If I have gone into all these details, it is only to show that photography of clouds is a very easy operation, and within the reach of all amateurs. And let me just add, that with the darkest screen (saturated bichromate) and Prazmowski's lens, with a focus of 160 millimetres, and diaphragm of $\frac{1}{30}$, I obtain negatives with a maximum exposure of six seconds for cirrus, with an ordinary amount of light with a Zeiss' object-glass, a diaphragm of $\frac{1}{15}$ and very bright cirrus, having an exposure of $\frac{1}{30}$ of a second, has sometimes been more than sufficient, even too much.

It would be very interesting if amateurs in photography, so numerous at the present time, would try to photograph clouds which strike them as having interesting shapes, noting with care the hour when they were taken, and also the direction in which the clouds appeared.

SCIENCE IN THE MAGAZINES.

ONE of the most interesting contributions to this month's magazines is an illustrated account in the *Century* by Mr. Borchgrevink, of his voyage in the *Antarctic*, prefaced by a note by Mr. A. W. Greely. The article will give an impulse to the movement in favour of an expedition to explore the Antarctic continent. Referring to Mr. Borchgrevink's account, Mr. Greely says: "From a scientific standpoint the interest depends entirely upon the discovery by Borchgrevink, on Possession Island and Cape Adare, Victoria Land, of a cryptogamous growth, probably an unidentified lichen. The importance of this discovery rests in the fact that hitherto no land vegetation of any kind or description had been found within the confines of the Antarctic circle. The strained deduction has been drawn that the climatic conditions of the Antarctic zone must have changed since the voyage of Ross, who discovered no vegetation. It should be borne in mind, however, that the great botanist, Sir Joseph Hooker, who served with Ross, was unfortunately prevented from landing with his commander; otherwise it may not be doubted that low forms of vegetable life which escaped the attention of Ross would have been noted by Hooker. In a practical way it emphasises the possibility of much more extended exploration in the Antarctic Ocean, through the agency of the steam-power of to-day, than was practicable for the greatest of Antarctic navigators—Cook, Balleny, Weddell, Wilkes, and Ross—under sail alone in the past." Ethnologists will be interested in the studies of Indian life given by Alice C. Fletcher in the *Century*, under the title "Tribal Life among the Omahas."

An illustrated description of the magnificent new building of the Boston Public Library, contributed by Mr. T. R. Sullivan to *Scribner*, shows how very thoroughly the American people are working for the advancement of learning. The building will hold a million and a quarter volumes, and everything has been done to make it beautiful, while all that modern contrivance can offer has been utilised to secure comfort. "The reference reading-room of the library," we read, "and its seven thousand volumes are free to all who care to take them down, without the intervention of an attendant. At the southern end, always open for consultation, is the card-catalogue of all the books contained in the building; any one of these will be furnished and brought from the main library to the designated table at a few moments' notice. There is room for hundreds of readers to sit here from early morning to a late hour of the night in undisturbed pursuit of knowledge. Those who have tried to work in the overcrowded libraries of Europe, hampered by annoying restrictions and wearisome delays, will fully comprehend the blessing which such freedom brings." In the same magazine there is an article on "Water-ways, from the Ocean to the Lakes," by Mr. T. C. Clarke, dealing chiefly with the great canal from Lake Erie to the Hudson River. In the editorial notes, reference is made to recent gains in the speed of travel. It appears that the distance between Buffalo and Chicago—512 miles—has been covered at a rate of over sixty-five miles per hour, stops excluded. The distance between New York and Washington is now done in about five hours, but a railway exists (on paper) the trains of which are to shoot over this distance of 240 miles in two hours! The track is to be elevated above the ground on a single line of upright piers, and the trains are to be driven by electricity, each car carrying its own motor machinery. The most distinctive mechanical feature of the enterprise is the so-called "bicycle" arrangement, by which a single line of wheels run on single rail. The train is to be kept upright by an auxiliary rail on each side, which will not, however, come into play except in rounding curves.

In the *Popular Science Monthly* Prof. G. F. Wright discusses the "New Evidence of Glacial Man in Ohio," afforded by a small chipped chest implement found by a trustworthy observer close to Brilliant Station on the Ohio River. He concludes that the discovery "must go far to close the question of man's antiquity on the Western continent, and to dispel the doubts upon the subject which, for one reason or another, have heretofore existed." Prof. James Sully continues, in the same magazine, his "Studies of Childhood," and among the other articles are "The Anatomy of Speed Skating," by Mr. R. Tait McKenzie; a criticism by Mr. Le Sueur of Prof. Forbes' article on the work of the Cataract Construction Company, published in *Blackwood's Magazine* for September 1895; "Health Experiments in the French Army," by Mr. Stoddard Dewey; and "Prehistoric Engineering at Lake Copais," by Mr. J. D. Champlin.

Mr. W. H. Mallock continues in the *Contemporary* his essay on "Physics and Sociology." He holds that the struggle which causes social progress is a struggle of the few against the few, and is fundamentally different from the Darwinian struggle for existence. In his words: "Within the limits of the minority, composed of the exceptionally gifted, whether their gifts are those of scientific knowledge, or knowledge of men's characters and wants, or of a power to direct men, there does undoubtedly take place a struggle strictly analogous to that with which Darwinian science has familiarised us, the result being, as Mr. Spencer's celebrated formula expresses it, the survival of the fittest. Only it is not a struggle for existence, if the word existence is taken to mean life; it is a struggle for existence in a position of rule or domination. It is, moreover, not a struggle with the majority of the community, but with the minority only. The fittest, the survivors, the winners, instead of depriving the majority of the means of subsistence, on the contrary, increase those means, and their unsuccessful rivals are defeated, not by being deprived of the means of living, but only of the profits and privileges that come from directing others. That there is a subsidiary struggle amongst the majority, a struggle to obtain work, not to direct work, is true, as has been said already; but, as has been said also, this is not the struggle which primarily either causes the advance of civilisation or maintains such advances as have been made. It contributes to these results, and how far and in what way it does so will require to be discussed hereafter; but it is not the principal, it is not the primary cause of them. The primary cause is the struggle which causes the survival, not of the largest number of men of average capacity, but of the largest number of men of exceptional capacity—the largest number of great men." Thus, according to the argument, the *domination* of the fittest is the true counterpart in the social world of the *survival* of the fittest in the physiological world. The *Contemporary* also contains a short paper by Mr. Herbert Spencer, on the development of the architect, the paper being the ninth of a series on "Professional Institutions." The view is taken that "the earliest architecture bequeathed by ancient nations was an outcome of ancestor-worship."

In *Science Progress*, Dr. H. E. Armstrong describes "The Plan of Research in Education," and makes a powerful plea for scientific teaching and scientific research, both on account of education and industrial progress. Prof. F. O. Bower discusses recent work on mosses and ferns, with special reference to Prof. Campbell's volume on the subject; Mr. J. W. Rodger continues his statement of "The New Theory of Solutions"; Mr. Philip Lake describes "The Geology of Egypt"; and Mr. G. T. Holloway traces "The Evolution of the Thermometer."

A brief mention will suffice for the remaining articles in the magazines received by us. *Good Words* has a short illustrated paper on sponges, by the Rev. T. Bird, and one on "A School of Mackerel," by Mr. Edward Step. The *Strand Magazine* has several splendid reproductions from photographs of frost patterns on window-panes, obtained by Mr. James Leadbeater. The *Phonographic Quarterly Review* always contains two or three scientific articles. The current number has in it "In a Canadian Forest," by General Sir Charles Wilson, K.C.B., F.R.S. "St. Bartholomew and his Hospital," by Dr. W. R. Gowers, F.R.S., and several other articles of interest to scientific phonographers. The *Fortnightly* has an article on "The Climate of South Africa," by Dr. R. Roose; and among the information articles in

Chambers's we notice one descriptive of the Loofah, or Luffa, by Prof. Carmody.

We have received, in addition to the magazines and reviews named in the foregoing, the *Humanitarian*, *Sunday Magazine*, *National*, *English Illustrated*, and *Longman's*, but the articles in them do not call for particular comment in these columns.

RECENT PROGRESS IN OPTICS.[1]

The reviewer who aspires to give an account of recent progress in any department of science, is met at the outset by two causes for embarrassment. What beginning shall be selected for developments called recent? What developments shall be selected for discussion from the mass of investigations to which his attention has been called? So rapidly is the army of workers increasing, and so numerous are the journals in which their work is recorded, that the effort to keep up with even half of them is hopeless; or, to borrow a simile employed by the late Prof. Huxley, "we are in the case of Tarpeia, who opened the gates of the Roman citadel to the Sabines, and was crushed under the weight of the reward bestowed upon her."

I have selected a single branch of physics, but one which can scarcely be treated rigorously as single. From the physical standpoint optics includes those phenomena which are presented by ether vibrations within such narrow limits of wave-length as can affect the sense of sight. But these waves can scarcely be studied except in connection with those of shorter and of longer period. Whatever may be the instruments employed, the last one of the series through which information is carried to the brain is the eye. The physicist may fall into error by faulty use of his mathematics; but faulty use of the senses is a danger at least equally frequent. Physiological optics has of late become transferred in large measure to the domain of the psychologist; but he in turn has adopted many of the instruments, as well as the methods, of the physicist. The two cannot afford to part company. If I feel particularly friendly to the psychologist, more so than can be accounted for by devotion to pure physics, it may be fair to plead the influence of old association. If I am known at all in the scientific world, the introduction was accomplished through the medium of physiological optics. But, with the limitations imposed, it is not possible even to do justice to all who have done good work in optics. If prominence is assigned to the work of Americans, it is not necessary to emphasise that this Association is made up of Americans; but, with full recognition of the greater spread of devotion to pure science in Europe, of the extreme utilitarian spirit that causes the value of nearly every piece of work in America to be measured in dollars, we are still able to present work that has challenged the admiration of Europe, that has brought European medals to American hands, that has been done with absolute disregard of monetary standards; work has been recognised, even more in Europe than in America, as producing definite and important additions to the sum of human knowledge.

In drawing attention to some of this work it will be a pleasant duty to recognise also some that has been done beyond the Atlantic—to remember that science is cosmopolitan. The starting-point is necessarily arbitrary, for an investigation may last many years and yet be incomplete. To note recent progress, it may be important to recall what is no longer recent.

Light Waves as Standards of Length.

You are therefore invited to recall the subject of an address to which we listened in this section at the Cleveland meeting in 1888, when Michelson presented his "Plea for Light Waves." In this he described the interferential comparer, an instrument developed from the refractometer of Jamin and Mascart, and discussed various problems which seemed capable of solution by its use. In conjunction with Morley he had already used it in an inquiry as to the relative motion of the earth and the luminiferous ether (*American Journal of Science*, May 1886, p. 377), and these two physicists together worked out an elaborate series of preliminary experiments (*ibid.*, December 1877, p. 427) with a view to the standardising of a metric unit of length in terms of the wave-length of sodium light. By use of a Rowland diffraction grating, Bell had determined the sodium wave-length with an error estimated to be not in excess of one part in two hundred thousand (*American Journal of Science*, March 1887, p. 167). Could this degree of accuracy be surpassed? If so, it must be not so much by increased care in measurement as by increase of delicacy in the means employed. The principle applied in the use of the interferential comparer is simple enough; the mode of application cannot be clearly indicated without a diagram, but probably all physicists have seen this diagram, for it was first brought out eight years ago (*ibid.*, December 1887, p. 427). By interference of beams of light, reflected and transmitted by a plate of plane parallel optical glass, and then reflected back by two mirrors appropriately placed, fringes are caught in an observing telescope. One of the mirrors is movable in front of a micrometer screw, whose motion causes these fringes to move across the telescopic field. If the light be absolutely homogeneous, the determination consists in measurement of the distance through which the movable mirror is pushed parallel to itself and the counting of the number of fringes which pass a given point in the field of view. According to the theory of interference the difference of path between the distances from one face of the plate to the two mirrors should be small; beyond a certain limit interference phenomena vanish, and this limit is smaller in proportion as the light is more complex. In the case of approximately homogeneous light there are periodic variations of distinctness in the fringes. For example, assume sodium light, which in the spectroscope is manifested as a pair of yellow lines near together. In the refractometer there are two sets of interference fringes, one due to each of the two slightly different wave-lengths. When the difference of path is very small, or nearly the same for both of these radiation systems, the fringes coincide. The wave-length for one is about one-thousandth less than that for the other. If the difference of path is about five hundred waves, the maximum of brightness for one system falls on a minimum of brightness for the other, and the fringes become faint. They become again bright when the difference of path reaches a thousand wave-lengths. The case is entirely similar to the familiar production of beats by a pair of slightly mistuned forks.

The method of interference thus furnishes through optical beats a means of detecting radiation differences too minute for resolution by ordinary spectroscopic methods. Spectrum lines are found to be double or multiple when all other means of resolving them fail; and the difficulty of attaining truly homogeneous light is far greater than was a few years ago supposed. By the new method it becomes possible to map out the relative intensities of the components of a multiple line, their distance apart, and even the variations of intensity within what has for convenience been called a single component. Each of the two sodium lines is itself a double whose components are separated by an interval about one-hundredth of that between the long-known main components; and an interval yet less than one-fifth of this has been detected between some of the components of the green line of mercury. Indeed Michelson deems it quite possible to detect a variation of wave-length corresponding to as little as one ten-thousandth of the interval between the two main sodium lines (*Astronomy and Astrophysics*, p. 100, February 1894.)

This new-found complexity of radiation, previously thought to be approximately if not quite simple, proved to be a temporary barrier to the accomplishment of the plan of using a light-wave as a standard of length. It necessitated careful study of all those chemical elements which give bright lines that had been supposed to be simple. The red line of cadmium has been found the simplest of all those yet examined. The vapour in a rarefied state is held in a vacuum tube through which the electric spark is passed, and under this condition the difference of path for the interfering beams in the refractometer may be a number of centimetres. A short intermediate standard, furnished with a mirror at each end, is now introduced into the comparer, and moved by means of the micrometer screw. Its length is thus measured in terms of the cadmium wave-length. A series of intermediate standards, of which the second is double the first, the third double the second, &c., are thus compared, and finally in this way the value of the metre is reached.

The feasibility of this ingenious method having been made apparent, Michelson was honoured with an invitation from the International Bureau of Weights and Measures to carry out the measurement at the observatory near Paris, with the collaboration of the director M. Benoît. After many months of labour, results of extraordinary accuracy were attained. For the red line of

[1] Address delivered by Prof. W. LeConte Stevens before the Section of Physics of the American Association for the Advancement of Science, at the Springfield meeting, August 1895.