clouds; although, according to the best of my recollection, luminous filaments seemed to extend from the clouds for a short distance into the span of the arch. EVAN MCLENNAN.

Brooklyn, Iowa, U.S.A., November 22.

Electrical Figures.

I RECENTLY noticed a pretty form of electrical discharge, which has probably been described before, but was new to me. Perhaps one of your readers will be able to refer us to an account of it.

The poles of a Voss machine are put very near together: a plate of ebonite $\frac{1}{16}$ inch thick is placed between them. As the machine works, a succession of delicate ramified discharges run over both surfaces of the plate: they are bright green, and each crooked line is discontinuous—a series of dashes, as if stitched out in silk, now above and now below the surface.

Winchester College, December 6. W. B. CROFT.

NEW DOUBLE STARS.

THE highest quality of seeing, as of acting or of thinking, needs initiative. A mental impulse is the spring of discovery, even by a purely visual process. The mind prompts the eye, interprets what it suggests, bodies out its semi-disclosures. So that to perceive what has never been perceived before is, in a sort of way, an act of *invention*. It thus happens that an accurate is not always an original observer. Novelties, as such, are almost inaccessible to many persons with exquisite powers of vision for whatever is already known to be within its range.

The late Baron Dembowski was an example of a first-rate observer but slightly endowed for detection; Mr. Burnham, on the other hand, is a born discoverer. The accidents of his career have turned his attention almost exclusively to double stars; and his glance seems to have a compulsive power of turning simple into compound objects by long and intent looking. His Chicago thousand of new pairs are famous; he bids fair to accumulate an equally imposing array at Lick. Nor does he neglect the old in the search for the new. The more exciting is not permitted to exclude what is in many respects the more useful occupation.

Progress in double-star astronomy is absolutely dependent upon remeasurements of the relative positions and distances of known pairs. We can otherwise learn nothing as to the nature of their connection. Inquiries about them can, by this means alone, be pushed through the three successive stages leading up towards complete knowledge. In the first place, it has to be decided whether the stars shift their places perceptibly with reference one to the other. If they are "fixed," but with a common proper motion, then they may safely be set down as physically coupled, although centuries may elapse before the character of their mutual revolutions becomes apparent. In the next place, the nature of relative motions, where they exist, has to be ascertained. Should they prove to be rectilinear, that fact alone overthrows the possibility of any real connection between the stars. Each pursues its way independently of the other. Finally, in the interesting cases in which curvilinear motion shows itself, persistent micrometrical measures are required to determine the shape and period of the orbit traced out.

Yet the majority of these objects receive little or no attention. This is in part due to their great numbers. About 12,000 double stars—using the term in the widest sense—are now known; nearly 5000 are in really close conjunction—so close, in some 1400 instances, as to render the chances of accidental juxtaposition all but evanescent. Only between fifty and sixty stellar orbits have, however, as yet been computed, and many of them from most inadequate data. The truth is, that this branch of work wants organizing. It is too vast and too important to be abandoned to the capricious incursions of irresponsible amateurs, whose industry is often wasted by being misapplied. There ought, nevertheless, to be little difficulty in distributing the observational resources available as advantageously as possible by the intervention of some recognized authority, a central repository being at the same time constituted whence computers could obtain on demand the materials needed for the investigation of particular systems. The tasks of stellar astronomy are so multitudinous as imperatively to demand combination for their effectual treatment.

Discovery, meanwhile, must advance as it can. It is far from desirable that it should remain stationary. Although our acquaintance among double stars is already embarrassingly large, we cannot refuse to extend it. Every addition to it, indeed, is, for a variety of reasons, to be welcomed.

Information on the general subject of stellar compositeness can only be gained by continually widening the area of research. The comparative frequency of its occurrence can thus only be estimated. Struve found one in forty of 120,000 stars examined by him down to 1827 to be compound; but the proportion was naturally higher for the brighter stars, as being in general much nearer the earth, and consequently of more facile optical separation. Every twenty-fifth star in Piazzi's Catalogue, every eleventh in Flamsteed's, proved accordingly to have a companion within less than 32″. But the process of dividing stars has since made such strides as to show that the real preponderance of single over double ones must be much smaller than these numbers indicate. Perhaps, indeed, no star can be called absolutely single. Between a small companion sun and a large planet in its self-luminous stage it is not easy to establish a distinction. The star we know best may not always have been, in its "surpassing glory," so undeniably solitary as it now is. Jupiter, if it ever shone with anything like stellar lustre, would have constituted with it a fine unequal pair such as are plentifully exemplified in our catalogues.

The distribution of double stars is characterized by a somewhat irregular condensation towards the Milky Way. They abound in Cygnus and Lyra, are scanty in Cassiopeia and Cepheus; while Struve met with rich regions where lucid stars are few, in Auriga, Telescopium, and Lynx. Burnham, however, could detect no marked local preferences among his numerous pairs. Sir John Herschel was struck with the paucity of close doubles in the southern hemisphere; but no searching scrutiny has yet been carried out there with modern instruments.

The curious tendency of stars already in close association to split up still further when sufficiently powerful means are brought to bear upon them, has been strongly accentuated by Mr. Burnham's investigations. Primaries with double satellites, such as Rigel, or satellites with double primaries, such as ξ and β Scorpii, swarm on his lists. A fresh instance of the former kind is ζ Piscium (Σ 100), registered by Struve as somewhat widely double, but found to be triple last autumn with the Lick twelve-inch achromatic. The satellite of Struve's companion, at an interval of less than one second from it, is of the eleventh magnitude. The bright stars are estimated by Burnham as of sixth and eighth, but were photometrically determined at Harvard as of 5·4 and 6·4 magnitudes; and Webb thought that the chief of the pair occasionally rose to the fourth rank of lustre. A presumption is thus afforded that both fluctuate in light. Their spectrum, like that of most variable double stars, is of the Sirian type; and their real fellowship is made manifest by a community of proper motion. We have here, then, a genuine ternary system.

Aldebaran is the centre of a mixed group. A small star at 30″ detected by Mr. Burnham at Chicago on October 31, 1877, was described by him as making with the ruddy bright star, a pair resembling Mars and his outer satellite (*Astr. Nach.*, No. 2189). A drift together through space

is probable, Mr. Burnham's remeasurements after eleven years indicating relative fixity, notwithstanding Aldebaran's appreciable advance in the meantime. A more remote companion, however, discovered by Herschel in 1781, is certainly optical, and has been shown at Lick to be double (*ibid.*, No. 2875). Most likely it forms part of the cluster of the Hyades, upon which Aldebaran is casually projected.

The division of the leading member of the group known as σ Orionis illustrates Struve's remark that multiple stars are intermediate between double stars and clusters. Herschel saw it as doubly triple, one set being much fainter than the other. Each proved, under Struve's and Barlow's scrutiny, quadruple, with two very small stars between; while the chief of the decuple assemblage has been resolved at Lick into an excessively close pair, recalling the case of Sir J. Herschel's quintuple star 45 Leporis, broken up into *nine* components by Burnham in 1874. No relative, and scarcely any absolute motion is perceptible among the constituents of σ Orionis; but one of them, called "ashen" by Struve, "grape-red" by Webb, is perhaps variable in colour.

The "Pointer" next the Pole, α Ursæ Majoris, has so far been seen as double only with the giant telescope of Mount Hamilton. The extreme difficulty of the pair arises from the disparity of light between its members, the eleventh magnitude satellite at $0''{\cdot}83$ being almost swallowed up in the glare of its brilliant primary. This disparity, too, throws some shadow of doubt on the reality of the connection, since the supply of small stars for the occupation of chance positions is of course vastly greater than of large. The similar, but more distant companion of γ Cassiopeiæ (at $2''{\cdot}18$) also recently discovered at Lick, is hence not unlikely to prove merely optical, the Milky Way, in which this pair occurs, being pre-eminently rich in such objects; and the presumption is still smaller that a fourteenth magnitude neighbour of θ Cygni owns a genuine allegiance. But here, as Mr. Burnham points out, the proper motion of the larger star will speedily decide (*Astr. Nach.*, No. 2912.) There can, on the other hand, be no hesitation in admitting that η Ophiuchi, resolved last spring by the same indefatigable observer into two nearly equal components, at $0''{\cdot}35$, constitutes a physical system, and one in which rapid movements may be looked for. The stars evidently travel together, else they should have been, through the effects of a proper motion of one second of arc in ten years, so far apart a little time back that they could not possibly have escaped separate discernment. Their relation to the Milky Way is picturesque, and has been thought to be significant. "Situated at the extreme northern and pointed extremity of a luminous elongated patch of milky light," Mr. Gore remarks, η Ophiuchi "looks as if it were drawing the nebulous matter after it like the tail of a comet" (*Journal Liverpool Astr. Society*, vol. vii. p. 178). But we may safely regard the appearance as illusory.

Some of Mr. Burnham's measures of known doubles also supply results of interest. Thus, the duplex, sea-green companion of γ Andromedæ can now barely be "elongated" with a magnifying power of 2700 on the great refractor. Yet, so lately as 1881, the two stars could be distinguished with eight inches of aperture. The unequal pair, 99 Herculis, discovered by Alvan Clark in 1859, is even more recalcitrant. No amount of optical constraint can now extract from it the slightest indication of duplicity. Since 1878, 85 Pegasi has traversed 213° of its orbit; and Mr. Schaeberle's new elements, embodying the Lick data, give it a period of $22\frac{1}{3}$ years, and oblige us (on the dubious assumption that Brünnow's small parallax can be depended upon) to ascribe a mass to the system eleven times the solar, the components revolving at nearly eighteen times the distance of the earth from the sun. The sun and Jupiter, if of equal *areal* lustre, would present, at half the supposed distance of 85 Pegasi, just its telescopic aspect.

Like 85 Pegasi, δ Equulei is optically triple, while physically double, the companionship of Struve's more distant attendant being in each case temporary and accidental. The bright star of δ Equulei was divided by O. Struve in 1852, and the pair soon proved to be in exceptionally rapid motion. They constitute, in fact, the swiftest binary system yet known. Glasenapp's period, nevertheless, of $11\frac{1}{2}$ years is evidently too short. The Lick measures show the star to be lagging slightly behind its predicted place.

The investigation of stellar orbits has scarcely yet emerged from a tentative stage. Its results are for the most part loose approximations, largely open to future correction. There are very few stars of which the period is known within a few years; there are perhaps two—42 Comæ and ξ Ursæ—of which it is known within a few months. This is due to no lack of skill or diligence in the computers, but solely to the deficiencies, both in quality and quantity, of the materials at their command. Very small errors become enormous when they affect the relative situations of objects divided by a mere *hair-breadth* of sky; and there is no branch of astronomy in which "personality" has played a more conspicuous or a more vexatious part than in double-star measurements. This at least is abolished by photography; which has, however, as yet proved applicable only to a limited class of coupled stars. With the extension of its powers to all, a new era in the knowledge of stellar revolutions may be expected to open.

A. M. CLERKE.

GEOLOGICAL EXCURSION TO THE ACTIVE AND EXTINCT VOLCANOES OF SOUTHERN ITALY.

THE excursion of geologists to the volcanic regions of South Italy came to a very satisfactory conclusion. We have already referred to the first part of the excursion to the Lipari Islands, and the interesting state of activity in which the volcanoes of Vulcano and Stromboli were found to be in. On leaving those islands the party proceeded to examine the Val di Bove, the Cyclopean Islands, the slopes of Etna with its numerous parasitic cones and lava streams, and the central crater itself. The Italian Minister of Public Instruction allowed the party to sleep in the observatory near the mountain summit, and although the weather was rough and misty, about half the party were able to get a good view of the crater, which is now in a solfataric condition. The geologists had also the advantage of becoming acquainted with the mud volcanoes of Paterno. In this part of the excursion the party had the valuble help of Prof. O. Silvestri, to whom Dr. Johnston-Lavis handed over the direction at Etna, although still acting as general director and interpreting Prof. Silvestri's demonstrations. All along the journey the party were *fêted* by the prefect of the province and the mayors of the different communes, and found invaluable hospitality in the splendid villa of the Marquis Favara at Biancavilla. The second fortnight of the excursion was spent at Naples and its vicinity, under the direction of Dr. Johnston-Lavis, aided for the sedimentary rocks by Prof. Bassani of the University of Naples. Although the weather was not so favourable as in Sicily, the delay only amounted to two days. Many thanks are due to the mayor of Naples for his hospitality in providing for the party a splendid steam yacht for their visit to Capri and Ischia, so affording very greatly increased facilities for their excursions. The members gave a day to the examination of the reservoirs and other works connected with the new and most perfect and purest town water supply in Europe, as well as the new drainage works and destruction of the old town of Naples. Although the visit to the crater of Vesuvius had to be delayed for upwards of ten days for suitable weather,