in an ordinary rice trough. By pounding, the soft mealy mesocarp is partially separated from the kernels. The whole is then placed in a bamboo sieve, the meshes of which are just large enough to allow the mealy matter to be scrubbed through, and small enough to keep back the kernels, which are hard, black, and about the size of peas. From the mealy substance the tallow is expressed in primitive wooden presses. The oil is derived from the kernels in the following manner: They are dried in the sun and pressed between two mill stones held at such a distance apart, by means of a bamboo pivot, as to crush the hard shells of the kernels without injuring the white interiors. The whole is then passed through a winnowing, which separates the broken shells from the solid matter. The latter is thereafter placed in a deep iron pan over a fire, the crushed oily shells making an excellent fuel, and roasted till it begins to assume a brownish color, the process being accompanied by continual stirring to prevent burning. It is then crushed by a huge stone roller in a circular stone well, steamed, made into cakes, like cheeses, with bamboo and straw casings, and passed through the wooden press. The resultant is a good lighting oil of a brownish yellow color.

In Formosa this tree is utterly neglected, but in the great centers of tallow and oil manufacture in China it is grafted, and, consequently, yields superior fruit.

6. *Camellia thea*, Link.—In all the tea-growing districts throughout China, the seeds of the tea plant not required for raising new bushes are collected and treated for their oil, which is employed for both food and lighting.

7. *Cinnamomum camphora*, N. and E.—Although the camphor laurel is found in many of the provinces of China, where it is highly valued on account of its wood, yet Formosa is the only province in which camphor is manufactured. When the camphor is being distilled from the chips of camphor wood, an essential oil exudes and drops into the boiling water underneath. This, as well as the liquid which exudes from the camphor when awaiting shipment, is collected and exported under the name of camphor oil.

8. *Ricinus sp.*—The castor oil plant grows wild throughout Formosa; but in the north of the island oil is not extracted from the seed, nor is any use whatever made of the plant. In the south a little oil is extracted for purely local uses, but no attempt is made to cultivate the plant. The species, which has green stems and leaves, does not attain the height of *Ricinus communis*, which is distinguished by its purple stems, branches, and leaves. The latter, grown from imported seed, may be seen as an ornamental shrub in gardens near Tamsui.

Diospyros kaki, L. f., grows in Formosa as well as on the mainland. The juice of its fruit should be classed as varnish and not as oil.

VANILLA CULTIVATION IN MEXICO.

At the time of the conquest of Mexico, the Aztecs used the vanilla for flavoring chocolate. The Spaniards learned its use from them and introduced it into Europe. Gathered at first from the vines growing wild in the forests, its cultivation as a special industry became profitable, though just at what date there are no records to show; but we find that as early as 1760 there were *vainillales*, or vanilla plantations, in the vicinity of Papantla.

A native of eastern Mexico, this plant grows wild in the state of Vera Cruz, from one extremity to the other of its coast line, and from the sea beach up to the mountains of the Sierra. It is cultivated mainly in the cantons of Misantla and Papantla, in that state, the little that is produced in Oaxaca being for the most part gathered from the vines which grow wild and uncultivated in the forests.

The vanilla plant belongs to the orchid family, has a pulpy stem, which grows to several yards in length, attaches itself to trees, and appears to be little dependent on the soil for nourishment. The leaves are lanceolate and pulpy, and the yellow flowers bud from the axilla formed by the leaves with the stem. The fruit is a pod from six to twelve inches long, and about half an inch in diameter at its thickest part, tapering down toward the stem, curved in its entire length, dark green in its earlier stages, and yellow when fully ripe. It is filled with minute black seeds, somewhat resembling iron filings. When prepared for market, the pod becomes reduced to about a quarter of its original thickness, is black in color, and, it is needless to say, emits a very agreeable perfume.

Six varieties of vanilla are known in Mexico, namely, the *mansa*, the *cimarrona*, the *mestiza*, the *pompona*, the *puerco*, and the *mono*. Of these the *mansa* is the only one cultivated. The *cimarrona*, or wild vanilla, has a more pointed leaf and a thinner vine than the *mansa*; the pod is shorter, rounder, and thinner. The *mestiza* has more pointed leaves than the *mansa*, but less so than the *cimarrona*; the size of the pods is smaller than those of the *mansa* and larger than those of the *cimarrona*. This variety is scarce, and when prepared it can hardly be distinguished from the *mansa*. The *pompona* (*sigueante* or banana vanilla, as the Totonaco Indians, who occasionally eat it, call this variety) has larger and rounder leaves, and a vine one-half thicker than the *mansa*; the pod is double the size, and triangular in shape, resembling somewhat a badly nourished plantain: it has an extremely pleasant smell, not unlike anise, and is used in Havana by the tobacco manufacturers to mix with cigars. The *puerco* and *mono*, which grow wild and resemble the *cimarrona*, are not used in commerce.

There is yet another vanilla, called the *tarro*, or bamboo vanilla, which is considered by many as a distinct species, but is really nothing else than the *mansa* grown in the *tarrales* or bamboo thickets in the depths of the virgin forests, where it does not receive a sufficiency of sun and air, and produces a pod thinner and longer than the ordinary *mansa*.

The vanilla buyers formerly divided the prepared bean into four classes, namely:

1. The beans or pods from six and one-half inches long and upward, short in the neck or stalk, sound and black; the beans which become split or open, provided they have the foregoing qualities, and the split does not extend more than one-third of the pod. This class was again subdivided into *terciada*, which is composed of the shortest pods; *primera chica*, which

contains the next in size; *primera grande*, the next; *marca menor*, the next; and *marca mayor*, the largest of all.

2. Those pods which differ from the *terciada* only in being shorter, two of them counting as one of the first class.

3. *Zacate*, or the pods of all sizes which are imperfect through being gathered before becoming properly ripe, or being over-cured, *pescozuda*, *vana*, *cueruda* and *apocoyonada*, all names for pods in a more or less damaged condition; and *cimarrona* or wild vanilla in good or fair condition, three pods counting as one of the first class.

4. The *rezacate*, composed of the very short pods; of those split clear up to the stalk; of the badly damaged; of the very immature; and of the very much over-cured, which resembles a piece of wood; of this fourth class, six pods counted as one of the first class. The quantity of this and of the second class was always very limited.

At the present day, the only distinction made is between the best class and the *cimarrona* and *rezacate*, the last two being sold at a very much lower price than the former. Both buying and selling are carried on by count.—*Revista Financiera Mexicana*.

BLEEDING BREAD.

THE phenomenon known in Germany as "Blut im Brode," and to us as bleeding bread, has appeared in this country, to no little dismay of the peaceful inhabitants. The subjects of this visitation are not only bread and biscuit, but also boiled potatoes, rice, and other farinaceous substances, on which red stains appear, which resemble blotches of blood. In former times, before their nature was known, these blood stains created much consternation among the superstitious as portents of calamity. The first modern naturalist who described it in scientific terms was Dr. Sette, of Venice, who recorded its appearance in Padua, in 1819, and gave it the name of *Zoogalactina imetropa*. In this instance it is stated that "a peasant of Liguara, near Padua, was terrified by the sight of blood stains scattered over some polenta which had been made and shut up in a cupboard on the previous evening. Next day similar patches appeared on the bread, meat, and other articles of food in the same cupboard. It was naturally regarded as a miracle and warning from heaven, until the case had been submitted to a Paduan naturalist, who easily recognized the presence of a microscopic plant." Subsequently Ehrenberg saw the same production near Berlin, in 1848, and, as usual with him under like circumstances, referred it to the animal kingdom, under the name of *Monasprodigiosa*, but during the same year it occurred in the experience of Dr. Camille Montagne, who saw it on cooked fowls and cauliflower, at Rouen, and it was regarded as an alga, under the name of *Palmella prodigiosa*. The first definite record of its occurrence in Britain appears to have been in 1853, when H. O. Stephens communicated an account of it to the Bristol Microscopical Society, and submitted specimens to the late Rev. M. J. Berkeley, who declared it to be identical with the organisms described by Ehrenberg and Montagne, but which he regarded as a fungus.

The record of its appearance at Bristol is to the following effect: "I observed at table the under surface of a half round of boiled salt beef, cooked the day before, to be specked with several bright carmine-colored spots, as if the dish in which the meat was placed had contained minute portions of red currant jelly. Suspecting what these might turn out to be, I directed the beef to be placed aside. On examination the next day the spots had spread into patches of a vivid carmine red stratum of two or more inches in length. With a simple lens the plant appears to consist of a gelatinous substratum of a paler red, bearing an upper layer of a vivid red hue, having an uneven or papillated surface. The microscope shows this stratum to consist of generally globose cells, immersed in, or connected by, mucilaginous or gelatinous matter. The cells vary in size, and contain red endochrome; they seem to consist of a single cell membrane, and contain a nucleus. Treated with sulpho-iodine they become blue."

As to its place in the organic kingdom, Mr. Stephens was of opinion that it was a *Palmella* closely allied to *Palmella cruenta*, but distinct, the cells or granules of the latter differing from it, not only in their color but size, being very much smaller than those of *P. prodigiosa*. As to its propagation, he farther remarks that it seems to extend itself by elastically spurting a sort of jet or column of red particles, which Berkeley compared to a jet of blood from an artery, and by this method it was suggested that the extraordinary rapidity with which a large surface becomes covered can be explained. The vitality of the cells is not impaired (within a certain time) by desiccation, even at a high temperature, and when dry they retain their germinating powers for a considerable period.

The spherical cells are filled with a reddish oil, which gives to them a peach blossom tint, and when transferred to raw meat they assume a splendid fuchsia color, resembling spots of blood. The plant is only developed in the dark, and the nitrogen necessary for its nutriment must be derived from the air, especially when developed upon bread. About 1886 an epidemic appearance on the Continent was attributed to this source. Pieces of cooked meat presented a singular carmine red coloration, and stained vividly the fingers or linen with which they came in contact. These phenomena prevailed regularly for a period of three months. Food cooked overnight was found the next morning covered with red patches, and it then underwent rapid alteration. Coincident with a sudden and considerable fall in the temperature the epidemic ceased, and did not reappear.

Presenius records the result of his examination of this organism, in his "Beitrag," to the effect that "he took four boiled potatoes, and placed them in a drawer, having previously rubbed two of them slightly here and there with the red substance. After about twenty-four hours the two potatoes which had not been rubbed, and which had not been in immediate contact with

the other two, were affected with fresh spots of the red substance, while the spots upon the two which had been rubbed had increased in extent. The spots showed themselves in the form of irregular groups of blood red drops of different size, which in some places were distinct, and in others had run into one another. The individual bodies of which the spots consist are mere molecules, their diameter varying from one two-thousandth to one four-thousandth of a line. They are mostly round, occasionally oval, and sometimes slightly contracted in the middle, by way of preparation for increase by division into two small round cells. By far the greater number of them, when brought under the microscope in a drop of water, remain at rest—they lie close together in large numbers; when they are more dispersed in the fluid, they have a motion which is not distinguishable from ordinary molecular motion. When the drop of water moves, they are carried mechanically over the stage like other molecules, and when this motion ceases they remain at one spot in a sort of quivering state until a fresh current carries them in another direction. If the eye be kept carefully upon a part of the stage where the small bodies are thinly dispersed, it will be observed that they passively follow the current of the water, nor, when the current has become sluggish, or has even altogether ceased, are individual bodies ever seen to detach themselves from the group, and take a contrary direction, which real monads would do with great activity."

The present determination of this organism, according to some, is *Micrococcus prodigiosus*, but according to others it is *Bacillus prodigiosus*, and consequently one of the *Schizomycetes*. It has been pointed out that as the temperature rises this *Bacillus* loses its power of forming a pigment, and if it is grown on potato or bread paste, in an incubator at blood heat, instead of at the temperature of the room, the color is gradually lost, and the culture no longer smells of herring brine, but the power of forming lactic acid from milk sugar, with the accompanying precipitation of the casein, is frequently considerably increased; so that it would appear that the energy required for the building up of the pigment substance was in this case diverted into another channel, and lactic acid, and perhaps other substances, are produced in place of the usual pigment.*

The reappearance of this organism in this country, during the late hot weather, and especially on cooked potatoes, gives interest to its history, and is sufficient apology for these observations.—*M. C. Cooke in Nature*.

GREAT TELESCOPES OF THE FUTURE†

By ALVAN G. CLARK.

I HAVE been asked by the local committee, through their secretary, to prepare a paper for the Astronomical Congress, embodying my ideas on the future possibilities in the construction of great telescopes. I accepted the invitation somewhat reluctantly, for, while I appreciate the honor extended to me, I feel that the subject chosen by the committee is a somewhat delicate one to deal with, as I may say many things which do not coincide with the preconceived ideas of some that may be present. I beg therefore that they will regard the subject of this paper as simply the embodiment of my ideas. I shall endeavor not to state anything as a fact that has not been demonstrated as such by repeated experiments.

Much has been written and more said regarding the great telescopes of the future. It seems to me that the best method of studying the subject is by a careful consideration of what has been accomplished with the instruments already made. From my personal comparisons I find that most of the important original discoveries in the truly visual line have been made with the largest telescopes in use at the time. In making this statement I would say that I do not include such discoveries as have been made from observed irregular proper motions of stars, such as, for instance, the companion to Sirius, which was known to exist some years before it was seen, although this required the largest refracting telescope then in existence to show it to the human eye. When once seen, however, with the large glass, it was readily seen with small ones. Nor would I ignore the many double stars discovered with smaller telescopes. These discoveries have been made with instruments of superior defining power, under fine atmospheric conditions, and are valuable contributions to astronomy, yet I do not believe that a small telescope was necessary to make these discoveries. I am of the opinion that had the discoverers had at their command the largest telescope, the discoveries would have been more numerous and important. When the two 15 inch telescopes were made in 1846, one for Pulkova, the other for the Harvard Observatory, they were considered monsters. I believe it was thought by most astronomers that the limit in size had been reached. No larger refracting telescope was made for a period of more than fifteen years, the next largest being an 18½ inch. I mention this fact to show how and at what time the demand for larger telescopes came. I think that the order for the 18½ inch was given in 1860. As soon as the companion to Sirius was discovered with this glass, at once there seemed to be a desire for something larger. The next larger telescope was made for R. S. Newhall, of Gateshead, England. Then came the 26 inch for the United States Naval Observatory, and then Leander J. McCormick presented the University of Virginia with one of the same size. After that the 30 inch for the Russian Observatory was constructed, and, finally, the 36 inch for the Lick Observatory. Besides, there is now in process of construction, and well under way, a 40 inch telescope for the University of Chicago.

I have always been a believer in large telescopes for special work. I have had great experience with them, and it is from testing these instruments that I have been convinced that large instruments are needed to make original discoveries, such as new satellites to planets, and faint companions to bright stars, in fact to any stars, as well as for studying the planets and nebulae. For astro-physical work they are vastly superior to smaller ones. The trouble that early opticians

* Trouessart, "Microbes," etc., London, 1889, p. 126.

† H. O. Stephens, on *Palmella prodigiosa* in *Annals of Nat. Hist.*, vol. xii., December, 1853.

‡ *Pharmaceutical Journal*, January 29, 1887, p. 610.

* Dr. G. S. Woodhead, "Bacteria and their Products" (1891), p. 9.

† Read at the Congress of Astronomy and Astro-Physics, Chicago, August, 1893.—*Astro-Physics*

experienced in procuring good disks of glass seems to have passed away, and we are now able to procure disks of almost any size, the only obstacle being the time required to make them, and the money to pay for them.

Having given you some of my reasons for believing in large telescopes, I will now proceed with the subject of this paper, viz., my ideas of the future possibilities in the construction of great telescopes. It is my idea that the great telescopes of the future will be refractors, not reflectors, and I shall confine myself entirely to the refractor. I would not wish to say anything that might lead you to suppose that I underestimate the value of the great discoveries made with reflecting telescopes, or the great minds that have made and worked with them, yet one person of eminence did remark that large reflecting telescopes have never accomplished much except in the hands of the opticians who made them; and my own experience has been sufficient to convince me that the reflector is extremely sensitive to any changes either of temperature, or air currents, or more particularly to flexure, and that while the refractor is also affected by these changes, it is by no means so injurious to the definition.

As I have said, I believe that good disks of any size, both crown and flint, may now be procured. Having once procured them, all that is required is an optician to work them. He must be an artist in light and shade, and in color also, for the very best correction of the chromatic aberration. As in the light and shade we search for and locate the spherical aberration, so we work among the different colors for the chromatic corrections. It is a very difficult task, and as the size is constantly being increased, the difficulties also increase. Personally I do not believe this work can ever be accomplished by machinery. Not that machinery might not be made available for the rough work and the first polishing, for we ourselves polish all our large surfaces in a machine in a preliminary way. The fine grinding and smoothing, however, is always done by hand. It is after the first machine polishing is done, and the glass appears to be finished, that what I have referred to as artistic work begins, that is, the work to locate the errors from observations, and correct the surfaces of the glass by the tentative method till all the light from a point at an infinite distance will be refracted to a point at the focus of the objective so accurately that the image there formed will bear the highest magnifying powers without showing any distortion. I believe that this can be accomplished only by most careful study of the light that has passed through the objective, and that all the errors must be worked out by what is termed local corrections.

When the time is ready, I think the man capable of making the necessary observations and locating the errors with precision, as well as skillful enough to work them out on much larger objectives than have yet been attempted, will be found. The simple preliminary grinding and polishing of large lenses is not a very difficult operation; this, with the centering, is purely mechanical. But if the glass itself has the slightest unevenness in its density, be it ever so small, the refraction will be different through the different densities. This cannot be determined with certainty until the disks have been worked into an object glass, or at least, ground and polished for that purpose. If, after this grinding and polishing has been done with the greatest care, we find the image produced by the lens which is achromatic is not symmetrical, and that a star at the focus is not round, but possibly is elliptical, rectangular, or in fact of any shape, what is to be done? After so much expense and labor, shall we condemn the glass, and wait perhaps years for other disks which, after going through the same process, may give no better result? I will state here that of all the large glasses, that is to say over 18½ inches aperture, that have been made by Alvan Clark & Sons, only one, viz., the Princeton 23 inch, came from the polishing machine giving a perfectly round image. All the others we had to round by local work.

I believe the optician that is to make the large telescopes of the future, as well as the present, must be able to do this work. In my opinion it is not more difficult than the correction of the spherical aberration proper, though if much out, it may prove more laborious. Surely I believe this work should be done rather than condemn the disks and try others. Each glass can be rounded separately. For this purpose set the combined lens in front of a collimating mirror. An artificial star is produced from a lamp by reflecting the light from a minute lens within the eye tube, and close to the optical axis and focus of the objective. The light from this artificial star passes through the tube to and through the object glass, then on to the collimating mirror, which should be as flat as possible. From the mirror the light returns to all portions of the objective in parallel rays. There must, however, be a little offset, so that the returning light from the star will not fall on the minute lens where the star was first formed, but the deviation from the true optical axis is but a mere trifle. Of course it would be almost impossible to secure perfect definition under these circumstances with a very large glass, as the combined errors or imperfections are made to appear twice as great as they really are, from the fact that the light has passed both ways through the objective, so that the imperfections in the material, that is the glass itself, and workmanship also, are made to appear double what they will be when used as a telescope for viewing celestial objects direct. Nor is this all, for we have the imperfections of the mirror to contend with, and who can conceive of a mirror of five or six feet in diameter resting on its edge, being perfectly symmetrical. You may think it strange if I say that while I should much prefer to have everything perfectly correct for this work, I believe it impossible, and we must do the best we can under the existing circumstances. I remember a time when a distinguished professor was shown by my father our apparatus and methods of testing lenses. The professor asked, Which are you testing, the mirror or the objective? My father's reply was, we are testing both, and surely we can test both by the method used.

After observing all the appearances in one position, the next thing to be done is to give the whole or combined glass, that is the crown and flint together, a partial turn. If appearances are changed, it is certain there is some error in the objective, for if the glass

worked perfectly, no matter what imperfections were in the mirror, they would be the same whichever way you turn the objective. Having ascertained that the combined glass is not round, or rather does not give a round image of a star a little out of focus, the next thing is to locate the error or errors. Are they in the crown or flint lens? Probably in both. This is, however, ascertained by first revolving one glass. If an irregularity is detected that rotates with the glass, it must be corrected by skillfully working the surfaces, so that the portions that are of short focus shall be lengthened and those of long focus shortened until the rays shall come together at the general focus. After having rounded this lens so that no apparent change is visible by rotation, this glass must remain fixed, and the other must be examined and worked in the same manner. This work having been carefully carried out on both crown and flint lens, they are surely round, though they may not give a round image from the mirror. After the glass is rounded, the mirror itself may be corrected in the same way, but this is not absolutely necessary, as we already know the errors. This rounding of a large glass is very laborious, and sometimes requires months to accomplish. Yet the party that is to make great telescopes in the future, as well as the present, should in my opinion make himself familiar with all these tests, and have the ability to work out the errors that I have described, together with those that may arise from concentric rings of different foci.

Having stated my ideas as to the necessary requirements to make large telescopes, I will now call your attention to my idea of the great telescope itself. As before stated, I am of the opinion that it will be a refractor, and that its size will progressively increase. It will be mounted equatorially, and provided with the best driving clock that can be devised. I am in favor of the long polar axis, known as the English plan, for such an instrument, my reasons being, first, that a large driving wheel may be applied without setting the telescope to one side of the axis. The polar axis itself may also be braced in any or all directions, without interfering with, or obstructing anything. This axis can be made exceedingly stiff by bracing, and the tube itself can be braced to the axis in any position. Such mounting could be easily provided with all the clamps and slow motions that are needed. To make it all complete, we should have two telescopes, one for visual and the other for photographic work, so hung on trunnions as to counterpoise one another, thus requiring very little or no extra weight. I think an instrument mounted in this way would be much more stable than the style Americans have generally adopted in the case of great telescopes.

Now that I have spoken so favorably of these instruments, I must say in conclusion that very much will depend on the localities in which they are placed. To insure the best results, the best places should be selected as the result of thorough preliminary examinations. Doubtless there are many places, both at ordinary and high altitudes, of fine atmospheric conditions. A great telescope, even when used under ordinary circumstances, must be productive of great results, but under the very best conditions of still greater. The increase in size of even our present great refractors is not a possibility but a fact, and with this will come large acquisitions to our present stock of knowledge. The new astronomy, as well as the old, demands more power. Problems wait for their solution, and theories to be substantiated or disproved. The horizon of science has been greatly broadened within the last few years, but out upon the borderland I see the glimmer of new lights which wait for their interpretation, and the great telescopes of the future must be their interpreters.

A FIELD FOR WOMAN'S WORK IN ASTRONOMY.*

By Mrs. M. FLEMING.

In the earliest records of ancient Greek history we can trace the great interest which centers in the heavenly bodies, and in astronomy, the greatest of all sciences, but in no way do we find women connected with the study of this science until a comparatively recent date. Caroline Herschel, Mary Somerville and Maria Mitchell were, as women, pioneers in this work. We cannot say these were the only women of their time capable of devoting themselves successfully to this work and of adding to our knowledge of the heavenly bodies and of the laws which govern them. Caroline Herschel and Maria Mitchell had rare opportunities afforded them, the former in that she had a brother who was thoroughly devoted to the work. Probably through him her interest was aroused and she became his assistant and his untiring companion in his researches. Maria Mitchell, in all likelihood, acquired a similar interest in astronomy from her father, and her high standing as an astronomer is acknowledged by all connected with the study of this science. A great many women of to-day must have a similar aptitude and taste for astronomy, and if granted similar opportunities would undoubtedly devote themselves to the work with the same untiring zeal, and thus greatly increase our knowledge of the constitution and distribution of the stars.

The United States of America is a large country, with a large-hearted and liberal-minded people. Here they have made room for comers from all other countries, have welcomed them and have given them a fair open field and equal advantages in pursuing their labors or studies, as the case may be. There is no other country in the world in which women, not as individuals, but as a class, have advanced so rapidly as in America, and there is no other country in which they enjoy the same unlimited freedom of action which affords them the opportunity to find their own level. In their studies they encounter very little narrow-mindedness or jealousy in their brother students or fellow-workers in the same field of research, but in general they are treated with the greatest courtesy, encouragement and assistance being graciously accorded. Women, therefore, who have taken up any branch of science, or indeed work of any kind, need not be discouraged in it even if one

* Read at the Congress of Astronomy and Astro-Physics, Chicago, August, 1893.

or two of the great mass which goes to make up the whole in their superior judgment refuse to give credit to their work. Labor honestly, conscientiously and steadily, and recognition and success must crown your efforts in the end.

Photography, as applied to astronomy, is one of the greatest advances which has been made in this the oldest of sciences, and this same advance has opened a comparatively extensive field for woman's work in this department. Dr. Henry Draper, of New York, was the first scientist who photographed successfully the lines in a stellar spectrum. His wife, Mrs. Anna Palmer Draper, was his constant companion and assistant in all his experiments and researches. On the interruption of his valuable investigations by his sudden death in 1882, Mrs. Draper, knowing the great value of the work already done, decided that the investigations should be continued at the Harvard College Observatory under the direction of Professor Edward C. Pickering, and she set aside a liberal sum of money to be used for this work, thus founding the department known as "The Henry Draper Memorial." In 1886 there were three women computers engaged in the work in this department; at the present day there are twelve women engaged in the same or in similar work. Miss Catherine W. Bruce, of New York, has shown her appreciation of the photographic work now being carried on at the Harvard College Observatory by her generous gift to that institution of \$50,000 for the erection of a photographic telescope of the largest size. The observatory has a corps of about forty assistants, seventeen of whom are women, and twelve, as stated above, are engaged more or less on the photographic work.

The photographs obtained with the various telescopes now in use at the Harvard College Observatory in Cambridge, and at the auxiliary station near Arequipa, Peru, are of various classes, the most important of these being chart plates having exposures of from ten to sixty minutes, or more, spectrum plates having exposures of from ten to sixty minutes, and trail plates having several exposures of a few seconds' duration. The women assistants are not engaged during the night in taking these photographs, but find their time during the day sufficiently occupied in examining, measuring and discussing them, and in the various computations therein involved. Catalogues, for reference, of the plates taken with each instrument have to be kept up to date, the plates have to be compared with the charts of the part of the sky which they are supposed to represent, in order to check the correctness of the record made by the observer, and to ascertain that the region intended is contained on the plate. The chart plates are then filed carefully away and are used in the confirmation of variable stars or other interesting researches. The most important work at present being done from the chart plates taken with the 8-inch Draper telescope in Cambridge, and with the 8-inch Bache telescope in Peru, is the measurement of the faint stars for standards of stellar magnitudes. These measurements of about forty thousand stars are now being made by Miss Eva F. Leland. She is also engaged in the measurements of the brightness of the stars in clusters. Miss Louisa D. Wells and Miss Mabel C. Stevens have shown great skill and accuracy in making the identification of stars shown in the photographs with those contained in existing catalogues. The photographs of stellar spectra are all carefully examined in order to detect new objects of interest, such as third type stars, fourth type stars, fifth type stars, or those whose spectra consist mainly of bright lines, and similar to those discovered in Cygnus by Wolf and Rayet, planetary nebula, and variable stars. All of these except the first named class differ so much from the general mass of stellar spectra that a trained eye has little difficulty in detecting them on the photographic plates, even although the objects found are sometimes as faint as the ninth magnitude. If an object is detected on any of the photographs showing a spectrum of the third type, having also the hydrogen lines bright, it is at once suspected of variability, since only variables of long period are known to possess this peculiarity. The catalogues of the plates taken with the different instruments are then consulted, and a list is made of all the plates covering the region of the star suspected of variability. So you have, ready to your hand and for immediate use, the material for which a visual observer might have to wait for years and certainly for months. This material must also be considered more reliable, for in the case of a visual observer, you have simply his statement of how the object appeared at a given time as seen by him alone, while here you have a photograph in which every star speaks for itself, and which can at any time, now or in the years to come, be compared with any other photographs of the same part of the sky.

Many interesting discoveries have been made from the study of these photographs of stellar spectra. First in importance among them was the discovery that ζ Ursæ Majoris is a close binary star, the two components revolving around each other at a velocity of about a hundred miles a second, in a period of about fifty-two days. This discovery was made by Professor Edward C. Pickering, his attention being first attracted to it by the fact that in the photographs of the spectrum of this star the lines appear sometimes double and at other times single. This discovery led to the finding of a second object of this same class, β Aurigæ, by Miss Antonia C. Maury. This last star has attracted public attention much more widely than ζ Ursæ Majoris, and may be considered more interesting in that the period of revolution of the two components is only 3 days 23 hours and 36.7 minutes. ζ Ursæ Majoris and β Aurigæ are such close double stars that they could not possibly be separated visually with the most powerful instruments at present in use. A third object of this class is suspected in β Lyræ, which shows a similar change, or rather it shows a reversal in the position of the bright lines with regard to the dark lines in its photographic spectrum, that is, they apparently cross and recross each other. This is doubtless associated with the variation in the light of this star, since the period is the same for both. The examination of the photographs of the brighter stars has been made by Miss Maury, who has also been engaged on their classification. The micrometric measurements of the lines