reefs. Whether modern observers will adopt his terminology in this respect or not is aside from the point here at issue. The fringing reefs which Darwin regarded as the early stage of barrier reefs may have been either on-shore reefs or off-shore reefs; but if off-shore, the belt of water between them and the land must have been shallow. This is made perfectly clear by his explicit statement:

> Fringing reefs on steep coasts are frequently not more than from 50 to 100 yards in width; they have a nearly smooth, hard, surface, scarcely uncovered at low-water, and without any interior shoal channel, like that within those fringing reefs which lie at a greater distance from the land (55, 56).

These citations leave no doubt that, when the now-submerged barrier reef of Tutuila was first formed at a distance of a mile or two from the cliffed inner border of its shallow supporting platform, it would have been classed by Darwin as a fringing reef, because the "enclosed water channel" was then of small depth. But when subsidence continued and permitted reef upgrowth to such a height that the enclosed water channel or lagoon was increased in depth, then Darwin would have called it a barrier reef, as modern observers are united in doing.

The principle here involved is, however, of no great importance, because it was not Darwin but his successors who have emphasized the supposedly necessary sequence of fringing reef, barrier reef, and atoll, as a consequence of the theory of subsidence. Darwin's own discussion recognized this succession as characterizing the typical example of a subsiding island, like Bolabola; but he explicitly recognized other sequences in less typical cases. If the original reef foundation had been a bank close to sea level, the initial fringe would have become an atoll, as subsidence progressed, "without passing . . . through the intermediate form of a barrier reef," as a quotation (101) already made shows clearly enough. Or if a reef grew up from the rim of a still-standing submarine crater of proper depth, a possibility which Darwin explicitly recognized (89), an atoll would be formed without the preliminary formation of a fringing or a barrier reef. The point of all this is that Darwin conceived many conditions under which coral reefs might be established and transformed, and did not restrict himself to a special form of reef-foundation or a fixed sequence of reef development, even though he understood that the most probable explanation of the majority of barrier reefs is by the more or less intermittent upgrowth of fringing reefs from subsiding foundations, and that the best explanation of most atolls is by similar upgrowth from subsiding barrier reefs.

The object of this article is to point out that the full meaning of Darwin's broad discussion can not be condensed into a rigidly conceived theory, beginning with an island of a certain shape and proceeding through a perfectly definite sequence of transforming reefs. His treatment of the problem was far broader than that, as the citations given above must suggest, and as various other citations would confirm. Far from being inconsistent with his broadly conceived theoretical discussion, the reefs of Tutuila as described by Mayor, Chamberlin and others are remarkably close exemplifications of some of its most significant special phases.

W. M. DAVIS

HARVARD UNIVERSITY, CAMBRIDGE, MASS.,
May, 1921

A NOVEL MAGNETO-OPTICAL EFFECT

EARLY in April, 1921, while my son, Malcolm Thomson, was operating, in a building of the River Works plant of the General Electric Co., a resistance welder for closing the seams of steel Langmuir mercury vacuum pumps, in which work the current is applied and cut off at about one half second intervals, there was noticed by one of the working force, Mr. Davis, who happened to be favorably located, a peculiar intermittent illumination of the space near the welder as the current went on and off. My son at once placed himself in a similar position and saw the novel effect, and noted a number of conditions accompanying it, perhaps the most important being that a single turn loop from the welding transformer to

the work and back was carrying about 7,000 ampères, and that the luminous effect was spread in the space in which would be located the magnetic field from this loop; that the sunlight was entering the building through high windows and shining across the space in which the field was produced at intervals; that the effect was most conspicuous when one looked towards the shadows, and across the sunbeams, and also across the magnetic field.

This would be expressed by saying that the best effect was observed when the line of vision was downward at an angle intersecting the entering sunbeams, and into the shadows under the beam furnished fortunately by a partition a few feet high, over which the sunlight came. The magnetic field, neglecting the curvature of the lines, was, generally speaking, at right angles to the line of sight and to the direction of the sunlight. My son also noticed that the effect of increased luminosity was coincident with the putting on of the current and disappeared at once on cutting off the field. It was thus clear that it depended on the establishment of the magnetic field. He reported these facts to me and they were confirmed by me. Other observers were soon enlisted, and on several favorable sunny days all the above observations were confirmed by them. Further, my son had not been able to see any effect when looking across the sunbeam from the opposite side. This means that with the sunbeams streaming in from the south, the effect was observed looking southward and downward; the windows admitting the light being to the south. Looking from the south across the beam gave no result, though it was not possible to look directly across the beam on a slant upward into any dark shadows and at the same time have the line of vision cross the magnetic field.

It is interesting to note at this point that the luminosity filled the whole space and extended as far away as four feet or more from the magnetic loop, and that it was not especially noted as more intense near the loop than at a distance therefrom of say two feet or more.

Mr. Malcolm Thomson had further observed that by cutting out the loop from the secondary terminals (clamps) of the welding transformer and simply joining those terminals by an iron bar, as is done in resistance welding, the luminous effect in the neighborhood of the transformer was still visible, but was much more feeble than when the heavy loop was used. It occurred to me to examine the light by a large Nicol's prism. It was found that there was a distinct polarization of the light from the space. This means that when the magnetic field was on, the sunlight was scattered in the direction of the observer, from the space occupied by the sunlight beam and the magnetic field, and that such scattered or deflected light was polarized.

It occurred to me, as a possible factor in the case, that as the building was used in part to carry on arc welding by iron arcs, there might be suspended in the air of the building iron particles or finely divided oxides or compounds of iron, which in some way were oriented by the magnetic field, resulting in the scattered light noted. This was confirmed in part by making the test observations when the large doors of the building had been open for some hours. The effect was present though difficult to detect. This led to the suggestion to bring an iron arc into operation near the space in which the luminous effect had been seen. This was done and with an enhancement of the effect.

At this stage, the further observations were carried on in the Thomson Laboratory at Lynn, Mass., with the aid of the laboratory corps (A. L. Ellis, H. L. Watson, Dr. Hohlnagel, and others).

Two sets of test apparatus were prepared at my suggestion. One large welding transformer was mounted in a special room, into which the sunbeams could be received in the afternoon, as the windows faced south by west. The secondary terminals were joined by a large loop of heavy copper cable about 12 square centimeters section and of a loop diameter of .6 meter. The loop consisted of two turns. The plane of the loop was vertical and was nearly north and south, or in a plane parallel to the direction of the entering sun-

beams, so that the magnetic field would be in the main horizontal and transverse to the light of the sun entering downward as before. An iron arc was arranged to be operated so that the smoke from it would rise from below and enter the field of the loop, and by changing the relative position of the arc, the smoke column, widening as it rose, could be made to bathe the turns of the coil, cross its axis, or at a distance away, merely enter the field. As the experiments thus far had always involved connection to the shop plant, with 60 cycle A. C. current, a check apparatus was set up, consisting of a storage battery (of a type such as is used in automobile starting) arranged on a stand. In circuit with it, and under control of a switch was a coil of about .2 meter diameter and giving a field due to about 2,500 ampère turns when the switch was closed. This second apparatus could be moved about and was entirely independent of supply circuits, or static dusturbances which might be present in them.

The first tests were made with the transformer loop (representing a field of 20,000 ampère turns) and were very striking. The rising smoke from the small iron arc, only moderately visible in the sunbeam, became decidedly luminous when the field was put on. Each closure of the current switch to the primary of the transformer was instantly followed by the brilliant smoke effect, and the effect instantly disappeared on the opening. A black background had been provided in front of which the smoke rose. After the arc had been running a few minutes only, it was seen that the air of the room was carrying sufficient of the smoke particles to give the effect anywhere in the space covered by the magnetic field and the sunbeams, even a number of feet away from the coil. In this case the appearance was as if in the air there were diffused some substance or material which only became visible in the combined sunlight and magnetic field. That in this case the luminous effect is not greater near the coil loop than feet away, indicates that orientation, or whatever causes the effect, is complete even in a rather weak field. Thorough ventilation of the room by opening windows, caused the effect to fade out gradually by removal of the active particles.

The experiments with the D.C. current coil and battery conclusively showed that the effect was present with it, as with alternating current, and incidentally established the fact that the effect on the particles is independent of the direction of magnetization. It is doubtful if high frquency tests would allow us to discover whether the establishment of the effect requires time. Probably not. Observations made through the axis of the loop of two turns show a minimum of effect, from which it may be inferred that it is not present if the viewing is exactly along the field line direction.

Polarization. — Having obtained, as described in the foregoing, a controllable and relatively brilliant source of the luminosity, tests with the Nicol's prism were resumed. It was soon noted that the polarization was decided as controlled by the magnetic field. Moreover, the very curious fact was discovered by me that the fumes from the iron arc were composite so far as analysis by the polarizing prism was concerned. The bluish colored smoke arising gave but little effect, but there was with it a yellowish gray fume, which was highly luminous in one position of viewing by the prism and invisible when the prism was at right angles to that position. This indicates complete polarization when the field is on, for the light diffused from the particles in the yellowish gray fumes. This is an extraordinary effect, for which no evident explanation suggests itself, for the field lines are not straight but wrap themselves around the coil or loop in curved directions, and the effect is apparently complete even with the fumes rising in the space where the lines are strongly curved.

It remains to use a vertical beam of light and make tests from opposite directions across the field, also to use artificial light instead of sunlight. The design of a small demonstration apparatus seems possible, consisting of a coil to be put on a battery or lighting circuit, A.C. or D.C., a small iron arc between two wires, a box with darkened interior to be filled with

fumes, having two sides of glass, one for the admission of the light beam and the other a window at right angles for observation. Two coils placed outside the box space and opposite each other, or capable of application in different relations will have advantages. The addition of eye shields to cut out extraneous light and a tortuous chimney conveying the smoke but cutting off the light from the iron arc are desirable additions to the equipment, as also an analyzer as part of the apparatus for the polarization effect.

The Microscope.—Attempts have been made to catch the particles in the smoke from the arc upon a glass slide for microscopic examination as to their form under high powers. That they are exceedingly fine is evident from their remaining in suspension so long in the air and diffusing themselves rapidly throughout the air. That an exceedingly small amount of material suffices for making the whole air of a large room capable of showing the effect is evident also. The sunbeam may enter the room and its course is not disclosed by them unless the magnetic field exists. It seems natural to suppose that the particles consist of some form of iron or iron oxide, but without proof this can not be fully decided. Other particles might exist giving such an effect, but it must be confessed this does not seem probable. Other fumes and smokes from arcs so far have given no results. The smoke from a nickel arc does not give the effect. Neither does a cobalt arc yield fumes behaving like iron smoke.

The fumes and smoke of an iron arc were caught on a clean microscope slide until a patch of sediment of a slightly yellowish brown tint, but very pale, was deposited. Under moderate powers, very little of any definiteness is shown, but under the high power of an oil immersion lens of about 1.5 mm. focal length, there is disclosed a curious structure of particles seemingly between .0002 and .0001 mm. diameter, which particles are frequently strung together, 4, 5, 6, or more, in a line, giving the effect of a short piece of chain made of small roundish particles, slightly spaced apart, or of a short section of a string of beads (round beads) not touching one another. Many of these structures appear to be straight, and some are curved. Evidently in a magnetic field these chains of particles, presumably of oxide of iron, and magnetic, would line up and reflect or diffuse light of the sun striking them. If the direction of vision was such as to favor polarization of the rays in a direction nearly at right angles to the incidence of the solar beam, the polariscope effect would be accounted for, measurably. Aside from polarization, the lining up of the chains would also account for the extra *visibility* of the smoke under the conditions of the experiment.

It would seem from the foregoing that a considerable length of column of smoke from the iron arc, and subjected transversely to a magnetic field, might be expected to act as a means for obtaining polarized light in the direction of the beam itself. This assumes that there will be a considerable scattering of light polarized as above described in a direction sidewise, leaving the light which passes through polarized in a plane at right angles. The apparatus might be compared in its action to a Nicol's prism, transmitting rays in one plane and throwing out laterally those in the other plane. This suggestion will be tested as soon as proper arrangements can be made.

The polarized light which is sent out from the smoke particles in a direction transverse to the sunlight beams, when the magnetic field is put on, is in the same plane as that reflected from a sheet of glass at the polarizing angle receiving the same beam. This fact is in accordance with what might be expected if the short sections of chain or beaded particles were oriented or lined up by the magnetic field; the transverse waves of light vibrating in a plane intersecting the length of the chains would not be deflected on account of the extremely small diameter of the particles composing them, but waves vibrating in the plane of the length of the chains would be reflected to the side and this would account for their plane of polarization being what it is. Such waves would behave as if reflected

from short rods in line with the plane of vibration, while the extremely small diameter of the rods would not sufficiently intercept the light vibrating in a plane transverse to their length.

It is expected to continue the investigation with artificial light and other varied conditions, followed by a later account.

ELIHU THOMSON

THOMSON LABORATORY OF GENERAL ELECTRIC CO., LYNN, MASS.

May 23, 1921

EDWARD BENNETT ROSA

DR. EDWARD B. ROSA, chief physicist of the Bureau of Standards, at Washington, died suddenly at his desk on Tuesday afternoon, May 17, 1921. Dr. Rosa was at the time the chief of Division I. of the Bureau of Standards, the functions of which include research, standardization and testing in the fields of electricity, magnetism, photometry, radio communication, radium, X-ray, and public utilities. Dr. Rosa was appointed physicist in the Bureau in 1901. In 1910 he was given the grade of chief physicist. Dr. Rosa's painstaking accuracy in scientific research is well known among specialists in the fields in which he worked. His investigations have been published in 36 scientific publications of the bureau and 4 technologic papers, not to speak of a large number of special reports, circulars, and articles in technical journals.

Among the researches of unusual interest may be mentioned the precise determination of the value of the coulomb, the value of the ampère, and of the ratio between the electrostatic and the electromagnetic units of electricity. His other laboratory researches included a wide range of problems chiefly connected with the improvement of the standards and methods used in precise electrical measurements.

Perhaps one of the most striking examples of Dr. Rosa's thoroughness and success in securing the cooperation of the technical groups interested may be found in the development and publication of the National Electrical Safety Code, the revised form of which has just recently appeared as a "Handbook" issued by the Bureau of Standards.

In his work as administrator he successfully organized the work of electrical testing, photometry, radium testing, and research and standardization work involved in radio communication. Dr. Rosa showed a deep interest in all phases of the bureau's development, and will be remembered with profound respect and admiration by his colleagues. His work will endure as a permanent foundation for the branches of physics and electrical engineering to which he devoted so many useful years of his life.

S. W. STRATTON

DEPARTMENT OF COMMERCE, BUREAU OF STANDARDS

SCIENTIFIC EVENTS

THE HARPSWELL LABORATORY

THE Harpswell Laboratory was founded at South Harpswell, Maine, in 1898, as a summer school of biology by Dr. J. S. Kingsley, then professor of biology in Tufts College, Massachusetts. In 1913 it was reorganized as a scientific corporation under the laws of the state of Maine, with a board of ten trustees. Up to 1920, ninety-two scientists have worked in its laboratory at South Harpswell and over one hundred and ten papers have been published, as a result of this work, in American and foreign journals of biology.

In the spring of 1921 the Harpswell Laboratory became a member of "The Wild Gardens of Acadia" Corporation, and this corporation alloted to the Harpswell Laboratory a tract of land of abundant acreage for its purposes and further growth at Salisbury Cove, Maine, on Mount Desert Island, with shore frontage and favorable life conditions, upon which the Harpswell Laboratory has established its Weir Mitchell Station. In its new site the laboratory is in close contact with the wild life sanctuary of Lafayette National Park, created recently on Mount Desert Island by the United States through the efforts of a group of its summer residents. This is the only National Park in the eastern portion of the Continent and the only one in the country