APPLICATIONS OF PHOTOGRAPHY TO ASTRONOMY.

In taking celestial photographs the telescope is used as the camera, the sensitive plate being usually placed in the focus of the object-glass or mirror, and receiving the image directly upon it. From the impression thus produced enlarged copies may be subsequently taken. Sometimes the image is enlarged by a secondary magnifier before it is received upon the plate. Either the telescope or plate-holder must, of course, have a uniform motion communicated to it during the exposure corresponding to the motion of the object. A negative, when obtained with a clear and tranquil atmosphere, and free from all imperfections—such as are caused by a floating atom of dust, or the slightest tremor of the instrument, or pinholes in the collodion film—may be enlarged so far as to make apparent the minute granules of deposited silver used in the photographic process; but here is an end to the advantage gained by increase of size, no more detail being furnished by any further enlargement.

WONDERFUL RAPIDITY OF PHOTOGRAPHIC ACTION.

The image of the full moon can be fixed in less than one-fourth of a second, and that of the sun "instantaneously." According to the experiments of Mr. Waterhouse, a space of time no longer than one twenty-seven-thousandth of a second is required to fix the solar image. Even this small fraction, however, inconceivably short as it appears, is a tolerable length of time compared with that in which photographs are taken by the electric flash. The duration of the illuminating spark, according to the beautiful and trustworthy experiments of Mr. Wheatstone with his delicate chronoscope, does not exceed the *millionth* part of a second, and yet a clear and distinct photographic image is obtained by a single electric discharge. By this means may be shown the real form of objects to which a deceptive appearance is given by their rapid movement. If a wheel on whose side any figure is drawn in conspicuous lines be made to rotate with the greatest possible velocity, the figure will present to the eye only a series of concentric bands of different shades. Let it now be photographed while in motion by the electric flash, and the wheel will appear stationary with the figure perfectly well defined. A vein of water issuing from a small orifice, which appears to the eye as smooth as a stem of crystal, if seen or photographed by the light of the electric discharge, is shown to be composed of drops variously disposed and of various forms, some being elongated, others flattened, and others almost spherical.

THE MOON AND PLANETS IN THE STEREOSCOPE.

In combining pictures of the moon for the stereoscope, two photographs of the same phase are taken, but with an interval of one or more months between, in order that it may present in the latter picture its disk slightly turned from its position in the former, making the difference of libration from five to ten degrees—the two pictures, in fact (placed in a stereoscope), representing the moon exactly as it would appear if our eyes could be separated thirty thousand miles apart and each view the moon through a telescope at the same time. By the effect thus produced, the *globular form* of our satellite is demonstrated as a physical fact, being made as apparent to the eye as is that of an orange held in the hand. The telescope exhibits the inequalities of the moon's furrowed surface only as differences of light and shade, while the stereoscope reveals them as actual elevations and depressions, making as manifest the long mountain ranges and deep valleys, the isolated peaks and numerous saucer-like cavities or craters, as they would be in a bird's-eye view to a lunar inhabitant.

Ordinary stereoscopic pictures of the moon represent it as magnified from twenty to twenty-five times; a common stereoscope further magnifies it about one and a half times, so that it is seen under a power of about thirty-five.

The configuration of Jupiter's belts, and the diversity of light and shade on the surface of Mars, have enabled stereographs to be produced of those planets, the presence of detail or variety in the appearance of a body being necessary to their production. Mr. De La Rue hopes to obtain a sterograph of Saturn and his rings by the aid of the latter's periodical change of appearance in opening and closing. An interval of several years between the two photographs will be necessary. The planet itself will probably present only the appearance of a flat disk from the want of sufficient detail on its surface.

At Kew Observatory, near London, the sun's photograph—we might say autograph—is taken once or twice every day when the sky will permit. By this means we are obtaining a continuous history of the changes in the spots and faculæ on its face more accurate and more instructive than could be procured in any other way. An investigation of these sun-pictures is fast setting at rest many disputed points pertaining to solar physics. The existence of a comparatively cold atmosphere around the sun, outside of the luminous matter, and the connection of the solar spots with planetary influence (chiefly that of Venus and Jupiter), have been already established by them. Other questions relating to spots on the sun, and their connection with terrestrial magnetism, it is thought, will soon be solved, and perhaps all those concerning the movements of the supposed ring of asteroids (or, possibly, single planet) within the orbit of Mercury. An investigation is now being made with the view of determining with greater exactness the angular diameter of the sun.

MAPS OF THE HEAVENS.

But perhaps the most desirable application of photography, to the accomplishment of which the hopes of astronomers are strongly turned, is its employment in mapping the sidereal heavens. Mr. Rutherfurd, with his eleven-inch photographic object-glass, has carried the work in this direction to the farthest extent yet attained, having photographed stars of the ninth magnitude. He has taken one cluster of twenty-three stars within the space of one degree square, and another (the Pleiades) of forty-three stars, many of these being of the ninth magnitude, with an exposure of from three to four minutes. With a delicate micrometer, which he designed expressly for the work, Mr. Rutherfurd took careful measures of the star images in his photograph of the Pleiades. From these measures Dr. B. A. Gould has deduced the relative position angles, and distances (in arc) of the stars, and a comparison of his results with those obtained by Bessel from his observations of the same stars proves both the accuracy of Bessel's measures and the trustworthiness of the new method, while at the same time it shows the small amount of relative change which has taken place in this group during the last quarter of a century. The observations made by Bessel extended over more than eleven years, while the observations of Mr. Rutherfurd were made in a single night.

ADVANTAGES OF PHOTOGRAPHIC OBSERVATIONS.

The advantages of this method of observation, when so extended as to apply to the smaller telescopic stars, as stated by Prof. Bond, are its entire immunity from personal errors, errors of judgment or from want of skill on the part of the observer, with less liability to ordinary mistakes in reading and recording the indications of the micrometer. Besides which, the permanent record can at any time be re-examined to clear up doubtful points. Another advantage, equally decisive, is the extraordinary rapidity with which groups or clusters of small stars would be delineated, saving months and years of labor.

"The possibility," says M. Faye, "of dispensing with the observer (whose 'personal equation' varies not only with years, but from one moment to another, with the troubles of digestion, circulation, or nervous fatigue) has been fully demonstrated. The method consists in substituting for the eye a photographic plate, and in automatically registering by electricity the instant when the light is admitted to the dark chamber attached to the telescope." By this means M. Faye obtained in twenty seconds ten complete observations of the sun. Again, while the observer, in looking at an object, scrutinizes closely only the parts which specially interest him at the moment of observation, and nearly always permits the rest to escape his attention, the photograph, on the contrary, permanently registers every thing alike.

A recent example has shown that it is not always safe to rely on the appearance of exactness even in science which boasts of its perfection. It was supposed that the observations of the last transit of Venus across the solar disk in 1769 gave the sun's mean distance from the earth very correctly. But it is well ascertained to-day that the adopted value of this distance, which is the astronomer's measuring rod for celestial spaces, is too great by more than three millions of miles. Transits of Venus will again occur in 1874 and 1882, and it is proposed to employ the new and more accurate method in observing the phenomenon, though not designed that it should supplant observations with the eye.

It is well known that "the eternal and incorruptible heavens," as they were termed by Aristotle, are undergoing continual and marked changes. The so-called fixed stars—the "landmarks of the universe"—have their own proper motions not accounted for by that of the solar system. Sirius—as that wonderful aid to physical astronomy, the spectroscope, reveals—is shooting through space at the rate of a thousand million miles a year. The star known at 61 Cygni has a transverse motion alone of one thousand four hundred and fifty million miles a year. Many stars, more distant still, may even exceed this rate. Cooper's recent catalogue of stars shows that no fewer than seventy-seven stars previously catalogued are now missing. This, no doubt, is to be ascribed in part to the errors of former observations; but it is certain that to some extent at least it is the result of changes *actually* in progress in the sidereal system. Of temporary stars, about twenty have been observed, and more than six times that number are known to be variable. It appears quite certain also that some of the nebulæ have undergone a change for both form and brilliancy. When the celestial lamps shall by their own light record their history on the photographic page, our knowledge of these mysterious luminaries, whose fires wax and wane, or go out in utter darkness, will be less involved in doubt.

GREAT TELESCOPES NOW BEING MADE.

Mr. M. De La Rue is having a lens constructed of thirteen inches in diameter, soon to be in operation, from which, in the hands of so skillful a director, much is expected. Prof. Henry Draper has very nearly completed a new silvered glass reflector of twenty-eight inches diameter (the largest of the kind yet constructed, except one by Foucault). With this instrument the original negatives will be taken six inches in diameter, with provision for extending them to nine and a half inches if desirable. Such pictures will, of course, contain an amount of detail not possible in those taken with ordinary instruments, which vary from one to two inches in diameter, according to the size of the telescope. Prof. Draper expects thus to obtain photographs of larger size and sustaining higher magnifying power than any that have yet been produced. The amount of advantageous enlargement will not be limited by the appearance of the silver granulation, but will depend wholly on the sharpness of definition obtained in the original picture.

There is now being erected (if not already completed) at Melbourne, in Australia, a powerful reflecting telescope four feet in diameter, of the Cassegrain form, which will be supplied with the necessary apparatus for photography, as well as for spectroscopic investigation. This derives its importance chiefly from the fact that the work will be prosecuted in rich fields of the southern hemisphere.

THE BEST PLACES FOR OBSERVATION.

It was suggested by Newton that the serene and quiet air which is so often found on the tops of mountains above the grosser clouds would very much favor celestial observations. Such elevated stations would seem to possess peculiar advantages for the application of photography, since the atmosphere is not only less subject to disturbance, but is also more favorable to the chemical action of light. The results of the expedition to Teneriffe in 1856 prove these suppositions correct.

In a paper presented to the British Association in 1863, Prof. Piazzi Smith, who had charge of the expedition, states that the chief object at Teneriffe was to ascertain the degree of improvement in telescopic vision at a high elevation. Observations were taken at various points, reaching an altitude of eleven thousand feet, or a little more than two miles. At that hight the majority of clouds were found to be far below, the air dry, and in a very steady and homogeneous state. A photograph taken near the sea level could not be made to show the detail on the side of a distant hill no matter how marked the detail might be by rocks and cliffs illuminated by strong sunshine. Even the application of a microscope brought out no other feature than one broad, faint, and nearly uniform tint. But on applying the microscope to photographs of distant hills, taken at a high level, an abundance of minute detail appeared. Each little separate bush could be distinguished, though the hill side was four and a half miles from the camera.

The important results obtained by this expedition has led to the establishment by the Russian Government of an astronomical observatory at an elevated station on Mount Ararat, near Tiflis.—*Professor Merriman in the Methodist Quarterly.*

Teleiconographe.

M. Revoil, an architect well known in France, in the course of his attempts to arrive at exactness in the drawings of distant objects, by the aid at one time of the camera lucida, and at another, of the ordinary telescope, has invented an apparatus combining the principles of the two instruments. This instrument he calls the Téléiconographe. The principle involved is that of allowing the image transmitted by the object glass of a telescope to pass through a prism connected with the eye-piece. The rays of light that would in the ordinary use of the telescope be transmitted direct to the eye, are refracted by the prism, and thrown down upon a table placed below the eye-piece. The distance between the prism and the table determines the size of the image projected on the latter, and it is easy for the observer to trace on a paper placed on this sketching table the actual outlines indicated by the refracted light. The telescope has both vertical and horizontal motion, and is so constructed that a connected drawing can be made of a larger area than can be included in the object-glass at one view; in fact, an entire panorama can be traced, if the relative positions of the axis of the telescope and the surface of the sketching table are undisturbed. The account from which the above description is taken, states that by means of this instrument a perfect drawing of the summit of one of the towers of Notre Dame Paris, was made at the distance of 300 yards, and also that two mountain peaks, in Provence, were most admirably sketched. For the faithful delineation of objects so distant as to require the use of a telescope to distinguish their details, for military surveying, &c., its services promise to be of great value.

Wasteful Mining in California.

The San Francisco *Bulletin*, speaking of mining interests in that region, says:

"It will be well for the State when all of our mining interests shall pass into the hands of private individuals, for then there will be no question as to the right of taxation; and besides, the sooner the timber throughout the mountainous regions of California shall be protected, the better it will be for the people.

"Waste has been going on in the mines since 1849. There have been waste in working mines, waste on timber lands, and in fact waste in nearly everything throughout the mining region of California. There has even been wastefulness by erecting temporary buildings. Chinese have run over the placers, exhausting them of their gold, and with very little to the people. We wish to see every foot of land, not only that fit for farming purposes, but that in which there is a particle of gold, belong to individuals. When this comes about, the interior may be expected again to prosper."

THE FLOODS.—Accounts reach us of much damage caused by the recent heavy rains. All along the upper Hudson, in the Connecticut Valley, in New Hampshire, in New Jersey, and further South, we hear of broken dams and canals, damages to telegraph lines, and "wash-outs" in railway tracks. In some instances houses have been swept away and loss of life has resulted. A recently arrived passenger states that out at sea the weather was calm on the day of the heavy rainstorm which caused the floods, but there has been some damage to vessels along the coast. The storm has, however, been more beneficial than destructive, as many sections visited by it were parched with drought up to the date of its occurrence. New York city may thank the rain for cleaner streets than it has seen for six months past.

MESSRS. GRAEB AND LEIBERMANN, of Prussia, have recently obtained a patent in this country for the preparation of alizarine. They state that their process consists in first preparing bibromanthrakinon, or bichloranthrakinon, and then converting these substances into alizarine.