Correspondence.

A SIMPLE METHOD OF CONSTRUCTING AN ELLIPSE.

To the Editor of the SCIENTIFIC AMERICAN:

In your issues of July 14th and August 25th for the year 1906, two methods are suggested for drawing an ellipse with the aid of a compass. But the compass has never produced a true ellipse, and these results are merely close approximations. Also, in the last-named issue, there is a method for constructing an ellipse by means of a network of tangents. This method also was proved inaccurate by Mr. Warwick Worthington in the number for July 31st, 1909; and he in turn offers a solution by a network of tangents which I believe gives a perfect ellipse, although the method is somewhat cumbersome for ordinary use.

There is, however, a simple way of constructing an ellipse of any desired dimensions solely with the aid

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of straight-edge and pencil. No originality belongs to my method; but it is readily proved to accord with correct mathematical principles.

On a straight-edge or ruler mark off a distance QP , equal to half the desired major axis; also, from point P , a distance PM , equal to half the desired minor axis.

Referring now to the drawing, we construct perpendiculars AA' and BB' , and lay the ruler down so that the points Q and M fall exactly upon these perpendiculars. The point P will then fall somewhere on the curve of the proposed ellipse. By shifting the ruler about, in such a way that Q and M always fall on lines AA' and BB' , respectively, the mark on the ruler at P will give the position of any number of points, which afterward may readily be joined by a continuous line.

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Astronomical Photography.

BY F. V. COLLINS.

The plan of photographing the entire heavens originated with Mouchez in 1887. The death of this eminent man of science was one of the adverse factors which have conspired to delay the work, which now, however, promises to draw to a triumphant conclusion.

The importance of the universal photographic star chart to the astronomer of the future cannot be overestimated. It is now generally acknowledged that the stars are in motion with respect to one another, and our entire solar system is in motion through space, so that one day the constellations will be seen from a sensibly different point of view. Changes will come to pass in the apparent arrangement of the star groups, and in the course of years they will develop, so that something may ultimately be discovered of the real structure and laws of the distant bodies of the universe. It may be that the chart now being prepared will enable the astronomer of some centuries hence to learn as much of the great universe of stars as we know of our comparatively minute solar system revolving within it.

Though photography has been demonstrated of late years to be the only method of revealing the structure of those fascinating formations, the nebulae, at all adequately, the star chart on a large scale, though it be more prosaic to lay observation, possesses an incalculable value of itself. The wonderfully accurate photographic chart may lead, with the aid of a correspondingly accurate system of measurement, to the discovery of entirely new laws of the universe which directly affect our own planet. Seth Chandler discovered the law and evaluated the magnitude of an oscillation in the position of the axis of the earth's figure, which had for years puzzled his astronomical colleagues, not as a result of any special series of observations made for the purpose, but upon the examination of measures made for divers ends at numerous observatories throughout the whole of the last century. And so it has always been a result of measurement when any great advance has been made in a knowledge of the laws which govern the universe. So it will have to be in the solution of the problems which confront astronomers to-day in every direction. The photographic chart, by making these measures more rapid and more certain than is possible by the old visual method, has practically revolutionized this most valuable field of astronomical research.

The reason of the superiority of the photographic

chart over the older method of observation is quite simply explained. The image of a star in the telescope is very rarely absolutely steady, for the light, prior to its reaching the instrument, has to pass through the veritable sea of our own atmosphere, constantly disturbed, in practically all portions, by cold and hot-air currents. Rifle shots are familiar with the sort of effect which is thus produced. On a blazing hot day, when currents of air are rising from the heated ground, the target seems to dance before the eyes, growing taller and shorter and breaking in pieces, with the bull's eye now in one corner and now altogether vanished. Something of the same thing happens to the star image when the telescope is set up in any but a very few tranquil places, and especially when it is in a country much broken up by mountain chains or arms of the sea. On all but two or three nights in the year the star image will be seen dancing and quivering in the telescope, more or less as the air is much disturbed or uniform. And when the observer tries to set the spider line of his measuring apparatus upon the image, he has to make some sort of estimate of its mean position and set upon that. It is really surprising how accurately this can be done after long experience, but the unsteadiness of the object is bound to set a limit to the accuracy which even the most practised observer can obtain. Now it might be thought that this constant vibration of the object would be more fatal to the photograph than to visual observation, but this is not the case. For the motion is very rapid; several times a second does the star make a small jump from its mean position and return to it, and, on an average, it jumps every way with equal frequency. The consequence is that the photographic plate, which keeps a record of every jump, produces in the end an image which is certainly larger than it ought to be, but which is, as a rule, enlarged equally in every direction, so that its center remains still where the center of the image belongs. And when the plate is put under the microscope of the measuring machine—a device capable of accurately determining a fifty-thousandth of an inch—and the threads which are moved by the measuring screw set upon the photographed image, the enlargement of the latter is more than compensated for by any advantage which accrues from a steady image.

But the superiority of the astronomical photograph over visual observation is not confined to the star chart. Numerous articles in popular periodicals have acquainted the general reader with the wonders of the nebulae as revealed by the photographic plate. The cumulative effect of light upon the latter renders it possible to obtain exquisite delineations of faintly luminous objects by means of a sufficiently long exposure. Vast new regions of space are thus being explored, and still vaster regions await further exploration. Prof. E. Ray Lankester, in an address before the British Association, stated that "the invention of the dry plate, which has made it possible to apply photography to astronomical work, is the chief cause of the great expansion of astronomy since 1881." To quote Prof. Lankester further: "It was the dry plate which made long exposure possible, and thus enabled astronomers to obtain regular records of faintly luminous objects, such as nebulae and star spectra. Roughly speaking, those visible to the naked eye may be stated as 8,000; this is raised by the use of the best telescopes to 100,000,000. But the number which can be photographed is indefinite, and depends on length of exposure; 1,000,000,000,000 can certainly be so recorded. By the photographic method hundreds of new variable stars and other interesting objects have been discovered. New planets have been detected by the hundred. Up to 1881, 220 were known. During 1881 only one was found, namely, Stephania, being No. 220, discovered on May 19th. Now a score, at least, are discovered every year."

The appearance of Halley's comet this year suggests the fact that some of the most extraordinary revelations of photography in astronomy have been in the case of these strange members of the solar system. The vast size and tenuity of comets render them very liable to disturbances from other celestial bodies. The photographic plate has shown that the comets utterly transform themselves in a few hours' time. These transformations are sometimes evidently due to gravitation from some neighbor, and again, apparently, from actual collision with planetary bodies or matter, which not only distorts but sometimes breaks the tail. This was the case with one of the comets of 1893, where photographs on successive nights show the tail dissipated and broken, evidently by such an encounter. The presence of a new planet or of inter-planetary substance may be thus revealed. It is interesting to note that the present appearance of the comet of Halley will signalize the first occasion on which this famous body has been photographed.

According to Prof. G. W. Ritchey, of the Yerkes Observatory, it is now possible, with the aid of improved optics and mechanics, to construct a photographic re-

flecting telescope with as much precision and refinement as have been expended upon the great refracting telescopes. Prof. Ritchey has obtained splendid results from his two-foot photographic reflector, and his photographs thus obtained of the nebulae have a wider appeal than to the scientific mind alone. To many a person untrained in astronomical lore, indeed, the photograph of the great spiral nebula in the constellation of Andromeda, obtained with the Yerkes two-foot reflector, would probably appeal at once as that of a most marvelous spectacle—a vast planetary system in the making. About the same proportion of the sun to the planets in our own system is to be observed in the great central spherical condensation of the whirling mass and the smaller condensations in the latter. Some of these smaller condensations, at varying distances from the central semi-formed orb, have assumed an almost perfectly spherical shape; others, again, are formless, though vastly denser than the nebulous matter extending, in a circular or elliptical form, throughout the entire spiral system. It may be observed that the spiral character of this nebula was never even suspected until it was photographed in 1888 by Roberts with a reflecting telescope. Yet the result then obtained was crude indeed when compared with what was obtained by the instrument at the Yerkes Observatory. Seen by the naked eye, this great nebula appears only as an indistinct hazy spot among the stars. The greatest visual telescope in existence fails utterly to reveal the amazing spiral structure so brilliantly shown in the photograph.

Judging from the results obtained with the two-foot instrument, Prof. Ritchey estimates that an eight-foot reflector, if used in a climate where there are suitable atmospheric conditions, would photograph stars which are fifty times fainter than the faintest stars which can be seen with the largest modern refractors. "This means," says Prof. Ritchey, "that such a reflector would enable us to penetrate seven times farther into space than can now be done with the greatest visual telescopes, and therefore that such an instrument would reveal to us a universe seven times seven times seven—more than three hundred—times greater than the universe which is revealed by the most powerful modern refractors. . . . I know of no opportunity which has ever been presented in the entire history of astronomy greater than that which now awaits us in the construction of a large modern reflector and its use in astronomical photography."

It is estimated that the cost of such an instrument as Prof. Ritchey advocates—that is, one of eight-foot aperture, and embodying the latest developments in optics and mechanics—would be about one-thirtieth that of building a battleship of the "Dreadnought" type.

The Current Supplement.

One of the most important articles in the current SUPPLEMENT, No. 1796, is that by George Neumann, in which the compulsory working of German patents is discussed, a matter of great importance to American manufacturers. The adhesion of locomotives is a most important factor in designing engines, and must be considered at every step in the preparation of a general design. An article on this subject appears in the current SUPPLEMENT. Roze's excellent description of a profile puppet-show, and how it can be made and used, is continued. When shipbuilders commenced turning out iron and steel vessels, navigators found themselves confronted with the problem of overcoming the magnetic forces of their ships, and making their compass needles point toward the magnetic north. How the problem is solved is told by William C. Ward in a paper entitled "Compass Deviations." Frank C. Perkins writes on Canadian pulp making in the Algoma district, Ontario. Irish linens and some features of their production are discussed by Sir William Crawford.

Three kinds of bench marks were used by the United States Geological Survey in the spirit leveling in Ohio from 1898 to 1908, inclusive, according to a bulletin by Messrs. S. S. Gannett and D. H. Baldwin. The first form was generally used in the vertical walls of public buildings, bridge abutments, or other substantial masonry structures, being a circular bronze or aluminium tablet, $3\frac{1}{2}$ inches in diameter and $\frac{1}{4}$ inch thick, appropriately lettered, and having a 3-inch stem cemented into a drilled hole. The second form was employed where masonry or rock formation was not accessible, and consisted of a hollow wrought iron post, 4 feet long and $3\frac{1}{2}$ inches in outer diameter, split at the bottom and expanded to 10 inches so as to resist pulling from the ground. These posts were sunk 3 feet in the ground—after having been coated with asphalt—and a bronze tablet similar to the one already described was then riveted to the top. The third form was little used and is now altogether discontinued, being the ordinary split bolt of copper, 1 inch in diameter and 4 inches long.