

SCIENCE

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THE PHOTOCRONOGRAPH.

THE observations described and discussed in a recent publication of the Georgetown College observatory had their origin in a visit made by Professor Frank H. Bigelow and Mr. G. Saegmüller to that observatory in the summer of 1889. Their object was to use the observatory's five-inch equatorial for a series of experiments in photographing star transits. All the resources of the observatory were most cordially placed at their disposal by the director, the Rev. J. G. Hagen, and on Aug. 12, 1889, the first apparatus was tested.

The experiments were repeated on Aug. 26 with an improved apparatus, and were then broken off, for the time being, by the appointment of Professor Bigelow to the West African eclipse expedition.

The purpose of the method of observation described is the removal of the "personal equation" in transit observations, by means of photography. One night, Professor Bigelow, to whom the idea is due, and Mr. Saegmüller, an instrument-maker of Washington, were sitting with the director of the observatory at the table in the library, and consulting as to the best way of putting the idea to a test. The long focus of the equatorial and the electrical connections for the time-signals and incandescent lamps came in very handy for the purpose. The first camera was soon constructed and screwed to the eye end of the telescope, and a few evenings later the star Alpha Aquilæ was made to trace its diurnal motion on a small plate not quite two inches square, while the sidereal clock made the whole camera move in a vertical direction once every second. Finally, the spider-lines of the micrometer were photographed on the same plate by means of an incandescent lamp held for a few seconds before the object-glass. The development of the first plate, in the dark-room of the cellar, was watched with great expectation, and, to the satisfaction of all the bystanders, brought forth two parallel trails, broken into dashes, each representing a second of time, and the whole reticule of the micrometer lines. The first apparatus was soon superseded by a second, and the second by a third, each being improved as the experiments suggested.

Shortly afterward Professor George A. Fargis was attached to the observatory, and at once put in charge of the Ertel transit-instrument. The "photochronograph" in its present shape, and and the improved method of photographing the reticule wires without injury to the star-trails, are entirely his inventions.

The principal idea in photographing the transits of stars is to translate the phenomenon of an object moving over the field of view in a telescope—the instant at which it passes a thread being noted by eye or ear, or by the chronograph—into a picture of the same which can be measured leisurely as a fixed object. The error of the personal equation depends ultimately upon the difference of time required by the eye to receive the impression of a bright object and to let the same go. Impression is more rapid than the letting go, and the relative times of retention vary with individuals, and with the variable physical condition of the individuals. As stars are momentarily occulted behind a thread in transit, this element of retention throws the apparent place of the star beyond the thread; hence eye and ear observations, being taken at intervals from the thread, with the star in full vision, are more accurate, and need a positive correction usually to be reduced to transits by chronograph taken on the thread.

A photographic plate reduces to a minimum this correction, both as to its amount and its variability; and whatever other corrections may be introduced by the process, they are mechanical and can be obtained by the discussion of results.

For the work of making a standard catalogue of bright stars for fundamental differential comparisons, for longitude determinations, for latitude, and also for physical observations in laboratories, it seems very important to eliminate by some process the error of the personal equation, which is in fact the greatest source of error in all such measures.

The first experiments to determine time by photographs of star transits were made by Professor E. C. Pickering, at the Harvard College observatory, in January, 1886, the account of the work being given in the *Memoirs of the American Academy* (Vol. XL., p. 218).

The star images of the Pleiades were allowed to trail over a sensitive plate, the eight-inch Bache telescope being used, for known intervals of time. It was found that microscope settings on the marks could be made with a probable error of only 0^s.03, thus indicating the possibilities opened up by the method.

It now remained to apply it to transits in some way available in accurate reductions. There are two steps to be taken: (1) that which should connect the star trail definitely with the astronomical clock; (2) another enabling the transit to be referred to the collimation axis of the telescope. Both must be simple, and free from all important objections. At the suggestion of Professor Pickering and Mr. Willard P. Gerrish, it was, in the summer of 1888, at the Harvard College observatory, attempted to solve the first in the following way. A small plate was attached to the armature of a magnet by which a movement up and down, perpendicular to the star trail through a very small interval, could be communicated to it by making and breaking the circuit at fixed intervals, either by hand or by the clock, the latter requiring a commutator in which the makes and the breaks should be of equal lengths. The effect was to leave on the plate a pair of dotted lines close together, the dots alternating in the perpendicular direction. The beginnings of the intervals and the endings were definitely marked, and settings of a micrometer thread could be made on them very accurately, the probable error being not greater than 0^s.02 in second-intervals.

Professor Bigelow constructed an apparatus for testing this process, the plate being kept in a paper-holder inserted in a slide attached to the rocking armature which responded to the currents in the magnet. The telescope used was the eight-inch equatorial and the current was made and broken by hand. In the autumn Mr. Gerrish constructed a commutator by which the clock made the motions of the plate automatically.

Omitting for the moment mention of the second part of the process, for the sake of the chronological order, the next piece of apparatus was constructed by Mr. Saegmüller of Washington, D.C., at the suggestion of Professor Bigelow, and was tried a few nights at the Georgetown observatory in the summer of 1889 by the kindness of the director, the Rev. J. G. Hagen. This piece embodied an important improvement, while retaining the alternating motion of the plate. A frame was made to carry a small plate-holder, which could be very readily interchanged with a common observing eye-piece. The star having been received into the field and adjusted by the direct vision, in five seconds the plate could be placed to receive the transit, this being a great practical improvement, as otherwise the adjustment of the star trail depended upon the finder to the telescope.

The eclipse expedition to West Africa, 1889, withdrew Professor Bigelow's attention from the subject, and further development devolved wholly upon the Georgetown College observatory.

Returning to the second division of the experiment, namely, the referring this trail to the middle wire and thence to the collimation axis of the telescope, without which the observation would be worthless, a number of combinations were discussed at the Harvard College observatory. Professor Bigelow's first experi-

ments consisted in using large threads which should interrupt the star trail by their own occultation of the star. This divided a continuous trail nicely, in two opposing cones of density, and was effective, but had obvious disadvantages for a transit instrument. Finally he found that by shining a light into the objective for two or three seconds, the whole plate could be fogged down without obscuring the dotted trail, which seemed only to advance in its density, while the lines behind the threads failed to be fogged, and, retaining the original density of the unexposed plate, received definite edges suitable for microscopic measures by bisection or parallelism of threads. Small threads, even the ordinary ones used in the transit reticule of observatory instruments, are amply distinct for this purpose, and this part of the process leaves nothing to be desired.

There is no doubt that in a six-inch transit instrument stars can be taken to the fourth magnitude, and wherever the elimination of personal equation is sufficiently important the utility of the method can hardly be doubted. It is believed, however, that the chief field of usefulness will be found in the physical laboratory, where any amount of artificial light can always be used, and the automatic record can be made to assume any degree of accuracy desirable. It is known that many experiments in physics are afflicted with personal equation, and thus there is a hope of avoiding them by the introduction of this apparatus.

NOTES AND NEWS.

THE *Boston Medical and Surgical Journal*, quoting an English medical publication, says that the theory has been more than once advanced that the origin of ether-drinking in Ireland can be traced to the success of Father Matthew's crusade against drunkenness in its ordinary forms. Alcoholic nature, driven out by his eloquence, returned in a new disguise, and the last state of the victims was as bad as the first. This theory has been called in question, but it receives accidental confirmation from what is at present happening in Norway. The sale of liquor is, in that country, encompassed about with more restrictions than that of the most deadly poison is with us. Temperance, in fact, is the law of the land in Norway. But these people, made sober by act of parliament, have now discovered how to get drunk without violating the law. Ether-drinking, according to a Norwegian contemporary, is becoming quite common in certain districts. The farmers buy it in considerable quantities, especially at Christmas time and on other festive occasions, and they treat each other and get drunk on ether, as they formerly did on potato or barley brandy. Ether is said to be drunk by young and old, men and women, rich and poor. If this be true, it seems to point a moral which perhaps thorough-going temperance advocates have not taken sufficiently into account. Is there, after all, a grain of truth in Byron's thesis that "man, being reasonable, must get drunk," and can the moderate use of ordinary stimulants be suppressed only at the risk of the evil spirit, which has been cast out, coming back after the house has been swept and garnished, bringing with him seven devils worse than himself?

— A correspondent of *Science-Gossip* writes to that periodical as follows: "A friend of mine keeps a quantity of fowls. They are the common kind, usually called, I think, 'barn-door fowls.' On Thursday, April 9, a number of eggs were collected. A few were given to the gardener. His wife boiled one for his breakfast on April 10, and when he cracked it a pin was found in the yolk. The yolk and white were, in places, of a blue-black color. I should feel obliged if any reader would inform me whether they have ever heard of anything being found before inside an egg, and how it got there."

— Bulletin No. 13 of the Experiment Station of the Iowa Agricultural College contains the results of a feeding experiment conducted by the farm and chemical sections. Corn fodder, corn ensilage, sorghum cane ensilage, and mangels were fed for sixty days to eight cows. The milk was sampled at every milking, and the composite samples analyzed every five days. The effect of the four different fodder rations was tabulated and results indicated from the butter fats and total solids produced by each ra-

tion, calculated from a dry matter basis. Corn fodder shows slightly better results than corn ensilage, which exceeds sorghum cane ensilage. The mangel ration is superior to any of the others. Clover hay was fed with all the rations, a double amount being given with the roots.

— A simple method of applying concrete under water has been used by the French engineer Heude in connection with the foundation work of the bridge over the River Loire, at Blois. As described in the *Railroad Gazette*, the concrete was deposited at the desired points by means of a wooden pipe composed simply of four boards and being about sixteen inches square in section. This pipe or tube was lowered vertically into the water, and was made of such length that when the lower end reached the bottom the upper end projected about five feet above the surface of the water. By means of suitable lifting tackle and scaffolding the tube could be easily raised and lowered, and moved from place to place as desired. The tube was filled with concrete, and, on being slightly raised from the bottom, the concrete could flow out and spread itself over the surrounding surface without previously coming into intimate contact with the water. By moving the tube about over any desired area, layers of concrete could thus be readily put down varying in thickness from twelve to sixteen inches. The only point to be specially observed was that the level of the concrete in the tube was always above the level of the water on the outside, thus maintaining a sufficient head of concrete to overbalance the tendency of the water to enter at the lower end of the tube. To secure this entire exclusion of water from the tube, the primary filling with concrete was accomplished after having first closed the lower end of the tube with a board; the tube having been filled this board was withdrawn. It is stated that with one such tube about eighty yards of concrete could be deposited per day, and that, in general, the results of the method were entirely satisfactory.

— The winter forcing of tomatoes is little understood by gardeners, and the literature of the subject is fragmentary and unsatisfactory. Yet it is a promising industry for all the older parts of the country, particularly in the vicinity of the larger cities, as winter tomatoes always find a ready sale at good prices. The crop is one which demands a high temperature, an abundance of sunlight, and great care in the growing, but the profits, under good management, are correspondingly high. Tomato forcing is one of the most interesting and satisfactory enterprises for the winter months. Careful experiments upon it during two winters, made at the Cornell University Experiment Station by Professor L. H. Bailey, have met with uniform success. Details of the experiments are contained in Bulletin 28 of the station named, dated June, 1891.

— The Census Bureau at Washington has issued a bulletin on the distribution of population in accordance with altitude. It appears that in the area less than five hundred feet above sea-level is included nearly all that part of the population engaged in manufacturing and in foreign commerce, and most of that engaged in the culture of cotton, rice, and sugar. Between five hundred and fifteen hundred feet above the sea are the greater part of the prairie States and the grain-producing States of the North-west. East of the ninety-eighth meridian 1,500 feet is practically the upper limit of population, all the country above that elevation being mountainous. Between 2,000 and 5,000 feet above sea-level the population is found mainly on the slope of the great western plains. Between 4,000 and 5,000 feet, and more markedly between 5,000 and 6,000 feet, the population is decidedly in excess of the grade or grades below it. This is mainly due to the fact that the densest settlement at high altitudes in the Cordilleran region is at the eastern base of the Rocky Mountains and in the valleys about Great Salt Lake, which regions lie between 4,000 and 6,000 feet. Above 6,000 feet the population is almost entirely engaged in the pursuit of mining, and the greater part of it is situated in Colorado, New Mexico, Nevada, and California. While the population is increasing numerically in all altitudes, its relative movement is decidedly toward the region of greater altitudes, and is most marked in the country lying between 1,000 and 6,000 feet above the sea. The density of population is greatest near sea-