of these seeds belong to the families of Leguminosæ, Nelumbonaceæ, Myrtaceæ, Malvaceæ, and Cistaceæ. The same remark applies to the eggs of certain crustaceans which are deposited in the mud of ditches, marshes, and streams which often run dry. Thus Giard, in his researches on anhydrobiosis, informs us that the dried eggs of Apus survived for twelve years until the arrival of the water necessary for hatching.

Many bacteria profit by their state of latent life to await for years a time favorable for their multiplication. It is in this way epidemics suddenly appear. As Pasteur has shown, anthrax germs from a buried sheep brought to the surface of the earth by earthworms sooner or later make a pasture dangerous to the flocks. In the same way the wretched hovels in which people die of tuberculosis from generation to generation, notwithstanding ineffective disinfections and numerous removals of tenants, owe their danger to the presence of dried bacilli in the dust that is inhaled during sweeping.

The persistence of vitality of cells may also be characteristic of tissues of the human body and may be advantageously utilized. This is what the splendid researches of Dr. Carrel are demonstrating to-day. This investigator, profiting by the experiments of Paul Bert, of which I have already spoken, has succeeded in preserving in a state of latent life certain tissues gathered aseptically from fresh corpses, such as fragments of skin, cornea, blood vessels, and tissues. These tissues protected from the air in sterilized vaseline at a temperature of 3 deg. to 5 deg. Cent. have preserved their vitality for forty days, and consequently may be used for grafting. When some method shall have been perfected it will render inestimable service to surgery.

Still other biological deductions result from the conservation of latent life, particularly when it is under the influence of low temperatures. For instance, germs arrested in their development may at this moment be subjected to the actions of complex causes which are determining their evolution. Borings made on continents covered with ice, such as the South Pole and the vicinity of the North Pole, where the temperature oscillates between 40 degrees and 60 degrees below zero, will perhaps permit us to gather seeds or old spores which have conserved their germinating power for many thousands of years under the action of the cold.

Arrhenius goes still further in his deductions. He thinks that latent life is sufficient to enable germs to traverse the icy void of interstellar space intact during an almost unlimited period. To determine it, the Swedish scientist has formulated his ingenious theory of interastral panspermism. I have already had occasion elsewhere to explain and discuss this hypothesis.[10]

Unfortunately, worlds cannot be sown with germs in latent life, propelled by light from one to the other, because the action of the stellar ultra-violet rays in the center of the solar systems and even in the atmosphere of planets is too harmful, but also because there would be needed a very improbable concurrence of extraordinary conditions. So it is necessary to seek other modes for the propagation of germs in infinity. In advance of their discovery, there results from my researches upon latent life, from the point of view of the future of life on the globe, a conclusion which, notwithstanding its great probability, will not fail to astonish us. This conclusion is that on the day when the sun shall be extinguished, when all the gases of our atmosphere shall have disappeared, as took place on the moon, when active life shall be destroyed, latent life will still be able to exist for a long time on the surface of the earth.

Indeed, at that moment there will be found realized by nature the vacuum, dryness, and low temperature, the three conditions necessary for the conservation of germs which we have obtained simultaneously in our experiments. Upon that day, on this frozen, uninhabitable planet, wandering in the darkness of cosmic space, what will become of the stored seeds, and eggs, and spores? If the planet should be captured by a new solar system, will there be produced under the action of new radiations, an atmosphere and a wakening of latent life, the beginning of a new evolution of beings? If this contingency is not fulfilled, and the planet is demolished by a shock or an explosion, will its débris, charged with germs, as Lord Kelvin believes, sow other worlds?

For my part, I do not believe so, because at the present time the study of meteorites does not justify this conjecture. And it is a pity, because latent life, which is a true Providence for the terrestrial conservation of beings, would have been the best means that nature could have employed to confer on certain animal and vegetable species a sort of celestial immortality.

*From the last Annual Report of the Smithsonian Institution. Translated by permission from *Revue Générale des Sciences pures et appliquées*.

[7]Svante Arrhenius; *L'évolution des mondes* (translation by Seyrig), p. 138.

[8]Paul Becquerel: C. R. Acad. of Sc., April 19, 1909, and May 30, 1910.

[9]Lodge, *La vie et la matière*. Alcan, Paris, 1907.

[10]Paul Becquerel, La Panspermie interastrale devant les faits; *Revue Scientifique*, February 18, 1911, and C. R. Acad. des Sc. July 4, 1910.

Cross-Channel Communication*

Between England and France—Various Plans Reviewed

In view of the renewed attention that has been attracted of late to the idea of constructing a tunnel between England and France under the Straits of Dover, it is interesting to recall that this solution of the problem of cross-channel communication is by no means the only one that has been proposed.

In the course of the last century schemes were suggested literally by the score for tunnels through the ground under the sea, tubes resting on the bed of the sea, tubes floating below the surface of the sea, chariots traveling on a submerged viaduct and rising above the sea, bridges over the sea, and ferries conveying railway trains bodily across the sea. While some of these were the crude imaginings of amateurs, others embodied the serious investigations of experienced engineers, and any of them would have attained more or less completely the primary object aimed at, of permitting goods and passengers to be conveyed between Great Britain and the Continent without the cost in labor and time entailed by the double transfer from rail to boat and boat to rail at the two sides of the channel.

EARLY TUNNEL SCHEMES.

Probably the tunnel plan can claim priority in point of time. It was at the very beginning of the nineteenth century that Mathieu, a French mining engineer, enlisted the sympathies of Napoleon in a proposal to construct a carriage road under the Straits, emerging midway between Folkestone and Boulogne at the Varne shoals, where there was to be an international town and harbor of refuge. Some thirty-two years later a tunnel was again proposed by Thomé de Gamond, a French engineer, whose name is conspicuous in the history of the subject, since at different times he advocated nearly all the different solutions that have been suggested, including one peculiar to himself—a solid masonry isthmus across the Straits, with three large openings for navigation, to be crossed by floating pontoons or joined by submarine passages. His first tunnel was to be between Calais and Dover, his second between Calais and the South Foreland, but for a time he abandoned the plan of a tunnel because his geological inquiries led him to anticipate serious engineering difficulties. He revived it in 1856, selecting a line between Cape Grisnez and Eastware Point, between Dover and Folkestone, where he thought the geological conditions would be suitable, and his plans were regarded with favor by English engineers such as Brunel and Robert Stephenson. Ten years later he put forward another plan which reproduced the idea of Mathieu for an artificial island and harbor on the Varne shoal, with a submarine station reached by a spiral line.

CHANNEL TUNNEL COMPANIES.

Meantime William Lowe in England had suggested a tunnel in the lower gray chalk, which he thought would prove continuous between Far Hole, near the South Foreland, and Sangatte, near Calais. He joined forces with Thomé de Gamond in a scheme known as "The Channel Tunnel Railway," which secured the cooperation of Sir James Brunlees and Sir John Hawkshaw. In 1868 an international committee was formed and brought the question to the notice of Napoleon III. A special committee of inquiry which in consequence was appointed in France reported that there was a reasonable chance of success, but progress was interrupted by the Franco-German War. On the conclusion of peace, the British Government having intimated that it had no "objection in principle" to the tunnel, the "Channel Tunnel (Limited)" was formed, and in 1875 an act was obtained authorizing preliminary works at St. Margaret's Bay. The English company was not able to do much before its powers expired in 1880, but the allied French company took a considerable number of soundings and began a gallery under the sea from Sangatte. In 1882 a rival English company formed by Sir Edward Watkin, of the Southeastern Railway, asked for powers to make a tunnel starting from the Shakespeare Cliff, near Dover, but its efforts, like those of the Channel Tunnel Company, which also applied for powers, were brought to naught by the joint select committee, which reported in 1883 by a majority that it was inexpedient that Parliamentary sanction should be given to a submarine communication between England and France. In consequence the gallery which had been driven for more than a mile under the sea at Shakespeare Cliff was closed, and the two companies were combined into the Channel Tunnel Company, which has remained in existence ever since. Its present plans, drawn up by Sir Francis Fox, in agreement with M. Sartiaux, of the Northern of France Railway, contemplate a tunnel with two parallel galleries running from the Shakespeare Cliff to Sangatte, with a total submarine length of about thirty miles. The cost is put at 16 millions sterling.

TUBES.

The era of cast-iron tubes or masonry or concrete structures resting on the bed of the sea really began in the middle of the last century. The idea, however, is nearly as old as that of the tunnel, having been proposed in 1803-4, and it was one of those considered and rejected by Thomé de Gamond. After many wild and extremely expensive schemes had made their appearance, Bateman and Revy in 1869 described a carefully thought out plan for a cast-iron tube 13 feet in diameter. It was to be composed of rings 10 feet long, which were to be put together from within a large horizontal chamber sliding telescopically with water-tight joints over the last half-dozen completed rings and moved on by hydraulic power as each ring was put in place. The line selected for it was that between Dover and Cape Grisnez, where it was believed that the maximum depth was about 200 feet and the gradients would not exceed 1 in 100. According to another scheme, for which Zerah Colburn was responsible, sections of tube 1,000 feet long or more were to be built in dry dock and to be attached successively by ball and socket joints to the portion already completed, which was meanwhile to be towed out to sea. Finally the tube was to be lined with brick and sunk to the bottom. Thomas Page, again, the engineer of Westminster Bridge, whose experience in the construction of the Thames Tunnel led him to doubt the possibility of an ordinary tunnel under the straits, proposed to sink eight shafts, each consisting of two concentric cylinders separated by an annular space filled with concrete, at equal distances across the channel, and then to connect them by tubes in long sections lowered into positions prepared for them by divers.

BRIDGES.

After the veto placed on a submarine communication with France by the British Government in 1883, attention was given to the idea of a bridge, and plans for one were exhibited in 1889 by the Channel Bridge and Railway Company, with which Sir Benjamin Baker was associated. The route chosen was between Folkestone and Cape Grisnez, by way of the Varne and Colbart shoals, where it was thought the construction of the foundations would be facilitated by the shallowness of the water. Masonry piers rising to the level of the water were to carry two round steel piers, which in turn were to support the main girders some 160 feet above the sea, the rails being still higher. The total number of spans was to be about 120; their length varied, but the longest was 540 yards. The structure was estimated to cost 34 millions sterling and to require ten or twelve years for completion.

But this was neither the first nor the last of the bridge schemes. The industrious Thomé de Gamond was probably the first in the field, and in 1836 and 1837 he drew up five different schemes for bridges in masonry or iron. Thirty years later a compatriot, Boutet, showed Napoleon III. plans and models of a structure with spans half or three-quarters of a mile long, while about the same time Charles Boyd, an Englishman, went to the opposite extreme and studded the channel with piers only 500 feet apart. Another French proposal of slightly later date was that of Mottier, who had evidently been attracted by the tubular bridge over the Menai Straits. He proposed to form between the South Foreland and a point between Capes Grisnez and Blancnez about forty islands of iron and concrete, 110 yards in diameter. These were to be connected by means of an iron tube, fifty-five yards above the sea, with a double line of railway and a road for carriages and foot passengers. The clear distance between the islands or piers was to be 700 yards.

But even with spans of this order a bridge would not be welcomed by navigators, and it was the consciousness of this objection that induced the Channel Bridge and Railway Company to draw up plans for a submerged bridge, some fifty feet below the sea level. This was to be made of armored concrete, and on it was to travel a vehicle elevated above the water and carrying a number of railway wagons, which would be transferred to or from it at either end without disturbance of their loads.

TRAIN FERRIES.

The only other method, apart from aircraft, that has been proposed for carrying goods and passengers across the channel without transshipment is the train ferry. It, too, was thought of by Thomé de Gamond, but perhaps its most conspicuous advocate was Sir John Fowler, one of the engineers of the Forth Bridge. Half a century ago he prepared plans for the ferry boats and their landing places on the English and French coasts, Lord Armstrong designing the hydraulic lifts for raising or lowering the railway wagons to the level of the steamer's decks, according to the state of the tide; but in spite of repeated efforts he failed to get Parliamentary sanction to his scheme. The ferry scheme was again pressed forward eleven or twelve years ago by the Intercontinental Railway Company. Plans for landing quays at Dover were prepared by Sir Douglas Fox, for steamers by Sir William White, and for electric lifts by the Compagnie de Fives-Lille; but though a permissive act was obtained no definite progress was made toward actually carrying out the scheme, largely because it failed to secure the sympathy of the railways immediately concerned on the two sides of the channel.

Train ferries are by no means an untried conception, for they are working successfully in various parts of the world, and on the Great Lakes of America in particular they have to encounter weather conditions quite as severe as those that prevail in the English Channel. If they were adopted for communication between England and France they would secure the transit of goods without unloading just as a tunnel or a bridge would, and in the same way passengers would be able to travel in through carriages, say, from London to Paris, though it must be admitted that they might not be entirely immune from the discomforts of sea-sickness. The advocates of a ferry urge that the necessary works could be constructed much more rapidly and cheaply than a tunnel and, further, that the scheme would be more elastic in that the number of boats and landing places could be gradually increased as warranted by the traffic. It would not preclude the construction of a tunnel later, and in fact might be regarded as preparing the way for it, just as the train ferries which formerly existed in Scotland across the Forth and the Tay prepared the way for the bridges which were ultimately built in their place.

*London Times Engineering Supplement.

Light Railways in the Trenches

Light railways are playing a most important part in the present war, both in trench warfare and when an army is advancing.

Mr. Winston Churchill, referring to this arm of the service in his speech in the House of Commons, pointed out that the foundation of a good trench line was a system of light railways behind the line "far more elaborate and extensive than anything at present existing." He urged that these railways should be used much more abundantly, thereby relieving the roads, which were "blocked up with enormous loads of costly motor transport, with several men on each motor."

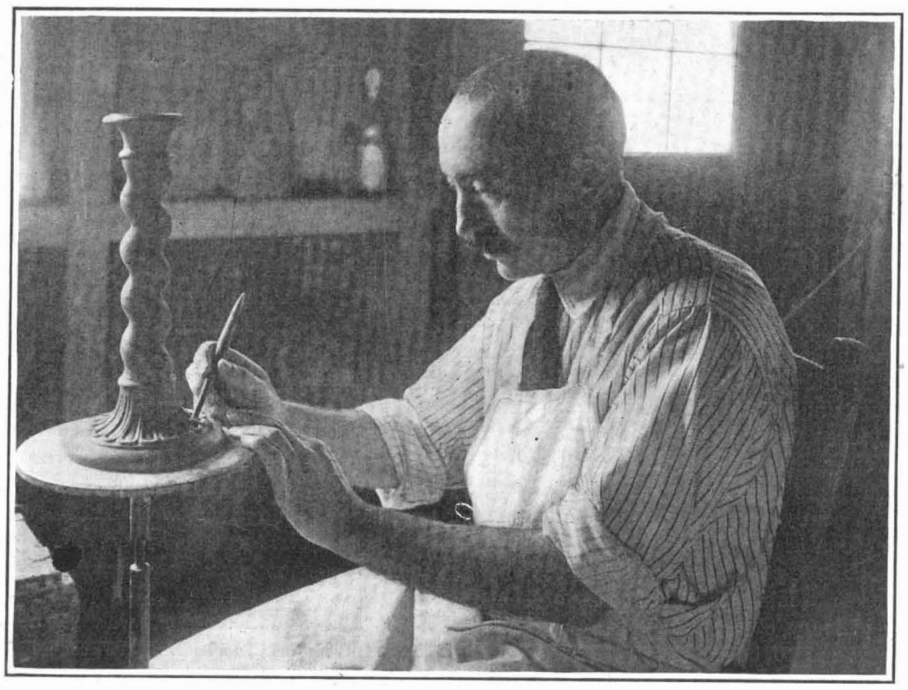
The French have made excellent use of 2-foot gauge light railways, employing them for ordinary traffic from the rear to the firing zone, motor transport being generally reserved for cases of emergency and for supplementary requirements.

Each railway truck on these lines carries about 10 tons, that is, it has a carrying capacity approximately three times as great as that of the average motor lorry. The big load is carried without any damage to the track, which can readily be maintained in perfect condition, while it is well known that the keeping of the roads behind the trench lines passable for the motor transport is a tremendous undertaking, requiring vast quantities of material and much labor.

The French light railways go practically up to the front line trenches wherever the ground provides reasonable cover. A smaller gauge of 16-inch is used actually in the trenches themselves, though the trucks are here hand-propelled. Nevertheless, they enable a man's working power to be increased several times. It is obvious how difficult it must be to carry heavy loads by hand along winding trenches, and that rail transport must be better in every way.

It has been calculated that with a truck running on rails in trenches a soldier can do as much work in the direction of hauling up ammunition, supplies, etc., as can be done by 30 men without this invaluable mechanical aid.—*London Daily Telegraph.*

An artist shaping the clay by hand on a potter's wheel.



Before glazing and firing each piece is carefully retouched by an artist.

Artistic Pottery Made in America

It may be safely claimed that the potter's art is one of the very oldest in the world, for man must eat to live, and, after contriving implements to enable him to obtain food, the next necessity in life must have been to devise means for preparing that food for consumption, for it cannot be imagined that any people would continue many years to eat their food in the same way that the animals do, and it is logical to suppose that simple utensils of sun dried clay would soon succeed the primitive flat stone.

Wherever human life has been discovered, there has been found the remains of domestic utensils of pottery, for clay of some description is to be found everywhere throughout the world; and from a study of these fragments much of the life history of long departed races has been deciphered.

Not only may pottery making be considered one of the first arts learned by man, but the practice of this art apparently led to the invention of the first known machine, for among the earliest remains discovered have been specimens that indicated the use of the potter's wheel; and, strange to note, in this age of intensive invention, where almost every conceivable thing has been improved time and again, the potter's wheel still survives in much of its primitive form to this day wherever artistic work is produced. Attempts have been made to ascribe the invention of the potter's wheel to various peoples in different parts of the earth, but the pottery remains of widely scattered races would indicate that this simple and useful machine was independently invented in many lands, between which an exchange of ideas or customs was obviously impossible.

One peculiarity of the ceramic art is that all of its best and most artistic productions are almost exclusively hand work, for even where molds are employed the pieces so formed must undergo much correction and retouching by hand. Another feature is that the simple processes, many of which still survive, are greatly conducive to individual effort, and admit of the workman embodying his own artistic ideas in the articles he produces, and encourage the free exercise of artistic taste.

All countries have had their famous potteries, and everyone is acquainted with the beautiful and graceful forms characteristic of the best days of Greece, and the elaborately decorated specimens of Moslem nations; and these have had their influence on the work of all succeeding ages. Many other nations, both of Europe, Asia and the Americas, in times past, have also been noted for their artistic ceramic work, for it is a branch of art that continually appeals to everyone, and even the lowliest appreciate a beautiful vase or other article formed of clay for domestic use or ornament. This is made plainly evident by the very pleasing designs of the Indian tribes of the southwestern parts of our country, whose art has been transmitted for generations, not to speak of the remarkable work left by the prehistoric races of Central America, and the graceful earthenware of the Incas, embellished with graceful reliefs, which are so highly prized by collectors.

America has had no school of its own, which is not surprising when we consider the comparative newness of our country, and the heterogeneous composition of our people; neither have we any great establishments that turn out choice work in any quantity, but there are a few small establishments where skilled workers of artistic tastes are producing charming specimens of the ceramic art that command the admiration of all lovers of the beautiful. One such ceramic studio is tucked away in a quiet corner of New York State, and the accompanying photographs, showing some of the processes, were taken there; and it may be stated that most of the workers learned their art in foreign lands.

One of these pictures shows a workman treading out a batch of clay, a method of kneading and tempering the material which has been followed in all countries from time immemorial, and although many attempts have been made to devise machines for doing this work, the old procedure is still found to produce the best results where fine work is being done. Another scene shows the potter at his wheel, engaged in carefully shaping a graceful dish with his hands, while he operates the wheel by his foot at any desired speed, in the good old fashioned way of primitive man. On the front page is seen the process of dipping some handsome pieces in a special mixture which, on baking in the kiln, produces a lustrous glaze to the surface.

From this studio many choice objects of art are being turned out by the artist workers—for in such matters everyone connected with the establishment must be an artist—together with magnificent table sets fit for the service of a king.

The Recovery of Laboratory Waste*

With chemicals at their present prices it is important that as many reagents as possible should be recovered and used again. Of course, it would not pay to keep all waste solutions, because in many cases the cost of the reagents required in the process of recovery would be greater than the value of the materials recovered. But there are a number of chemicals in common use that should certainly not be thrown away, quite apart from salts of the rare metals, properly so called.

The following substances are at present sufficiently expensive to warrant recovery: gold, lithium, molybdenum, platinum, silver, titanium, and possibly bromine, iodine and potassium.

The writer's method, which has been found to work admirably, is as follows: All waste solutions from analyses or experiments that contain anything worth preserving are put into a large earthenware vessel instead of being thrown into the sink. The material is kept fairly concentrated, using waste heat from hot water and distilled water apparatus as far as possible. Soiled acids, especially strong nitric and hydrochloric acids, as well as alcohol and ether, are preserved separately for use in effecting the separations. Some of the group and separatory reagents are also obtained cheaply by the simple process of preserving for use in this connection contaminated samples that would be of no use for other purposes. The method of recovery will now be described.

Evaporate the waste solution to a small bulk, with the addition of a few cubic centimeters of strong nitric acid, and without filtering off any of the mud that is sure to be present, add a quantity of washing soda, and boil. Evaporate to dryness and heat the residue to dull redness. This decomposes any organic matter which might interfere with the subsequent operations, and also converts bromates and iodates into bromides and iodides. Boil out the soluble portion of the ignited residue with water, making a concentrated solution, and filter. Wash the insoluble residue once with boiling water, adding it to the filtrate. The filtrate will contain bromine and iodine (together with chlorine and numerous acidulous radicals) in the form of soluble sodium salts. The metals of the alkalies—potassium, sodium, and possibly a little lithium—will also be present. The insoluble portion contains all the heavy metals.

Consider the filtrate first. If lithium has been used lately, and is likely to be present, part of it may be expected to remain in solution. The usual flame coloration test for lithium is inapplicable in this case, owing to the masking effect of a large excess of sodium salts. Therefore add to the still boiling solution a strong solution of phosphate of soda (disodium hydrogen phosphate) until no further precipitate is formed. The white precipitate of lithium phosphate may be washed and preserved as a material from which lithium salts may be prepared. The filtrate, after removing the above precipitate, contains bromine, iodine and potassium. It does not follow that it will pay to recover any of these. Much depends upon current prices, quantity present and reagents available. However, the following processes may be applied, if desired:

Remove the excess of washing soda as far as possible by passing a current of carbonic acid gas (generated from native chalk and crude hydrochloric acid) through the well cooled solution. This precipitates the bicarbonates of soda and potash, which are less soluble than the normal carbonates. The precipitate may be filtered off, washed, dried and ignited, giving a mixture of the anhydrous carbonates that forms a useful second quality fusion mixture. The filtrate now contains nothing of value but the halogens. Neutralize with any crude mineral acid that may be available until test paper is unaffected, then add a solution of cupric sulphate and drop in sulphurous acid until no more precipitate is obtained. If this separation is carried out with care all the iodine will be removed as greenish-white cuprous iodide, leaving the bromides and chlorides in solution. Collect the precipitate and wash thoroughly. The iodine may be recovered by boiling with caustic potash, filtering off, and rejecting the insoluble oxide of copper, and recrystallizing the resulting potassium iodide, either at once or when a quantity has accumulated.

Unless the quantity of bromine remaining in the filtrate is considerable, it is not worth troubling about. However, it may be recovered by evaporating to dryness and distilling with manganese dioxide and strong sulphuric acid. If a small distilling flask is used for the receiver the bromine may be condensed, while the chlorine—which will be liberated simultaneously from the chlorides present—escapes through the side tube. The bromine should be redistilled. Or, instead of evaporating to dryness, add a sufficient quantity of chlorine water to liberate the bromine, the latter being removed by shaking up with ether. The addition of caustic soda to the ethereal solution gives a mixture of bromide and bromate, which, after ignition to decompose the latter,

*From the *English Mechanic*.

may be heated with manganese dioxide and sulphuric acid to recover the bromine. The ether can be distilled off and used again.

It remains to deal with the insoluble residue after boiling the waste solution with soda. This contains all the metals, except part of the lithium, which will have been recovered from the filtrate. Dissolve the residue, or as much of it as can be dissolved, in dilute hydrochloric acid. Any residue shown to be clearly insoluble may be dissolved in nitric acid, the crude acids being used in both cases. Mix the two solutions. If a precipitate forms, add more hydrochloric acid until no further precipitate is obtained. Filter and set aside the precipitate marked (*A*). If either gold or platinum be suspected to be present—that is, if their solutions have been used since the waste vat was last treated—they should be removed at this stage. Upon heating with oxalic acid, gold is precipitated as a brown powder, which may be removed by filtration. The platinum is obtained by adding ammonium chloride, which forms yellow ammonium platinochloride. After adding the ammonium chloride, evaporate to dryness, add a little water, and evaporate again, then pour on some methylated spirit. Upon filtering, the double chloride of ammonium and platinum is left as an insoluble residue, which, if washed with alcohol and ignited, yields metallic platinum. To the filtrate add water and a few drops of hydrochloric acid, and boil until the alcohol is expelled. Then add a little sulphureted hydrogen water, and if a precipitate is formed pass the gas for some time. Filter, marking the precipitate (*B*).

Boil the filtrate to expel sulphureted hydrogen, add a few drops of nitric acid, and boil again. Add ammonium chloride solution and afterward ammonia, removing the precipitate by filtration. Pass sulphureted hydrogen through the filtrate if lithium is known to be present, and filter off a second precipitate. Mark the first precipitate (*C*), and reject the second.

The filtrate may be rejected unless it is believed to contain lithium in sufficient quantity to warrant recovery, and but very little barium, calcium or strontium. Add ammonia and ammonium carbonate, and filter off the insoluble carbonates of these three metals. From the filtrate, concentrated by evaporation if necessary, precipitate lithium phosphate by boiling with phosphate of soda, as already described.

The individual metals may now be separated from the various precipitates.

Precipitate (*A*) contains nothing of value but silver. Wash thoroughly with boiling water to remove lead, and dissolve the silver chloride off the filter by means of ammonia, rejecting any black residue that remains. Upon neutralizing the ammoniacal filtrate with an acid the silver chloride is reprecipitated, and when fused with sodium carbonate in a crucible yields a button of metallic silver.

Molybdenum, if present in sufficient quantity, may be profitably extracted from precipitate (*B*). After washing, this should be warmed (but not boiled) with ammonium sulphide to dissolve out molybdenum and other sulphides. Evaporate the solution to dryness, and mix the residue with twenty times its volume of a mixture of sodium peroxide and fusion mixture in equal proportions. Fuse this for ten minutes in a nickel crucible, then extract with cold water and filter. Acidify the filtrate with hydrochloric acid, then make strongly alkaline with ammonia, and, finally, add "magnesia mixture" (solution of magnesium and ammonium chlorides), and filter off any precipitate that forms. Upon concentrating the solution, white molybdic acid is precipitated by nitric acid, and may be washed and preserved.

Precipitate (*C*) is worthless unless titanium is known to be present. In the latter case dissolve in a little sulphuric acid, dilute to a large bulk with water, and boil for half an hour or so. Filter the precipitate, and wash with very dilute sulphuric acid. This consists of metatitanic acid.

It is assumed that none of the really rare metals are present, the methods of separation being suitable for the recovery of certain constituents of ordinary reagents that are in constant use.

Destruction of Cockroaches

Mr. J. J. H. Holt, M.B., has studied systematically the question of the destruction and dispersal of cockroaches. Experiments were made with volatile liquids, essential oils, coal-tar derivatives, dusting powders and food poisons. The tolerance of the cockroach to arsenic is remarkable, and in any case its dangerous character unfits it for general use. The action of the phosphorized poisons was tested more fully, as there seems to be reliable evidence that they have been found effective. It would seem to be the fumes which drive away the cockroach, which is exceedingly sensitive to irritants, and this fact is of importance on other grounds.

The experiments show that a number of bodies kill the cockroach through the respiration very quickly. This is its most vulnerable point. Assuming that the bodies which kill most quickly are also the most irritant, it is reasonable to suppose that they will also drive the cockroach away most quickly.

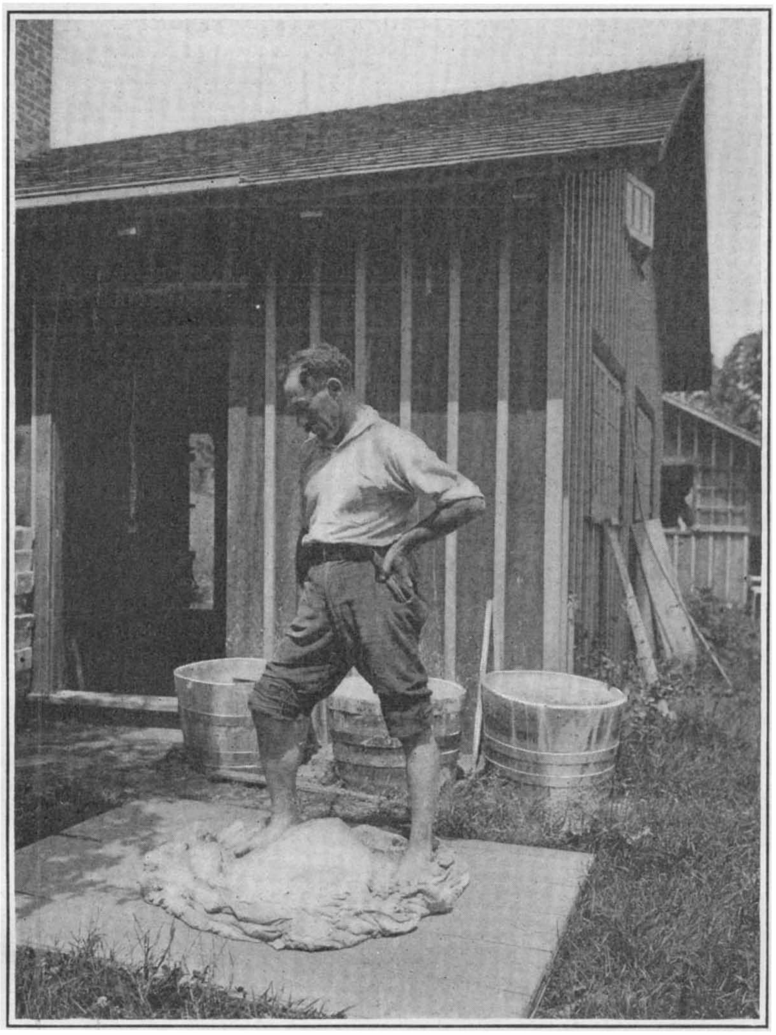
The problem seems to resolve itself into selecting from the respiratory poisons those which are the most irritant to the insect and at the same time least harmful to man. Of these substances bromine is the most active, but it disperses very quickly, and would therefore require the rooms to be sealed. Bromine is also expensive. Sulphur dioxide (from burning sulphur) is also very effective and is cheap. In this case, too, the rooms must be sealed. These are probably the best methods for use on ships, where destruction must be aimed at, as the cockroach cannot be simply driven away.

For domestic use the best available and most practical respiratory irritants are wood naphtha, one of the aromatic oils, or creosote. It is important to remember that a prolonged application renewed daily (or nightly) is necessary. If only used once or twice the cockroach might regard the vapor as a passing nuisance and return when its influence was spent. Two or three weeks are required to produce any lasting effect.

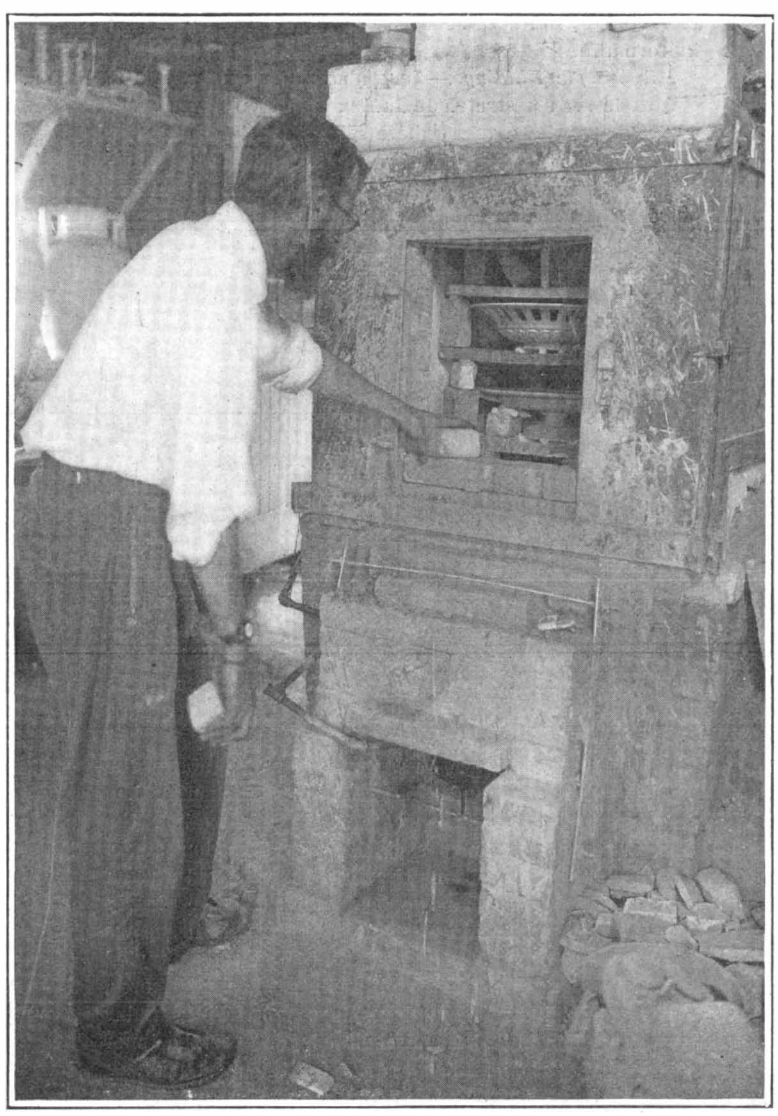
The paraffin derivatives, though very effective, are too dangerous for common use on account of their inflammability. Many of the aromatic oils are available. The oil of citronella, used by sailors to keep mosquitoes out of their cabins, and by travelers as a preventive, is useful. Tested by the cockroach, the oils of thyme, orange, rosemary and eucalyptus are more active, and would probably also be more effective with the mosquito. As these oils act by their odor, it would probably be better to sprinkle them upon the clothing, as more could thus be used and the effect last longer. These oils form the basis of many scents, which are therefore more or less anti-parasitic.

It is interesting to recall that camphor and lavender have been used for generations to keep moths away from clothing. The experiments indicate, also, that the direct paraffin-derivatives are more toxic than those of the coar-tar series. In both series the toxicity increases to a maximum as the boiling point rises, until a point is reached, after which it declines as the boiling point rises still further. Many of the dusting powders owe their efficacy to the volatile oil which they contain. Several are more effective than the Dalmatian insect powder, the reputed base of Keating's powder. Potassa sulphurata, which gives off sulphureted hydrogen, soon becomes inert. The best powder tried was sodium fluoride. This is very effective and keeps well. A mixture of equal parts of bleaching powder and boric acid also acts well and keeps well. Although boric acid is useful, borax is useless. The powder of veratrum album is slightly active, veratrum useless.

Summarizing the results of the experiments as a whole, they seem to indicate that many of the substances which have been supposed to kill the cockroach have really acted by driving it away and so leading to its disappearance. Such gregarious migrations have been observed, but have hitherto been otherwise explained. For quick destruction, stoving with bromine or sulphur dioxide is apparently best. For domestic application the daily use of creosote, wood naphtha, or the oil of rosemary, eucalyptus, or citronella placed near the haunts of the cockroaches for two or three weeks should effectually disperse them. Where these are inadmissible on account of their smell, odorless dusting powders may be used. Of these sodium fluoride was found to be the most effective. It is also cheap, and keeps indefinitely.—*Chemist and Druggist.*



Kneading the clay, an ancient method still followed.



A pottery kiln; after the kiln is filled the doorway is closely bricked up before the fire is lighted.

Histologic Effects of Heat on the Eye*

An Account of a Series of Experiments on Rabbit Eyes

By Wm. E. Shahan, M.D., and Harvey D. Lamb, M.D., Laboratory of Ophthalmological Pathology, Wash. University

THE following observations were made on rabbit eyes heated by direct application by means of a thermophor, as described in the article, "Effects of Heat on the Eye," published in the *Journal of the American Medical Association*, August 5, 1916.

Very briefly, the thermophor consists of a metal tube containing a thermometer and surrounded by a resistance coil to generate heat, while within the latter is placed a zinc-iron sensitive strip to permit the temperature to be kept at any constant point. Into one end of the metal tube are inserted applicators of various shapes, to be applied directly to the cornea.

The right eye of rabbit No. 2 was heated at 136 deg. Fahr. for 10 minutes under general anæsthesia (ether), with an applicator 7 millimeters in diameter applied to the upper middle portion of cornea. Immediately following the heating there was noticed a moderate clouding and loss of epithelium in the heated area. The epithelium was restored in 3 days, but the cloudiness persisted. At the end of one week there was a beginning keratoconus and an invasion of blood vessels into cornea from above. The keratoconus increased until the twelfth day, and then diminished, having about disappeared at end of 3 weeks. On the 15th day the iris opposite the heated spot showed a whitish area which remained. At the end of 4 weeks the keratoconus was gone, a vascular and somewhat pigmented scar occupied the center of the heated area and the upper third of the iris was gray. The eye was enucleated and fixed in formalin.

Microscopic Findings.—Sections through this eye show the thickness of the cornea increased through its upper half, reaching a thickness through the upper fifth of the cornea of about one and one-half times the normal depth. This increase in thickness is close to the newly formed connective tissue, just beneath the epithelium, containing several small capillaries, but few lymphocytes, leucocytes or plasma cells.

The posterior endothelial layer in the upper fifth of the cornea is rather thickly stippled on its surface with groups of small light brown pigment granules. This pigment, as we shall soon see, has undoubtedly come from the upper part of the iris. That it should be deposited here more thickly seems difficult to explain, unless this layer presenting a rather rough surface in its process of regeneration at this spot caught more of the floating pigment. This upper position of the posterior layer, it is true, would have the first chance at the pigment from the iris in our case since, according to the observation of Berg, there is a current upward in the posterior part of the anterior chamber, and one downward just behind the cornea.

The changes in the iris are much the most interesting. As noted above, the iris in its upper part was before death of a whitish appearance. We now see this to be due to a destruction of the cells in the iris stroma and a rearrangement of the pigment. (Where the iris has not been affected by the heat, a rather dense stroma is seen containing many stellate richly pigmented cells generally distributed, and in addition forming a thin layer just beneath the anterior endothelium and around the larger blood vessels.)

In a dense, poorly staining fibrous structure are seen a large number of round or oval shaped cells, some black with contained pigment, others less densely filled, being dark or light brown. Clumps of these pigment cells are also seen here and there just in front of the post-epithelial layers, and here without doubt these cells are epithelial in origin, having simply migrated from the retinal pigment layer. However, it must be that others of these cells, amœboid and phagocytic in character, are either plasma cells or enlarged polymorphonuclear leucocytes, which have taken up part of the pigment set free by the destruction of the stellate chromatophores. Some of this pigment, however, we see in a granular form lying more or less thickly between the large pigment cells. In many places some of these latter seem to be in the process of being taken up by phagocytic cells. The anterior endothelial layer seems almost everywhere intact.

The left eye of rabbit No. 2 was heated for 10 minutes at a temperature of 129 deg. Fahr., using an applicator 7 millimeters in diameter applied over the upper middle portion of the cornea. Immediately following there was an opal white clouding over the upper half of the cornea with loss of epithelium. The epithelium was restored in 3 days. A whitish atrophic area of the iris at the upper border of the pupil was noted after 2 weeks. At the end of 3 weeks the cornea was clear, except for slight pigmentation over the heated portion. A small gray cloud was formed in the anterior capsule of the lens, which had increased in density by the 25th day.

On the 54th day the upper part of the cornea was slightly cloudy and vascular; the upper part of the iris gray. The eye was removed and fixed in formalin.

Microscopical Findings.—The cornea for about 1 millimeter from the upper limbus shows the formation of a thin layer of scar tissue just beneath the epithelium containing many blood vessels, some deeper ones quite large. Infiltrating this tissue are many leucocytes and some large lymphocytes and plasma cells; the leucocytes being present in great numbers in the subconjunctival tissue at the adjacent limbus.

Descemet's membrane and the posterior endothelial layer show no changes. The pupillary edge of the iris above appears thickened and bulbous for about a third of the width of the iris where the same changes occurred as described for the right eye. The retinal pigment layer here, however, ends before reaching the pupillary edge, being partly replaced by small clumps of the round or oval pigment cells. The anterior endothelial layer is wanting over the margin of the iris where the heat effects were most marked.

An applicator with point 7 millimeters in diameter was applied to the left eye of rabbit No. 3 for 10 minutes at a temperature of 132 deg. Fahr. Slight cloudiness was caused which increased in density in the next few days. On the third day a purulent discharge was noted and on the 5th day a slight hypopyon; no staining with fluorescein. The hypopyon disappeared by the 7th day, although the iris appeared inflamed. On the 10th day the eye was quieter, the iris above buckled and gray looking, bullous keratitis over the spot of the former infection. On the 54th day the eye was quiet, a thin scar occupied the central part of the cornea, the upper part of the iris was gray and retracted upward. The eye was enucleated and fixed in formalin.

Microscopic Findings.—Just above the center of the cornea is seen a stretch including about one-fourth the diameter of the cornea where its thickness diminishes progressively to little more than half its ordinary thickness, and then increases again. The thinnest middle third of this stains more deeply with eosin, and seems more contracted. A thin layer of scar tissue lies just beneath the anterior epithelium over this quarter of the cornea. The margins of this stretch show a moderate amount of leucocytic infiltration. At the lower margin nuclei of polymorphonuclear leucocytes are seen in process of degeneration. At the upper margin, nearest the limbus, are seen many leucocytes, some plasma cells, all well preserved, being near several deep-lying blood vessels. The cornea above the superior margin is vascular and infiltrated with leucocytes for about half its thickness. The vessels in the neighboring subconjunctival tissue are quite hyperæmic. The anterior epithelium over this superior margin is much roughened and in places the layers are but loosely connected, as we should expect from the formation of vesicles noted. This irregularity and looseness of the epithelial layers continues up to the superior limbus, the thickness of the epithelium in this upper quarter, although very irregular, being less than elsewhere.

The iris in this eye in its entire width above the pupil is thickened and changed. This thickening has resulted in applying the root of the iris against the cornea, thus in this spot closing the filtration angle. The density of the fibrous tissue in the changed stroma of the iris can in this eye be made out quite clearly since it takes the eosin more deeply. In this tissue we see the same round or oval pigment-filled cells mingled with some plasma cells and stellate chromatophores, between which in many places is seen much granular pigment. The anterior endothelial layer over the inner third of the iris has disappeared for the most part.

The left cornea of rabbit No. 4 was heated for 10 minutes at a temperature of 124 deg. Fahr. with a 7-millimeter applicator. The epithelium was removed over an area 7 millimeters in diameter with no clouding. On the next day there was clouding of the cornea and the epithelium was gone over an area of 5 millimeters in diameter. Eye enucleated.

Microscopical Findings.—The cornea in its upper half is thickened slightly, and here are noticed on its anterior surface the presence of a few deep depressions, becoming most noticeable at about 3 millimeters from the superior limbus where they produced a scalloped appearance. This is undoubtedly due to the shrinking in the alcohol after an initial swelling caused by the heating.

The cornea over the quarter just above the center shows a loss of anterior epithelium. The epithelium adjoining this denuded area has a rather irregular and loose formation as if newly formed, most noticeable on the superior side where it extends to about 2 millimeters from the limbus. Bowman's membrane in spots near the center of the denuded area is broken up and roughened. This portion of the cornea uncovered by epithelium in its anterior half is irregularly and moderately infiltrated with polymorphonuclear leucocytes, most of which are elongated and flattened as they lie squeezed between the corneal layers. Posteriorly the endothelial layer shows a destruction of its cells beneath the heated area extending above to within 2 millimeters of the superior limbus. Although completely gone in some places, in others there remains of these cells some loose cytoplasm lying on the posterior cell membrane, anterior to which lies the intact Descemet's membrane. Several small groups of leucocytes are seen lying here and there on Descemet's membrane or on remnants of the endothelium. No further changes can be noted in the iris or elsewhere.

The right eye of rabbit No. 6 was heated at 119 deg. Fahr. for 10 minutes with a 7-millimeter applicator. The epithelium was removed in patches over an area 8 millimeters in diameter. Eye enucleated.

Microscopical Findings.—The cornea is slightly thicker in the heated area. In the center of the cornea a stretch of about 2 millimeters is quite devoid of epithelium. The anterior surface of this uncovered portion shows many indentations, giving an irregular scalloped appearance. Bowman's membrane is entirely intact, as are Descemet's membrane and the posterior endothelial layer. No cellular infiltration (for which there has not been time) has occurred. At neither limbus can there be seen any reaction whatsoever. No changes can be noted in the other structures.

We might therefore conclude from our findings that the immediate effects of the heated applicator upon a rabbit's eye are first a swelling of the heated portion of the cornea, due to a localized œdema, which with increase of heat is accompanied by destruction of the anterior epithelium, then a destruction of the posterior endothelial layer, further by a coagulation necrosis of Bowman's membrane and anterior layers of the substantia propria of the cornea, and lastly a swelling and coagulation necrosis of the iris. Later effects are: first, the appearance of the infiltration of the anterior layers of the cornea with polymorphonuclear leucocytes, then the formation of scar tissue and new blood vessels to replace the destroyed substantia propria of the cornea. Lastly, the new connective tissue with its round pigment cells, where before was iris stroma.

*The American Journal of Ophthalmology.

The Silver Voltameter

THE silver voltameter is the standard instrument by which the international ampere (the unit of electric current) is determined. The national laboratories of England, France and Germany, as well as the Bureau of Standards in this country, have conducted investigations of the voltameter with a view to improving its accuracy and also to provide specifications for its use, but as yet no international agreement has been reached for the specifications. The investigations at the Bureau of Standards have extended from 1908 to 1916, during which time the results have been published in a series of eight papers. The latest publication, Scientific Paper No. 285, of the Bureau of Standards, contains a summary of these eight papers and carefully drawn specifications, which are the practical result of the bureau's work. The bureau issues these specifications as its proposal for international adoption. A bibliography of papers dealing with voltameter problems is given in an appendix.

Stabilizing Ships by Means of Gyroscopes*

The Effect of the Gyroscope Compared With Other Methods

It is, of course, perfectly well known that the gyroscope has from the first been an essential element in the mechanism of the "Whitehead" torpedo, that the gyroscopic compass—as witness, for example, its reported employment on the German submarine UC 5—seems to be establishing its position, and that gyroscopic means for automatically controlling the stability of aeroplanes is attracting the attention of people other than pure theorists. These applications of the gyroscope, however successful or promising, do not assist us much, it must be confessed, in discussing the gyroscopic stabilizing of ships, for the conditions are either so dissimilar, or if similar, as in the case of the aeroplane, are on such a different scale, as to render comparison and deduction and all argument from the one case to the other impossible or futile. Direct experiment on the stabilizing of ships by means of gyroscopes will alone satisfy practical naval architects and shipbuilders. Neither theory nor success in other directions is likely to have the least weight with them, and in both these respects we think circumstances justify this course.

Looking into the subject as it presents itself to-day we find two main questions awaiting answers. First, can ships be satisfactorily stabilized by means of gyroscopes? Secondly, if so, what advantages do ships so stabilized possess over ships not artificially stabilized or stabilized by other means such as anti-rolling tanks? As regards the first question, the answer seems to be undoubtedly in the affirmative. The results of direct experiments can be adduced in support of this. Thus the German ex-torpedo-boat "See-bar" fitted with the Schlick system of gyroscopic steadying gear, was tested during 1906 and showed that an arc of rolling, "out-to-out," of 30 degrees could, when the gyroscope was brought into action, be reduced to one of one degree. The MacBrayne steamer "Lochiel," fitted with the same system, in 1908, had an unrestrained roll of 32 degrees, which, with the gyroscope at work, was brought down to about 3 degrees. The only other system of gyroscopic stabilizing of which anything of importance has been heard is the Sperry. Two sets of experiments with this system are referred to here. In one case purely experimental apparatus installed on board the United States destroyer "Worden," a notoriously bad sea boat, reduced the total roll in a heavy sea-way to a maximum of 5 degrees. More refined apparatus on board the "Widgeon," an oil-driven pleasure yacht of 165 tons displacement, quenched an unrestricted out-to-out roll of 50 degrees and reduced it to about 3 degrees. From these figures it clearly appears that gyroscopic apparatus can be used very materially to reduce the rolling motion of vessels—at least, of comparatively small vessels. Our first question, however, was qualified by the word "satisfactorily." The stabilization would clearly not be satisfactory if the stabilizing apparatus, however effective, occupied an excessive amount within the vessel or excessively increased its weight or absorbed in its driving an excessive amount of power. Nor would it be satisfactory if its action resulted in excessive stresses being thrown upon the hull framing, which would thereby threaten to buckle in every heavy sea. These points can only be discussed, of course, if we know the details of the design and construction of the gyroscopic apparatus installed. Descending therefore to the details of the only two practical systems—the Schlick and the Sperry—for which experimental results are available, we must notice a difference between the two systems which is of prime importance in our discussion of whether or no the stabilization obtained is obtained satisfactorily. It is somewhat difficult to express this difference in language simple enough for all to understand it. Matters, however, may be put something like this: The object aimed at in the Schlick system is not so much the generation of a rolling moment countering the rolling action of the waves as the lengthening of the natural period of oscillation of the vessel, so that this period shall no longer synchronize with that of the waves. As the two periods become increasingly out of step the waves themselves damp out the oscillations of the vessel. This effect is obtained by fitting a pendulum inside the vessel so as to vibrate in a fore and aft plane. By means of a gyroscope this pendulum is caused to oscillate when the ship rolls, but in such a way that the pendulum lags behind the swing of the boat. The turning moment applied to the ship by the waves is thus spent, not simply in one but in two directions. It has to cause the ship to roll against the natural righting moment derived from the wedges of immersion and emersion, and it has to cause the pendulum bob to rise against gravity. It follows, then, that whatever portion of the wave energy is spent on the pendulum bob is so much deducted from the wave energy spent on the rolling of the ship. The ship therefore rolls with a reduced velocity, so that in time its oscillations get out of step with the period of the waves. In the Sperry system, on the other hand, the object aimed at is the direct application to the hull of the vessel of an artificial moment which shall counter the rolling moment of the waves. The stabilizing gyroscope spins on a vertical axis and rotates within a casing provided with trunnions which rest in athwartship bearings. When the vessel rolls, say, to starboard, the port trunnion exercises a direct downward thrust on its bearing, while the starboard trunnion exercises an upward thrust on the cap of its bearing. This effect is secured simply by causing the gyroscope casing to rotate on its trunnions so that the top end of the gyroscope axis moves toward the bow or stern according as the vessel rolls to starboard or port. The rotation of the casing is brought about by a reversible electric motor. The forward and reverse circuits feeding this motor are made and broken by a small delicate control gyroscope provided with suitable contacts. The differences between the two systems are thus several and distinct. Under the Schlick system the force checking the rolling of the ship is really that of the waves themselves meeting the side of the hull moving on to the waves. In other words, the checking force is distributed over more or less the entire side of the hull. Under the Sperry system the checking force is concentrated at two bearings within the hull. These circumstances must be remembered in discussing the effect which gyroscopic stabilizers have on the structure of vessels in which they are installed. As regards the room occupied and the weight of the apparatus it may be mentioned that the Schlick apparatus in the "See-bar," a vessel of 56 tons displacement, had a weight of about 1½ tons, and occupied a height of 7 feet and a width of 8 feet 3 inches. As the extreme breadth of the vessel was 11 feet 9 inches, and its mean draught 3 feet 6 inches, it will be seen that the apparatus added some 2½ per cent to the vessel's displacement, and occupied a very considerable proportion of her maximum cross-sectional area. The Sperry apparatus on board the destroyer "Worden" admittedly took up a great deal of space and weighed more than was desirable. But this installation, and to a lesser degree that on board the "See-bar," was of an experimental nature, and from neither must rigid opinions be formed on this important aspect of the gyroscopic stabilizer. It seems to be undoubtedly the case that the larger the vessel the less proportionately will be the weight of and the space occupied by gyroscope stabilizers. Thus in the projected design of such apparatus on the Schlick system for a cross-Channel steamer of some 2,000 tons displacement the whole gear would weigh about 12 tons, or 0.6 per cent of the vessel's displacement, and would occupy over-all dimensions bigger only by a few inches than those of the "See-bar" apparatus. In the case of the "Widgeon" the Sperry apparatus weighs about one and one half tons, or something like one per cent of the vessel's displacement, while in the 10,000-ton transport now being built the apparatus will, it is believed, weigh not more than 0.8 per cent of the displacement. Regarding the consumption of power by gyroscopic stabilizing apparatus we can say very little for the present. There is, however, no reason to believe that the consumption would average a high figure, although it would, at least in the Sperry system, and probably to a lesser extent in the Schlick system, fluctuate momentarily to values considerably above the average.

It may, then, be taken as definitely established that ships can be satisfactorily stabilized by means of gyroscopes. The further questions, When is it desirable so to stabilize ships, and what advantages does this method possess over other means of securing the same ends? are quite apart from this, and should receive separate discussion. It may be noted that the only other system of artificially increasing the stability of ships which, so far as we know, has received extended practical attention, is that of Frahm's anti-rolling tanks. This system has, of course, already been considerably adopted both for war and for merchant vessels. Thus, all German dreadnought battleships, and battle-cruisers, for which reliable data are available, are so fitted. On the "Aquitania," "Vaterland," and "Imperator," to mention but three merchant vessels, similar tanks are to be found. Clearly, then, opinion is decidedly in favor of artificially increasing the stability of vessels, both for war and for other purposes. Why it should be so is evident, and need scarcely again be discussed. The arguments already heard in favor of the anti-rolling tank system apply with equal force to the gyroscopic system. We need not repeat them here, but will rather conclude our present discussion by dwelling briefly on the relative merits of the two systems. Under this heading we may note the statement which has been made that, whereas a pound of water in an anti-rolling tank is in its stabilizing effect a pound and little more, the value of a pound in the weight of a gyroscopic installation is multiplied many times. This, let us say, is a very misleading statement. In the case of the "Imperator," the displacement of which is 57,000 tons, the weight of water in the anti-rolling tank is 490 tons, or 0.86 per cent of the displacement. There is very little other weight than this involved in the device, so that we need not expect a great saving in weight, even if we get any, by adopting gyroscopes instead of anti-rolling tanks. On the other hand, the gyroscopic system absorbs power, and represents a considerable additional amount of machinery, very delicate in parts, to install and keep in order. Against this undoubted disadvantage we must put what may be called the flexibility of the gyroscopic system. We can by this control the anti-rolling forces, whereas, under the tank system, the control is limited by the design. To show the value of this flexibility, the gyroscopic stabilizer can be brought into action or shut off at will, whereas the control of the water in anti-rolling tanks is dead, except when the vessel is rolling. Thus, in a calm sea a gyroscopically stabilized vessel can be artificially heeled to port or starboard simply by the action of her gyroscopes. This possibility is a feature of the Sperry system—it is not inherent in the Schlick arrangement—and may be at times of considerable service. As we record elsewhere, it has already been made use of in order to "wriggle" a stranded vessel off a bank, and is being contemplated in its bearing upon the design of ice-breakers. It might also conceivably be made use of to correct a comparatively small accidental list caused, say, by the flooding of a wing compartment. This might prove of value in the case of warships in action, while in the case of merchant vessels it might make all the difference between being able to launch the boats from both sides of a sinking vessel and a repetition of the "Titanic" disaster. Into the question of how far gyroscopic stabilizers affect the steering of ships we cannot enter further than to say that in this respect the Schlick system seems to be as free from exerting an effect as are anti-rolling tanks. As regards the Sperry system, we believe there is an effect, but it is probably small enough to be insignificant.

*The Engineer.

Photographic Methods

Photographers frequently make use of inside kits in order to use a smaller plate in the usual plateholder, but in this case the opening of the kit lies on the same center as the main plate. However, it is possible to obtain quite an advantage by the use of an opening which throws the small plate off the center, that is, supposing the holder placed upright, the small plate lies higher up than it would usually do, the margin being thus larger at the bottom and smaller at the top. Such a position will add to the natural shifting of the camera-back, for this is often not enough for photographing small objects seen from the top, for instance, objects lying on a table. Here the camera-back is shifted up as high as possible, then the inside kit will throw the plate still higher up. Paste a screen on the back of the ground glass that coincides with the plate inside the holder. Such an inside kit can be easily made of heavy cardboard about as thick as the plate; cut out the opening for the small plate, and then the plate can be very well held in position by the use of rubber bands. The best plan is to stretch a band across each corner, and this is done very easily by cutting a nick on the two corresponding outside edges of the cardboard, stretching the rubber band upon the two nicks so that it comes on each side of the plate. With four such bands at the corners, the plate is well held in place and cannot fall out as in the usual inside kit. On this plan, the photographer can make up numerous sets of inside kits so as to work with many sizes of plates, and at practically no expense.

Bird Migration—I*

Wonderful Journeys Between Summer and Winter Homes

By Wells W. Cooke, Assistant Biologist

For more than 2,000 years the phenomena of bird migration have been noted; but while the extent and course of the routes traversed have of late become better known, no conclusive answer has been found to the question, Why do North American birds migrate? Two different and indeed diametrically opposite theories have been advanced to account for the beginnings of these migrations.

According to the more commonly accepted theory, ages ago the United States and Canada swarmed with nonmigratory bird life, long before the Arctic ice fields advancing south during the glacial era rendered uninhabitable the northern half of the continent. The birds' love of home influenced them to remain near the nesting site until the approaching ice began for the first time to produce a winter—that is, a period of inclement weather which so reduced the food supply as to compel the birds to move or starve. As the ice approached very gradually, now and then receding, these enforced retreats and absences—at first only a short distance and for a brief time—increased both in distance and duration until migration became an integral part of the very being of the bird. In other words, the formation of the habit of migration took place at the same time that changing seasons in the year replaced the continuous semitropical conditions of the preglacial eras.

As the ice advanced southward the swing to the north in Spring migration was continually shortened and the Fall retreat to a suitable Winter home correspondingly lengthened, until during the height of the glacial period birds were for the most part confined to Middle and South America. But the habit of migration had positively been formed among the birds and when the ice naturally receded toward its present position the birds followed it northward and thereby in time established their present long and diversified migration routes.

Those who thus argue that love of birthplace is the actuating impulse to Spring migration call attention to the seeming impatience of the earliest migrants. Ducks and geese push northward with the beginnings of open water so early, so far, and so fast that many are caught by late storms and wander disconsolately over frozen ponds and rivers, preferring to risk starvation rather than to retreat. The purple martins often arrive at their nesting boxes so prematurely that the cozy home becomes a tomb if a sleet storm sweeps their winged food from the air. The bluebird's cheery warble we welcome as a harbinger of spring, often only to find later a lifeless body in some shed or outbuilding where the bird sought shelter rather than return to the sunny land so recently left.

As a matter of fact, however, only a small percentage of birds exhibit these preseasonal migration propensities. The great majority remain in the security of their winter homes until spring is so far advanced that the journey can be made easily and with comparatively slight danger; and they reach the nesting spot when a food supply is assured and all the conditions of weather and vegetation are favorable for beginning immediately the rearing of a family of young.

If, however, a longing for home is considered the main incentive to their northward flight, there arises the question as to why birds desert that home so promptly after the nesting season is over. Data recently collected by the Biological Survey show that southward migration begins at least by the 10th and probably as early as the 1st of July. Indeed, most birds start south as soon as the fledglings are able to shift for themselves. The orchard oriole, the redstart, and the summer warbler of central United States and the nonpareil of the South all begin their southward journey early in July, long before the fall storms sound a warning of approaching winter and when their insect menu is particularly varied and abundant.

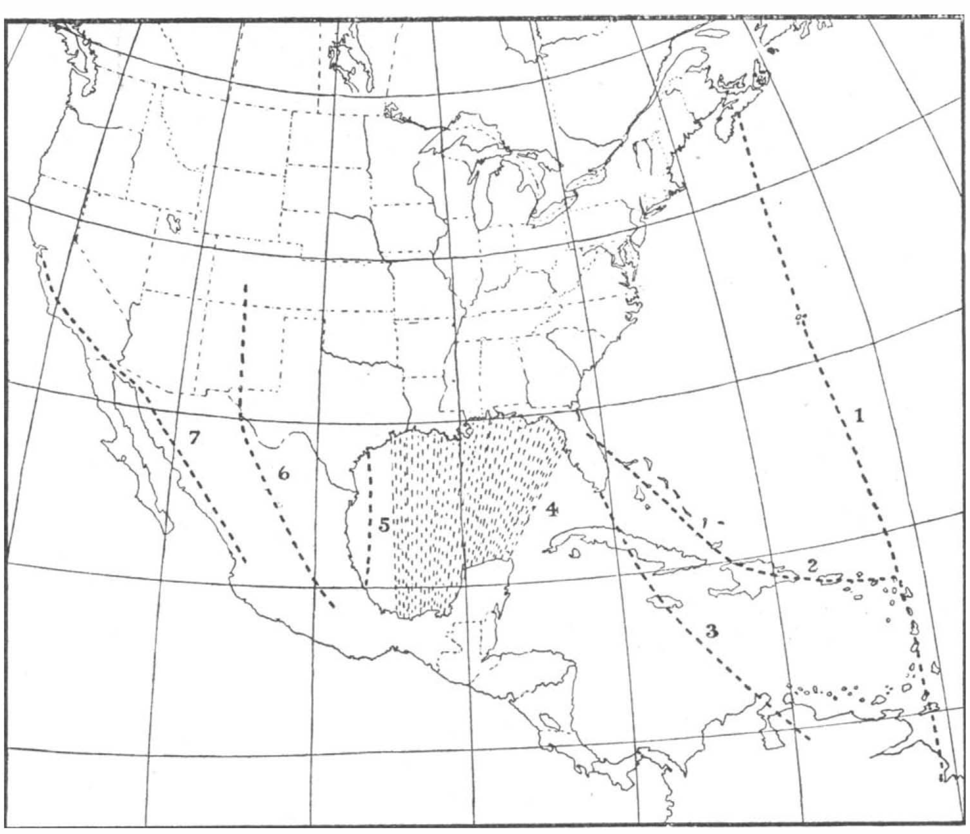


Fig. 2.—Principal migration routes of North America. Most migrants use route No. 4, though this necessitates a flight of 500 to 700 miles across the Gulf of Mexico. A few traverse the more direct route No. 3, and still fewer, route No. 2. Only water birds make the 2,400-mile flight along route No. 1, from Nova Scotia to South America.

According to the opposite migration theory, the birds' real home is the Southland; all bird life tends by overproduction to overcrowding; and, at the end of the glacial era, the birds, seeking in all directions for suitable breeding grounds with less keen competition than in their tropical Winter home, gradually worked northward as the retreat of the ice made habitable vast reaches of virgin country. But the Winter abiding place was still the home, and to this they returned as soon as the breeding season was over. Thus, in the case of the orchard oriole mentioned above, many individuals that arrive in southern Pennsylvania the first week in May leave by the middle of July, spending only 2½ months out of the 12 at the nesting site.

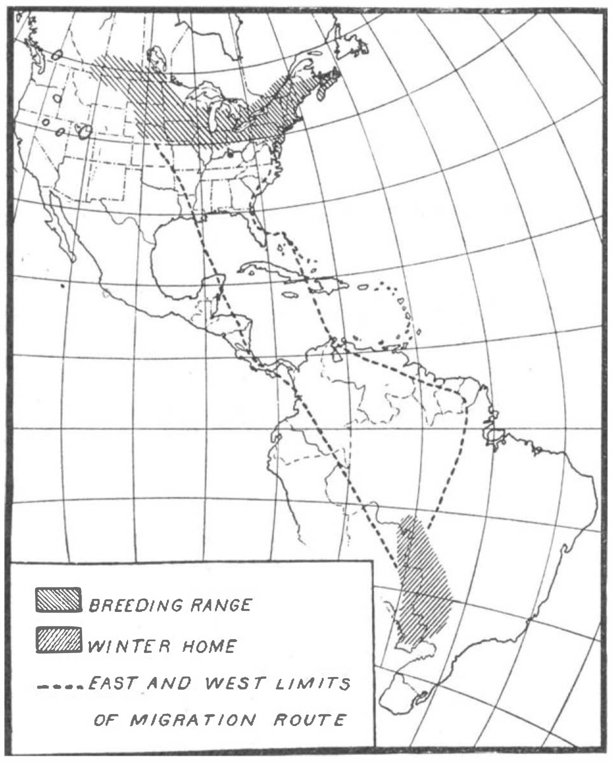


Fig. 1.—Distribution and migration of the bobolink, reedbird, or ricebird (*Dolichonyx oryzivorus*). Of late years the bobolink has been extending its range into newly irrigated districts of western United States (indicated on the map by small encircled areas). Here we can witness the process of a growth in the length of a migration route. So far those individuals, which have added a thousand miles to the route and range into western Nevada, return over the old route and show no tendency to shorten the trip by a direct flight across New Mexico to the Gulf coast of Texas.

Whichever theory is accepted, the beginnings of migration ages ago undoubtedly were intimately connected with periodic changes in the food supply. While North America possesses enormous Summer supplies of bird food, the birds must return south for the Winter or perish. The overcrowding which would necessarily ensue should they remain in the equatorial regions is prevented by the Spring exodus northward. No such movement occurs toward the corresponding southern latitudes. South America has almost no migatory land birds, for bleak Patagonia and Tierra del Fuego offer no inducements to these dwellers of the limitless forests of the Amazon.

The conclusion is inevitable that the advantages of the United States and Canada as a Summer home and the superb conditions of climate and food for the successful rearing of a nestful of voracious young far overbalance the hazards and disasters of the journey thither. For these periodical trips did not just happen in their present form; each migration route, however long and complex, is but the present stage in development of a flight that at first was short, easily accomplished, and comparatively free from danger. Each lengthening of the course was adopted permanently only after experience through many generations had proved its advantages.

RELATION OF MIGRATION TO WEATHER.

It may safely be stated that the weather in the Winter home has nothing to do with starting birds on the Spring migration, except in the case of a few, like some of the ducks and geese, which press northward as fast as open water appears. There is no appreciable change in temperature to warn the hundred or more species of our birds which visit South America in Winter that it is time to migrate. It must be a force from within, a physiological change warning them of the approach of the breeding season, that impels them to spread their wings for the long flight.

Weather conditions are not the cause of the migration of birds; but the weather, by affecting the food supply, is the chief factor which determines the average date of arrival at the breeding grounds. After the bird, in response to physiological changes, has started to migrate, the weather it encounters *en route* influences that migration in a subordinate way, retarding or accelerating the advance by only a few days, and having usually only slight effect upon the date of arrival at the nesting site.

Local weather conditions on the day of arrival at any stated locality are minor factors in determining the appearance of a given species at that place and time. The major factors in the problem are the weather conditions far to the southward, where the night's flight began, and the relation which that place and time bear to the average position of the bird under normal weather conditions. Many, if not most, instances of arrivals of birds under adverse weather conditions are probably explainable by the supposition that the flight was begun under favorable auspices and that later the weather changed. Migration in spring usually occurs with a rising temperature and in autumn with a falling temperature. In each case the changing temperature seems to be a more potent factor than the absolute degree of cold.

The direction and force of the winds, except as they are occasionally intimately connected with sudden and extreme variations in temperature, seem to have only a slight influence on migration.

DAY AND NIGHT MIGRANTS.

Some birds migrate by day, but most of them seek the cover of darkness. Day migrants include ducks and geese (which also migrate by night), hawks, swal-

*From *Bulletin* 185 of the U. S. Dept. of Agriculture.

lows, the nighthawk, and the chimney swift. The last two, combining business and pleasure, catch their morning or evening meal during a zigzag flight that tends in the desired direction. The daily advance of such migrants covers only a few miles, and when a large body of water is encountered they pass around rather than across it. The night migrants include all the great family of warblers, the thrushes, flycatchers, vireos, orioles, tanagers, shorebirds, and most of the sparrows. They usually begin their flight soon after dark and end it before dawn, and go farther before than after midnight.

Night migration probably results in more casualties from natural causes than would occur if the birds made the same journey by day; but, on the other hand, there is a decided gain in the matter of food supply. For instance, a bird feeds all day on the north shore of the Gulf of Mexico; if, then, it waited until the next morning to make its flight across the Gulf in the daytime it would arrive on the Mexican coast at nightfall and would have to wait until the following morning to appease its hunger. Thus there would be 36 consecutive hours without food, whereas by night migration the same journey can be performed with only a 12 hours' fast.

Migrating birds do not fly at their fastest. Their migration speed is usually from 30 to 40 miles an hour and rarely exceeds 50. Flights of a few hours a night, alternating with rests of one or more days, make the Spring advance very slow, averaging for all species not more than 23 miles a day, but with great variations of daily rate among the different species. The exact number of miles which a particular bird makes during one day's journey has not yet been determined, and can not be ascertained until the tagging or banding of birds by means of metal rings is carried out on a far more extensive scale than has yet been possible. If migration were a steady movement northward with the same individuals always in the van, numerous careful observations might make it possible to approximate the truth; but instead of this, most migrations are performed somewhat after the manner of a game of leapfrog. The van in Spring migration is composed chiefly of old birds, and as they reach their nesting places of the previous year they remain to breed. Thus the vanguard is constantly dropping out and the forward movement must depend upon the arrival of the next corps, which may be near at hand or far in the rear. Moreover, in our present state of knowledge we can not say whether a given group of birds after a night's migration keeps in the van on succeeding nights or rests and feeds for several days and allows other groups previously in the rear to assume the lead. It is known that birds do not as a rule move rapidly when migrating in the daytime, but from the meager data available it may be inferred that the speed at night is considerably greater. During day migration the smaller land birds rarely fly faster than 20 miles an hour, though the larger birds, as cranes, geese, and ducks, move somewhat more rapidly. The result of timing nighthawks on several occasions gave a rate of 10 to 14 miles an hour, the former being the more usual speed. This slow rate results from the irregularity of the flight, caused by the birds' capturing their evening and morning meals en route. In the evening the flight lasted about an hour and a half and in the morning about an hour. Thus a distance of approximately 30 miles would be traveled by each individual during the morning and evening flights.

Night migrants probably average longer distances in most of their flights, and this is known to be the case with some species. The purple martin, during the Spring of 1884, performed almost its entire migration from New Orleans to Lake Winnipeg during only 12 nights—an average of 120 miles for each night of movement—and some late migrants, like the gray-cheeked thrush, must make still greater distances at a single flight. That most of them can fly several hundred miles without stopping is proved by the fact that they make flights of 500 to 700 miles across the Gulf of Mexico.

DISTANCE OF MIGRATION.

The length of the migration journey varies enormously. A few birds, like the grouse, quail, cardinal, and Carolina wren are nonmigratory. Many a bobwhite rounds out its full period of existence without ever going 10 miles from the nest where it was hatched. Some other species migrate so short a distance that the movement is scarcely noticeable. Thus, meadowlarks are found near New York City all the year, but probably the individuals nesting in that region pass a little farther south for the Winter and their places are taken by migrants from farther north. Or part of a species may migrate and the rest remain stationary, as in the case of the pine warbler and the black-headed grosbeak, which do not venture in Winter south of the breeding range. With them Fall migration is only a withdrawal from the northern and a concentration in the southern part of the Summer home—the warbler in about a fourth and the grosbeak in less than an eighth of the Summer area. In the case of the Maryland yellow-throat, the breeding birds of Florida are strictly nonmigratory, while in Spring and Fall other yellow-throats pass through Florida in their journeys between their Winter home in Cuba and their Summer home in New England.

Another variation is illustrated by the robin, which occurs in the middle districts of the United States throughout the year, in Canada only in Summer, and along the Gulf of Mexico only in Winter. Probably no individual robin is a continuous resident in any section; but the robin that nests, let us say, in southern Missouri, spends the Winter near the Gulf, while his hardy Canada-bred cousin is the Winter tenant of the abandoned Summer home of the southern bird.

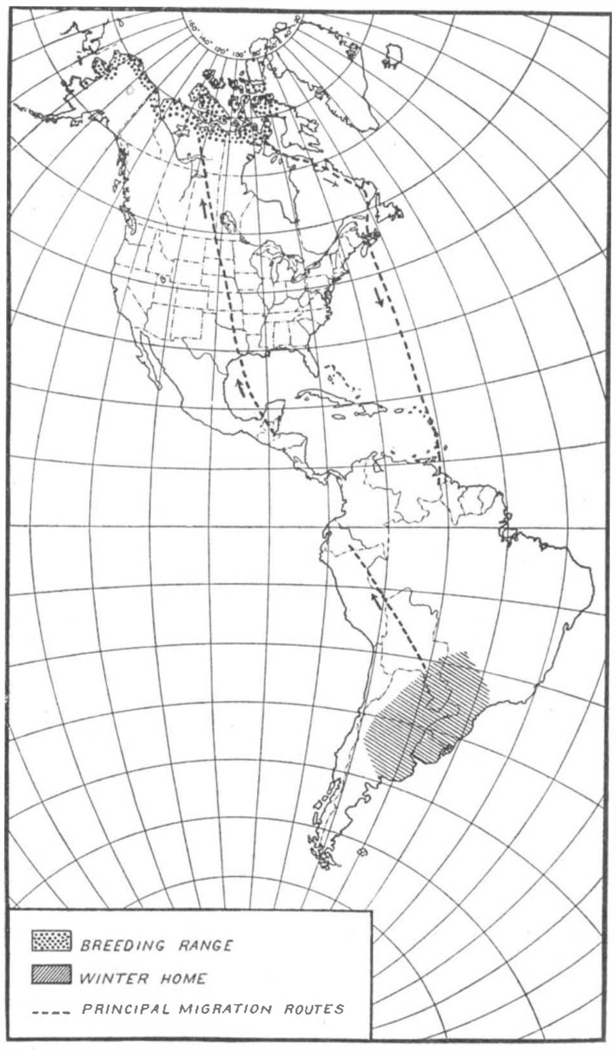


Fig. 3.—Distribution and migration of the golden plover (*Charadrius dominicus*). In fall it flies over the ocean from Nova Scotia to South America, 2,400 miles—the longest known flight of any bird. In spring it returns by way of the Mississippi Valley. Thus the migration routes form an enormous ellipse, with a minor of 2,000 miles and a major axis stretching 8,000 miles from Arctic America to Argentina.

Most migratory birds desert the entire region occupied in Summer for some other district adopted as a Winter home. These two homes are separated by very variable distances. Many species from Canada winter in the United States, as the tree sparrow, junco, and snowflake; others nesting in northern United States winter in the Gulf States, as the chipping, field, Savannah, and vesper sparrows, while more than a hundred species leave the United States for the Winter and spend that season in Central or even in South America. Nor are they content with journeying to northern South America, but many cross the Equator and pass on to the pampas of Argentina and a few even to Patagonia. Among these long-distance migrants are some of our commonest birds; the scarlet tanager migrates from Canada to Peru; the bobolinks (Fig. 1) that nest in New England probably winter in Brazil, as do purple martins, cliff swallows, barn swallows, nighthawks, and some thrushes, which are their companions both Summer and Winter. The black-poll warblers that nest in Alaska winter in northern South America, at least 5,000 miles from the Summer home. The land bird with the longest migration route is probably the nighthawk, which occurs north to Yukon and south, 7,000 miles way, to Argentina.

But even these distances are surpassed by some of the water birds, and notably by some of the shorebirds, which as a group have the longest migration routes of any birds. Nineteen species of shorebirds breed north of the Arctic Circle, every one of which visits South America in Winter, six of them penetrating to Patagonia, a migration route more than 8,000 miles in length.

The world's migration champion, however, is the arctic tern. It deserves its title of "arctic," for it nests as far north as land has been discovered; that is, as far north as the bird can find anything stable on which to construct its nest. Indeed, so arctic are the conditions under which it breeds that the first nest found by man in this region, only 7½ degrees from the pole, contained a downy chick surrounded by a wall of newly fallen snow that had been scooped out of the nest by the parent. When the young are full grown the entire family leaves the Arctic, and several months later they are found skirting the edge of the Antarctic continent.

What their track is over that 11,000 miles of intervening space no one knows. A few scattered individuals have been noted along the United States coast south to Long Island, but the great flocks of thousands and thousands of these terns which range from pole to pole have never been noted by an ornithologist competent to indicate their preferred route and their time schedule. The arctic terns arrive in the far north about June 15 and leave about August 25, thus staying 14 weeks at the nesting site. They probably spend a few weeks longer in the Winter than in the Summer home, and this would leave them scarcely 20 weeks for the round trip of 22,000 miles. Not less than 150 miles in a straight line must be their daily task, and this is undoubtedly multiplied several times by their zigzag twistings and turnings in pursuit of food.

ROUTES OF MIGRATION.

The shape of the land areas in the northern half of the Western Hemisphere and the nature of the surface has tended to great variations in migratory movements. If the whole area from Brazil to Canada were a plain with the general characteristics of the middle section of the Mississippi Valley, the study of bird migration would lose much of its fascination. There would be a simple rhythmical swinging of the migration pendulum back and forth, Spring and Fall. But much of the earth's surface between Brazil and Canada is occupied by the Gulf of Mexico, the Caribbean Sea, and parts of the Atlantic Ocean, all devoid of sustenance for land birds. The two areas of abundant food supply are North America and northern South America, separated by the comparatively small land areas of Mexico and Central America, the islands of the West Indies, and the great waste stretches of water.

The different courses taken by the birds to get around or over this intervening inhospitable region are almost as numerous as the bird families that traverse them, and only some of the more important routes will be mentioned here. (See Fig. 2.)

ISLAND ROUTES.

Birds often seem eccentric in choice of route, and many do not take the shortest line. The 50 species from New England that winter in South America, instead of making the direct trip over the Atlantic, involving a flight of 2,000 miles, take a somewhat longer route that follows the coast to Florida and passes thence by island or mainland to South America. What would at first sight seem to be a natural and convenient migratory highway extends from Florida through the Bahamas or Cuba to Haiti, Porto Rico, and the Lesser Antilles and thence to South America (see Fig. 2, route 2). Birds that travel by this route need never be out of sight of land; resting places are afforded at convenient intervals and the distance is but little longer than the water route. Yet beyond Cuba this highway is little used. About 25 species continue as far as Porto Rico and remain there through the Winter. Only adventurers of some six species gain the South American mainland by completing the island chain. The reason is not far to seek—scarcity of food. The total area of all the West Indies east of Porto Rico is a little less than that of Rhode Island. Should a small proportion only of the feathered inhabitants of the Eastern States select this route, not even the luxuriant fauna and flora of the Tropics could supply their needs.

A still more direct route, but one requiring longer single flights, stretches from Florida to South America via Cuba and Jamaica (see Fig. 2, route 3). The 150 miles between Florida and Cuba are crossed by tens of thousands of birds of some 60 different species. About half the species take the next flight of 90 miles to the Jamaican mountains. Here a 500-mile stretch of islandless ocean confronts them, and scarcely a third of their number leave the forest-clad hills for the un-

seen beyond. Chief among these is the bobolink, which, now well fattened on Fall seeds, is so full of strength and energy that the 500-mile flight to South America on the way to the waving pampas of southern Brazil seems a trifle. Indeed, many bobolinks appear to scorn the Jamaican resting point and to compass in a single flight the 700 miles from Cuba to South America. With the bobolink is an incongruous company of traveling companions—a vireo, a kingbird, and a nighthawk that summer in Florida; the chuck-will's-widow of the Gulf States; the two New England cuckoos; the gray-cheeked thrush from Quebec; the bank swallow from Labrador; and the black-poll warbler from far-off Alaska. But the bobolinks so far outnumber all the rest that the passage across the Caribbean from Cuba to South America may with propriety be called the "bobolink route." Occasionally a wood thrush or a tanager joins the assemblage, but the "bobolink route" as a whole is not popular with other birds, and, though many traverse it, they are but a fraction of the multitudes of North American birds that spend the Winter in the southern continent.

GULF ROUTES.

The main-traveled highway is that which stretches from northwestern Florida across the Gulf, continuing the southwesterly direction which most of the birds of the Atlantic coast follow in journeying to Florida (see Fig. 2, route 4). A larger or smaller percentage of nearly all the species bound for South America take this roundabout course, quite regardless of the several-hundred-mile flight over the Gulf of Mexico.

The birds east of the Allegheny Mountains move southwest in the Fall, approximately parallel with the seacoast, and apparently keep this same direction across the Gulf to eastern Mexico. The birds of the central Mississippi Valley go southward to and over the Gulf. The birds between the Missouri and the edge of the plains and those of Canada east of the Rocky Mountains move southeastward and south until they join the others in their passage of the Gulf. In other words, the great majority of North American birds bound for a Winter's sojourn in Central or South America elect a short cut across the Gulf of Mexico in preference to a longer land journey by way of Florida or Texas. In fact, millions of birds cross the Gulf at its widest part, which necessitates a single flight of 500 to 700 miles. It might seem more natural for the birds to make a leisurely trip along the Florida coast, take a short flight to Cuba, and thence a still shorter one of less than 100 miles to Yucatan—a route only a little longer and involving much less exposure. Indeed, the earlier naturalists, finding the same species both in Florida and in Yucatan, took this probable route for granted, and for years it has been noted in ornithological literature as one of the principal migration highways of North American birds. As a fact, it is almost deserted except for a few swallows, some shorebirds, and an occasional land bird storm driven from its accustomed course, while over the Gulf route night after night for nearly 8 months in the year myriads of hardy migrants wing their way through the darkness toward an unseen destination.

To the westward a short route (see Fig. 2, route 5) stretches a few hundred miles from the coast of Texas to northern Vera Cruz. It is adopted by some warblers, as the Kentucky, the worm-eating, and the golden-winged, and a few other species, which seek in this way to avoid a region scantily supplied with moist woodlands.

OTHER ROUTES.

Still farther west are two routes (see Fig. 2, routes 6 and 7) which represent the land journeys of those birds from western United States that winter in Mexico and Central America. Their trips are comparatively short; most of the birds are content to stop when they reach the middle districts of Mexico and only a few pass east of the southern part of that country.

The routes as outlined on the map must not be considered as representing distinctly segregated pathways with clearly defined borders. On the contrary, they are merely convenient subdivisions of the one great flightway which extends from North to South America. There is probably no single mile in the whole east and west line from northern Mexico to the Lesser Antilles which is not crossed each Fall by migrating birds. What is meant is that the great bulk of both species and individuals cross the Gulf to eastern Mexico, while to the eastward their numbers steadily diminish.

The map of the migration routes (Fig. 2) shows route No. 1 that has not yet been described. It extends in an approximately north and south line from Nova Scotia to the Lesser Antilles and the northern coast of South America. Though more than a thousand miles shorter than the main migration route, it is not employed by any land bird. But it is a favorite Fall route for thousands of water birds, notable among which is the golden plover.

The journey of this plover is wonderful enough to be given in detail. Its most striking characteristics are a single flight of 2,400 miles—the longest known flight of any bird—and an elliptical migration route following different paths for the Spring and the Fall migration (see Fig. 3). In the first week of June the golden plover arrive at their breeding grounds on the "barren grounds" above the Arctic Circle far beyond the tree line. While the lakes are still icebound they build their shallow nests in the moss only a few inches above the frozen ground. As soon as the young are old enough to care for themselves Fall migration is begun by a trip to the Labrador coast, where the plover fatten for several weeks on the abundant native fruits. Thence a short trip across the Gulf of St. Lawrence brings them to Nova Scotia, the starting point for their extraordinary ocean flight due south to the coast of South America, their objective point. In fair weather the birds fly past Bermuda without stopping, and many flocks do not pause at the first of the Antilles but keep on to the larger islands and sometimes even to the mainland of South America, accomplishing the whole 2,400 miles without pause or rest. How many days are occupied in the trip may never be known. Most migrants fly at night and rest in the day or vice versa, but the plover fly both night and day. After a short stop on the northern coast of South America they resume their journey and travel overland to the pampas of Argentina. Here they remain from September to March (the Summer of the Southern Hemisphere) free from the domestic responsibilities of their northern Summer home. The native birds of Argentina are at the time engrossed in family cares, but no wayfarer from the north ever nests in the south.

After a six months' vacation here the plover start back to the Arctic, but by an entirely different route. They cross northwestern South America and the Gulf of Mexico, reaching the United States along the coasts of Louisiana and Texas. Thence they move slowly up the Mississippi Valley and by early June are again at the nesting site on the Arctic coast. The round trip has taken the form of an enormous ellipse, with a minor axis of 2,000 miles and a major axis stretching 8,000 miles from Arctic America to Argentina.

The golden plover of the Atlantic Ocean, though often flying 2,400 miles continuously, could make intermediate stops if they so desired. Sometimes, when storm driven, they seek the nearest land and not infrequently appear at Cape Cod and Long Island. Some flocks stop for longer or shorter periods at Bermuda and on the islands of the Lesser Antilles. To the golden plover of the Pacific, however, no such convenient harbors of safety are available. Their flight of approximately equal length (2,000 miles) takes them across an islandless sea from Alaska to Hawaii. No matter what storms are encountered, when once they are started over the ocean they must continue to the end or perish. It seems incredible that any birds can lay a course so straight as to attain these small islands in midocean, 2,000 miles from the Aleutian Islands on the north, 2,000 miles from California on the east, and 3,700 miles from Japan on the west. And yet year after year golden plover in considerable numbers fly in Fall from Alaska to Hawaii, spend the Winter there, and the next Spring wing their way back again to nest in Alaska.

DIRECT AND CIRCUITOUS MIGRATION ROUTES.

All black-poll warblers winter in South America. Those that are to nest in Alaska strike straight across the Caribbean Sea to Florida and northwestward to the Mississippi River. Then the direction changes and a course is laid almost due north to northern Minnesota in order to avoid the treeless plains of North Dakota. But when the forests of the Saskatchewan are reached the northwestward course is resumed and, with a slight verging toward the west, is held until the nesting region in the Alaska spruces is attained.

Cliff swallows in South America are Winter neighbors of the blackpoll warblers. But when in early Spring nature prompts the swallows which are to nest in Nova Scotia to seek that far-off land, situated exactly north of their Winter abode, they begin their journey by a westward flight of several hundred miles to Panama. Thence they move leisurely along the western shore of the Caribbean Sea to Mexico, and, still avoiding any long trip over water, go completely around the western end of the Gulf. Hence as they cross Louisiana their course is directly opposite to that in which they started. A northeasterly flight from Louisiana to Maine and an easterly one to Nova Scotia completes their Spring migration. This circuitous route has increased their flight more than 2,000 miles.

Why should the swallow select a route so much more roundabout than that taken by the warbler? The explanation is simple. The warbler is a night migrant. Launching into the air soon after nightfall, it wings its way through the darkness toward some favorite lunch station, usually one to several hundred miles distant, and here it rests and feeds for several days before undertaking the next stage of its journey. Its migration consists of a series of long flights from one feeding place to the next, and naturally it takes the most direct course between stations, not avoiding any body of water that can be compassed in a single flight.

The swallow, on the other hand, is a day migrant. It begins its Spring migration several weeks earlier than the warbler and catches each day's rations of flying insects during a few hours of slow evolutions, which at the same time accomplish the work of migration. Keeping along the insect-teeming shores, the 2,000 extra miles thereby added to the migration route are but a tithe of the distance the bird covers in pursuit of its daily food.

The cliff swallow spends the Winter in Brazil and Argentina and breeds from Mexico to Alaska. Writing 10 years ago concerning it, the author made the following statement:

"It would be expected to reach the United States in Spring first in southern Florida and Texas, later in the Rocky Mountains, and finally on the Pacific coast. As a matter of fact, the earliest records of the bird's appearance in Spring come from northern central California, where it becomes common before the first arrivals are usually noted in Texas or Florida. The route the species takes from Brazil to California is one of the yet unsolved migration puzzles."

Since the above was written much additional information has been obtained on the movements of this species, and now it is possible to solve this migration puzzle. It is now known that the cliff swallows go around the Gulf of Mexico instead of across it. The isochronal lines on the migration map show that the birds advance along the Pacific coast of Mexico faster than along the Gulf side, so that on March 20, when the van has not quite reached the lower Rio Grande of Texas, it is already far north in California.

ECCENTRIC MIGRATION ROUTES.

The normal migration route for the birds of eastern North America is a northeast and southwest course approximately parallel with the trend of the Atlantic coast; the birds breeding in the interior take a line of flight parallel in general with the course of the three great river valleys—those of the Mississippi, the Red, and the Mackenzie—that form a highway rich in food supplies between their Winter and Summer homes. Many birds, however, follow migration routes widely differing from the normal. One of the most extreme exceptions is that of the marbled godwit. Formerly a common breeder in North Dakota and Saskatchewan, some individuals on starting for their Winter home in Central America took a course almost due east to the Maritime Provinces of Canada and thence followed the Atlantic coast to Florida and continued southward; others went in the opposite direction, traveling westward to southern Alaska and southward along the Pacific coast to Guatemala. Thus birds which were near neighbors in Summer became separated nearly 3,000 miles during migration, to settle finally in close proximity for the Winter.

The Connecticut warbler, choosing another eccentric course, adopts different routes for its southward and northward journeys. All the individuals of this species winter in South America, and so far as known all go and come by the same direct route between Florida and South America across the West Indies; but north of Florida the Spring and Fall routes diverge. The Spring route leads the birds up the Mississippi Valley to their Summer home in southern Canada; but Fall migration begins with a 1,000-mile trip almost due east to New England, whence the coast is followed southwest to Florida. The Connecticut warbler is considered rare, but the multitudes that have struck Long Island lighthouses during October storms show that the species is at least more common than would be judged from Spring observations, and also how closely it follows the coast line during Fall migration.

Another species having an elliptical migration route is the white-winged scoter. This duck breeds near fresh water in the interior of Canada and winters entirely on the ocean along the Atlantic and Pacific coasts of the United States. From its Summer home west of Hudson Bay individuals that are to winter on the Atlantic travel 1,500 miles almost due east to the coast of the most eastern part of Labrador; thence they cross the Gulf of St. Lawrence and follow the New England coast to their Winter home, which extends from southwestern Maine to Chesapeake Bay, with the center of abundance off Long Island and Massachusetts. In Spring the birds return to their breeding grounds by

an inland route traversing the valleys of the Connecticut, Hudson and Ottawa Rivers. Individuals that winter along the Pacific coast from Washington to southern California are known to pass by thousands up and down the coast as far north as that coast has a generally north and south trend; but as soon as the coast line turns westward near the northwestern point of British Columbia the birds disappear and are not known anywhere in the 500-mile strip between the Pacific coast and the Mackenzie Valley. Apparently this region is crossed at a single flight from the salt water of the coast to the fresh-water Summer home on the great lakes of the Mackenzie Valley.

A migration route entirely different from any thus far mentioned is that of the western tanagér, or Louisiana tanager, as it was formerly called. From its Winter home in Guatemala it enters the United States about April 20; another 10 days and the van is in central New Mexico, Arizona and southern California, marking an approximately east and west line. The next 10 days the easternmost birds advance only to Southern Colorado, while the western have reached northern Washington. May 10 finds the line of the van extending in a great curve from Vancouver Island northeast to central Alberta and thence southeast to northern Colorado. It is evident that the Alberta birds have not reached their breeding grounds by way of the eastern slope of the Rocky Mountains, a route which would naturally be taken for granted by anyone examining a map of the Winter and Summer homes. On the contrary, these Alberta breeders must have come by way of the Pacific coast to southern British Columbia and then crossed over the main range of the Rocky Mountains, which at this season (May 20) are still cold and partly covered with snow.

Still another strange migration route, probably unique, is that of the Ross snow goose. This species breeds on the Arctic islands north of Mackenzie and in Fall migration it travels up the valleys of the Mackenzie and Athabaska Rivers in company with thousands of other waterfowl bound for their Winter homes on the coasts of eastern United States and the Gulf of Mexico. But on reaching the northern boundary of the United States the Ross goose parts company with its traveling companions, and while they continue south and southeast along the usual migration route it turns to the southwest, crosses the main range of the Rocky Mountains, and settles for the Winter in California.

(To be concluded.)

How Felt Hats Are Made

All of us wear hats, and many of us, what are known as felt hats, but how many know that they are made of fur, or the difference between a soft felt and a stiff one?

One of the latest exhibits in the Division of Textiles of the National Museum at Washington shows clearly just how such hats are made—from the fur to the finished product—and includes many of the latest and most popular styles ready to wear, as well as special shapes manufactured for particular foreign markets. The exhibit is accompanied with photographs illustrating scenes in the factory of one of the largest and best-known American hat manufacturers. These enable the observer to connect the materials, apparatus and finished products shown into a tangible story. For the benefit of those who cannot see this interesting collection a brief review of the process is given herewith.

In the manufacture of one of the most popular brands of American hats the fur of North American beaver, South American nutria, Saxony hare, and English and Scotch coney are used. When the pelts of these animals are received at the factory they are first washed with whale oil soap, after which the long, coarse hairs are removed, since they would tend to make the felt too rough. The skins are then treated with nitrate of mercury, a process called "carroting," which gives the fur its "felting properties," making it knit together when hot water and pressure are applied. The skins are then brushed by a machine which removes all the dust and other foreign substances. The skin next goes to a cutting machine where revolving shears shave away the fur, cutting it close to the skin. From this machine the fur is carried away on an endless belt or apron, on which it lies complete, just as it was in the pelt, and it is hard to realize that the skin below has actually been removed. This is to facilitate the work of the sorters, who select from the belt as it passes them just the parts desired for various grades of hats. The sorting is according to color and quality, each sorter selecting a different part, such as the side, belly or back, suitable for a particular grade of hat.

Although it is now cleaned, carroted and sorted, the fur is by no means ready for use: it has to be seasoned, just like lumber, and is stored until ready for use. Some manufacturers have a million or two dollars' worth of fur seasoning in storage. When the fur is properly seasoned, it is mixed in certain proportions to produce the desired texture, and from here on the work is not done mechanically, but by hand, being mainly a question of art and skill. After various portions of different kinds of fur have been selected, the actual mixing is done by a machine which blows the batch about until the blending is perfectly even. A certain amount of fur is then weighed out, according to the hat to be made, and blown upon with a copper cone about 3 feet high and perforated with many thousand tiny holes, so that it looks like a sieve. An exhaust fan operates inside and below the cone so that the air and fur are drawn from the outside. The air passes through the openings but the fine particles of fur are caught and form an even film that covers the whole outer surface of the cone. The cone holding the film of fur is then enclosed in a snugly fitting jacket and lowered into a vat of boiling water, which develops the felting properties of the fur, and causes the hairs to mat and lock together, enabling the thin, delicate film of wet fur to be lifted from the cone. The resulting cone of fur is a very delicate embryo hat, except as to size; in that respect it might be the hat for a giant. A bundle of about twelve of these large forms is rolled in a wet condition until the fibers knit together slightly giving the hats firmness and strength. Then they are put into a sizzling kettle where they are shrunk in hot water, beaten, and manipulated until they are between 10 and 14 inches in diameter. Each hat is then stretched, pulled and blocked with the aid of hot water until it takes the form of a regular hat with crown and brim.

If the hat is to be a soft one, it has only to be placed on a block and finished with fine sand paper, which gives it a velvety appearance. The outside band and binding, and the sweat band are then added, after which the brim is curled.

Stiff hats, or derbys, are saturated with a solution of shellac before they are blocked. They are then put into an oven until they become pliable, when they are blocked with a tremendous pressure on a mould which shapes and curls them at one operation. Following which they are lined and trimmed.

Photometric Methods in Connection With Magic Lanterns and Moving Picture Outfits*

By J. A. Orange

There are two ways in which the illumination performance of magic lanterns and moving picture machines may be subjected to precise test.

The first is to take actual measurements of the illumination on a test-plate which can be moved systematically from point to point on the screen. A thorough test of this kind is both troublesome and laborious but it has the advantage of giving a measure of the *evenness* of illumination.

For most purposes it would seem to be preferable to proceed as described below, at least in those cases where the apparatus is not permanently installed in an operating booth.

A sheet of opal glass with flat surfaces finely ground is placed in front of the objective. A portable photometer is set up facing this at, say a distance not less than four times the objective diameter. Care is taken to avoid shading of the receiving plate of the photometer with respect to the illuminated part of the opal glass. With some photometers this involves unscrewing the shading tube which is normally in place.

In the case of magic lanterns one should use a mask in the slide-holder with an opening representative of the slides used. Moving picture machines have a "mask" corresponding to the film, viz.: the aperture-plate. The shutter will naturally be kept in motion while tests are being made; but there is a systematic error depending on the geometry of the arrangement —some 5 per cent. in the worst case.

Measurements of the candle-power of the opal glass made in this way give a measure of the total lumens emerging from the system.

The accuracy may be affected by want of uniformity in the opal glass and by departure from Lambert's Law. However, it is an easy matter to have the glass optically ground, while in the most extreme case the incidence is within 15 degrees of the normal and usually much closer. The emergence is within about 8 degrees of the normal even if the photometer is as close to the glass as was mentioned above. There is therefore little chance of error from this cause.

Next as regards the constant for the glass there are a number of simple ways of evaluating it. One is to make an illumination survey of a screen, measure the screen and so deduce the total lumens; then test the same projector in the manner here described. Another is to illuminate the opal glass by means of a high candle-power lamp which has been photometered, the filament center being at a distance from the plate about four times the effective diameter of the opal glass.

The glass should be provided with a black mask of known area on the face towards the lamp. Again the photometer is used to measure the candle-power of the opal glass. The lumens incident on the opal glass are readily calculated from the candle-power of the lamp in the appropriate direction, the distance from the filament to the opal glass and the area of the mask.

$$\text{Lumens} = \frac{\text{candle-power} \times \text{area}}{\text{distance squared}}$$

very approximately.

Thus the relation between photometer reading and lumens incident on the opal glass is obtained.

It should be noted that it is advisable to use a large, concentrated filament lamp in this standardization and even then it will be found necessary to use reducing screens of very low transmission factor in the measurements with a projector.

The amount of focusing necessary to deal with the various screen distances encountered is very small and it has no significant effect on the amount of light emerging from the projector. If the apparatus gives sensibly uniform illumination over a screen then the total lumens projected would appear to be the best gauge of performance as far as mere illumination goes.

A Simple Method of Studying the Intrinsic Brilliancy of Projection Sources.

This method is convenient for comparing the brilliancies of different sources and for finding the distribution of brilliancy over any form of light source suitable for projection.

Two cheap hand camera lenses equipped with iris diaphragms are used (each of 5-inch equivalent focus). One is set up opposite the light source at about 7½ inches distance. The other lens is deprived of its back component and then mounted in line with the first lens, at a distance of about 15 inches. A portable photometer is arranged at 30 inches from this second lens and readings taken on the candle-power scale.

The action is as follows: the first lens casts an image of the source at the position of the diaphragm in the second lens; the second lens casts an image of the diaphragm of the first lens into the plane of the photometer plate.

It should be noted that this latter image is to be larger than the photometer plate; the iris diaphragm in the first lens gives latitude in this respect. The diaphragm in the second lens enables one to select different parts and varying extents of the source image for the brilliancy test. The advantage of having a diaphragm in the first lens is that it gives a certain amount of control of the definition of the source image, control which is needed if one takes small areas of the source and measures "local brilliancy." Such a case calls for different distances from those instanced above.

As to the mode of estimating the brilliancies we may notice first:

1. If without changing the set-up or diaphragms one source is substituted for another the candle-power readings on the photometer are a measure of the relative brilliancies of the parts selected by the diaphragm of the second lens.
2. Changing the stop opening of the first lens is significant only as regards definition of the source-image and covering the photometer plate.
3. Changing the stop opening of the second lens is allowed for approximately if each candle-power reading is multiplied by the corresponding U. S. stop number.
4. Changing the system so that the distance from the second lens to the photometer is varied may be allowed for very approximately by multiplying the readings by the square of the distance. (It is sufficiently accurate to measure the distance from the lens diaphragm to the photometer plate.)

In general the mean brilliancy *of the selected part* of the source is given by the relation:

$$B = \frac{I.x^2}{A.T.\ 10{,}000}$$

Where

I is the photometer reading in meter-candles.

x is the distance from second lens to photometer, in centimeters.

A is the area of opening of the second lens (in square millimeters).

T is the transmission of the system. (About 70 per cent in the case here described.)

B is the brilliancy in candle-power/square millimeters.

*General Electric Review.

The Latest Revision of Radioaction Data

Two years have passed since the publication in *Le Radium* of the last table of radioactive constants, compiled by Kolowrat. The many determinations effected since then necessitate a revision, which has been prepared by Veudt.

In the attached table, the system of nomenclature now in use has been retained; it is probably still too early to seek to devise one which shall give universal satisfaction. Since the fundamental simplification introduced by Rutherford and Geiger, the discovery of a ramification of the three members of the C series of disintegration products has again led to confusion. It would seem that the term thorium C_2 ought to be replaced by thorium C^1, after Soddy, to correspond with radium C^1 and actinium C^1, and to drive home the analogy between the three very short-lived substances of the C series. Radium C_2 at present stands as analogue of thorium D and actinium D.

The radioactive elements now known are thirty-six in number. Varder and Marsden have confirmed the existence of actinium C^1, previously observed by Marsden and Wilson, and by Marsden and Perkins, and noted in the works of Mlle. Blanquies. The series of disintegration products comprising three members are then analogous up to the terms D. The discovery by Antonoff of a uranium Y has several times been confirmed; it is, nevertheless, difficult to assign to this element a place in the table. It is, using the expression suggested by Soddy, isotopic with uranium X_1 and with ionium, and derived from uranium 1 or from uranium 2, by emission of α-rays. Either mode of origin would be abnormal, necessitating that an element undergo two different disintegrations through loss of α-rays. The origin of actinium is an even greater enigma, which the combined labors of Fajans, Soddy and Russell have not been able to solve.

Certain things, however, appear to be definitely established. In the class of elements of short life are to be placed uranium X_2, radium C_2, actinium D, thorium D, and the three members C^1. The chemical properties of the more stable substances are deduced from the researches of Hevesy, Hevesy and Paneth, Fleck, McCoy and Viol, Metzener, and Klemensiewicz. The elements of the three series pertaining to the same chemical group, and which are found in the series along with the emanations, are isotopes. Numerous determinations of the atomic weight of lead of radioactive origin have shown that in spite of real differences in the atomic weights, the isotopic elements are chemically and spectroscopically inseparable. Hönigschmid and Horowitz have prepared a substance which is probably pure radium G, whose atomic weight, 206.04, is comparable with that of ordinary lead, 207.18. This makes radium G appear as a final product of the radium series, and justifies the hypothesis that the emission of an α-ray results from the loss of four units in the atomic weight.

The difference (19.93) between the values obtained by Hönigschmid for radium (225.97) and radium G is exactly equal to five times the atomic weight of helium (3.99). Still, the bonds of generation between the radioactive elements and ordinary lead are obscure. Rutherford and Andrade find that the atomic weights of radium B and of lead are the same, while the recent work of Richards and Wadsworth shows that the atomic volumes of radium G and of lead are also identical. Seeking the ultimate product of thorium, Soddy and Hyman find that the lead obtained from thorium ore possesses an atomic weight abnormally high, as though thorium E were stable and isotopic with lead. Hönigschmid and Horowitz have not verified this phenomenon, and Holmes and Lawson have been unable to determine any relation between the contents of lead and of thorium from old minerals. Mlle. Meitner has shown that pure bismuth is not radioactive and is therefore not derived from lead by emission of β-rays.

Recent determinations of the range of the elements from actinium, by Meyer, Hess and Paneth, have furnished an excellent verification of the rule of Geiger and Nuttall. The elements for which the present data do not accord with this rule are actinium A, thorium and ionium. The attached table gives the evolution of the periods of uranium 2, actinium and the terms C^1.

Substance.	Period.		Chemical Group.	Rays.	Range in Centimeters.
Uranium 1	5,000,000,000	years	6	α	2.50
Uranium X_1	24.6	days	4	β	....
Uranium X_2	1.15	minutes	5	β	....
Uranium 2	2,000,000	years?	6	α	2.90
Uranium Y	25.5	hours	4	β	....
Ionium	100,000	years	4	α	3.11
Radium	1,730	years	2	α β	3.30
Radium Emanation	3.85	days	0	α	4.16
Radium A	3	minutes	6	α	4.75
Radium B	26.7	minutes	4	β	....
Radium C_1	19.5	minutes	5	α β	....
Radium C_2	1.4	minutes	3	β	....
Radium C^1	1/1,000,000	second?	6	α	6.94
Radium D	15.83	years	4	β	....
Radium E	4.85	years	5	β	....
Polonium (Radium F)	136	days	6	α β?	3.84
Thorium	15,000,000,000	years	4	α	2.72
Mesothorium 1	5.5	years	2	?	....
Mesothorium 2	6.2	hours	3	β	....
Radiothorium	2.02	years	4	α	3.87
Thorium X	3.64	days	2	α	4.30
Thorium Emanation	54	seconds	0	α	5.00
Thorium A	0.14	second	6	α	5.70
Thorium B	10.6	hours	4	β	....
Thorium C_1	1	hour	5	α β	4.80
Thorium D	3.1	minutes	3	β	....
Thorium C^1	1/100,000,000,000	second	6	α	8.60
Actinium	200	years?	3	α?	3.56
Radioactinium	18.88	days	4	α β	4.20
(Radioactinium[1])?	60	hours?	?	α?	4.61
Actinium X	11.4	days	2	α	4.26
Actinium Emanation	3.9	seconds	0	α	5.57
Actinium A	2/1,000	second	6	α	6.27
Actinium B	36.1	minutes	4	β	....
Actinium C_1	2.15	minutes	5	α β?	5.15
Actinium D	4.71	minutes	3	β	....
Actinium C^1	1/1,000	second	6	α	6.45

For the benefit of the lay reader we may explain a little of the theory of radioactivity. This action is of such a nature that as the substance of the radioactive matter is wasted away, the radiation becomes less and less intense. It never ceases altogether, and the substance is never entirely demolished; but the intensity is always directly proportional to the mass remaining. This brings it about that no matter what weight of a given radioactive element we start with, it will always lose precisely half that weight in the same time. This time, fixed for each element and different for all, is called the period, *P*.

Mathematically, this state of affairs is represented by the equation

$$\frac{I}{I_0} = \epsilon^{-\lambda t}$$

where ϵ is the natural logarithmic base, I_0 the initial intensity, I the intensity after time *t*, and λ a fixed constant, different for each element. If in this equation $t = P$, then $I = \frac{1}{2} I_0$, and we have

$$\tfrac{1}{2} = \epsilon^{-\lambda t}$$

or

$$2 = \epsilon^{\lambda t}$$

whence

$$\lambda t = \log 2 = 9.69315 \ldots$$

So given *P* or λ, the other is known. While both are fundamental, we include in our table, in view of this simple relation, only that one, *P*, possessing a simple intuitional interpretation.

The rays given off are of three kinds, α, β and γ-rays. Not all radioactive substances give off all three of these, hence the column characterizing the rays of each substance. The γ-rays are not entered in this column, because they are given off by those elements, and only those, which emit β-rays. The effects of the rays may be described in general as an ionization of substances through which they pass or on which they fall. The range, *R*, over which this effect is felt is different for each substance and varies with the temperature; our table gives the figures for 15 deg. Cent.

The values given for *P* and *R*, which differ in many cases from those of Kolowrat's table, are derived from the works of Soddy and Mlle. Hitchins (ionium), of Meyer, Hess and Paneth (ionium, polonium and the actinium series), of Hahn and Mlle. Meitner (uranium Y), of Thaller (radium D and E), of Mlle. Heimann (thorium), and of McCoy and Leman (radioactinium). The table itself first appeared in the *Physical Review*. Our discussion is translated from *La Revue Générale des Sciences Pures et Appliquées*, with certain amplifications.

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