not be of immediate necessity in the conservative lines of astronomical inquiry.

DAVID P. TODD.

LETTERS TO THE EDITOR.

*** Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

A method for determining the unit of light.

IN all photometric work hitherto undertaken, one of the main difficulties has been to obtain a satisfactory standard of light, — one which will be always constant, and which can be accurately duplicated. Heretofore, all experiments in this direction have been failures. The plan here suggested contemplates, not the employment of a unit quantity of light, but the employment of a certain effect produced by that unit quantity as a standard. In other words, it makes not the light, but the photometer, the constant.

This photometer must, then, be some device for measuring radiant energy. But, for photometric purposes, we wish only to measure that portion of the energy which has a wave-length readily visible to the human eye. With the great differences in color of our modern sources of illumination, it is absolutely impossible to state an exact equivalence between the yellow light of a candle-flame, and the blue light of an electric arc. For really accurate work, we can compare only light rays of the same wave-length. As the human eye is most sensitive to light from that portion of the spectrum between the *D* and *E* lines, in the following plan I have selected that region of the spectrum to be used exclusively for the comparison of the brilliancy of the various lights. In all probability, the total brilliancy of an incandescent body does not increase in a ratio exactly proportional to the increase in brilliancy of the yellow rays; but this difference, within practicable limits, is probably so small as to be entirely negligable. And we have the advantage of being able to state an accurate arithmetical ratio between the lights, instead of what must be at best a mere general comparison of the relative effect of the two lights upon our eyes.

Briefly stated, then, the method I would suggest consists in moving the light to be measured towards the slit of a spectroscope, until a certain effect is produced upon a screen so placed as to receive the yellow rays. When this effect is produced, the spectroscope is receiving the standard amount of light from the source; and the brilliancy of the source can then be determined by measuring its distance from the slit.

In attempting to apply this method, the difficulty which at first arises is, to obtain an effect which can be measured with accuracy. By permitting the spectrum of a light to fall upon suitable screens, three classes of effects may be obtained; namely, heating, visual, and chemical. Of these, the second is evidently unsuited for the purpose of obtaining a standard. The third is too uncertain, and not susceptible of sufficient accuracy, so that the first alone remains. Of the two practicable heat methods of measuring radiant energy, the thermopile is the more sensitive; but the bolometer responds the quicker to changes of temperature, and has the narrower surface. The latter instrument has, therefore, been selected for this application of the method. The unexposed arm of the bolometer has a slight additional adjustable resistance thrown into its circuit, so that, when the instrument is not in use, the needle of the galvonometer will have a certain deflection dependent on the strength of the battery-current employed. When the light to be measured is placed in front of the slit of the spectroscope (which should be quite broad), the deflection will be diminished. As the light approaches the slit, the deflection will decrease, and finally become zero, at which time it is giving out the standard light. Its brilliancy can now be read off from its position upon a scale placed in front of the slit and parallel to the collimator.

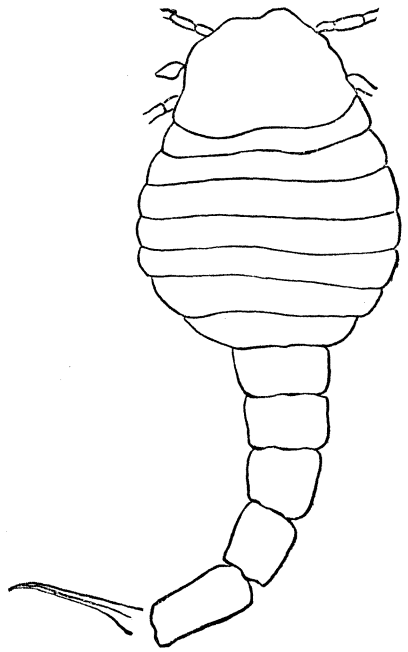
This photometer might also be used to adjust the position at which an incandescent electric or other lamp should be placed in order to furnish a constant supply of light. This source could then be used as a unit in an ordinary photometer.

WM. H. PICKERING.

An American Silurian scorpion.

The 'American scorpion' from the water-lime group of New-York State, described by Professor Whitfield on pp. 87, 88, is undoubtedly a young specimen of Eusarcus scorpionis (Grote and Pitt: Bulletin of the Buffalo society of natural sciences, vol. iii., pp. 1, 2), so named by an error, and which will be redescribed as Eurypterus scorpionis in the forthcoming vol. v. of the society's bulletin.

The enclosed is a sketch of the youngest specimen in my possession, drawn full size: the largest I have,



indicates an animal at least three feet long. There cannot be any doubt as to its zoölogical position; for the characteristics of the genus Eurypterus — eyes placed within the margin of the carapace, and a triangular spine as caudal appendage — can be distinctly identified.

All my specimens have been found in the water-lime group at Buffalo, associated with Eurypterus, Pterygotus, and Ceratiocaris. JULIUS POHLMAN.

Buffalo, N.Y., Aug. 5.

OF course it would be rather hazardous for me to say that the American scorpion, described in a former number of *Science*, was not the young of Eusarcus scorpionis (Grote and Pitt), in as positive language as Mr. Julius Pohlman says it is; for our knowledge of the embryonic features and development of the Eurypteridae is yet too little to allow of many positive assertions, where not accompanied by absolute evidence. Still I must say that I do not believe it to be the young of that or any other Eurypterid. The form of the limbs, the existence of the nipper-shaped palpus and of an apparently true mandible, resembling so much those of the Scorpionidae, are features which we should scarcely look for in an embryonic or undeveloped form of Eurypterus. If Mr. J. Pohlman had seen the photographs of the specimen instead of the rude cut, or had examined the specimen itself, I think he would have expressed a very different opinion.

R. P. WHITFIELD.

The geology of natural gas.

I do not wish to enter into a further discussion of the interesting question of the geology of natural gas, in anticipation of the results of a special investigation which has just been commenced in the oil and gas regions by Mr. John F. Carll for the State geological survey, but, in reply to Prof. I. C. White's criticism of my letter on this subject, I desire to state a few facts in support of my conclusion, that the 'anticlinal theory' alone is insufficient to account for the existence of natural gas, in all localities in the Pennsylvania and adjoining gas regions. In order to clearly understand this communication, reference should be made to *Science*, June 26 and July 17.

In the first place, it is important to know that the general statements contained both here and in my letter of July 17, refer, not only to all the gas regions of Pennsylvania which, with possibly the exception of the Erie district, are geologically connected with the oil-fields, but also to those other gas localities in New York, Ohio, and West Virginia which are not in the vicinity of producing oil-wells. The facts relating to the geology of natural gas, now in the possession of any one geologist, are not sufficiently numerous or connected to permit of the deduction of any ultimate theory; and it is only possible, for the present, to deduce special geotectonic conditions under which natural gas has so far been exploited. Some of these conditions are so varying and apparently antagonistic, that it is only possible to differentiate any one of the general laws controlling the occurrence of natural gas by a comparison of the individual facts obtained from innumerable well-drillings.

The facts given here will serve to elucidate my previous article, and I hope will prove to be sufficient to clearly define the few conclusions at which I have arrived, from field observations extending over a period of ten years, and from numerous studies in conjunction with Mr. Carll, of the results of his surveys, which are more thorough, complete, and valuable than any examinations which have ever been made bearing on the geology of both petroleum and natural gas.

The general structure of the strata drilled through by the gas-wells in the vicinity of Pittsburgh) now considered the most important gas district is the same as that of the strata in the different parts of the Devonian and carboniferous series pierced by the oil-wells at the Smith's Ferry (30 miles N. 60° W. from Pittsburg) and the Slippery Rock (34 miles N. 20° W. from Pittsburgh) districts, where in both districts heavy oil is obtained from the base of the coal measures, and amber oil from the Berea grit; in the Thorn Creek (25 miles N. 5° E. from Pittsburgh), and south end of the Clarion, Butler, and Armstrong (28 miles N. 20° E. from Pittsburgh) districts, where oil is obtained from the Venango (Devonian) sands; and in the Pleasant Unity (30 miles S. 65° E. from Pittsburgh), Dunlap Creek (31 miles S. 12° E. from Pittsburgh), Whiteley Creek (45 miles S. from Pittsburgh), and Dunkard Creek (48 miles S. from Pittsburgh) districts, where oil is obtained from the Mahoning sandstone (lower barren coal measures) and overlying strata. The discovery of oil at Mount Nebo, about eight miles north-west of Pittsburgh, and the several small oil-wells reported to have been obtained in close proximity to the Washington (Chartiers Creek) gas-wells, together with traces of oil found upon special examination in the gas from wells which are supposed to produce absolutely dry gas (the gas obtained from the Carpenter well on the Daum farm, Westmoreland county, was supposed to be free from oil or water: when, however, the gas was confined under a pressure of a hundred and sixty pounds to the square inch, water was precipitated), the existence of natural gas, either in or near *all* the productive oil-pools, under geological and physical conditions similar to those found to obtain in what are frequently spoken of as 'natural-gas regions proper,' are all sufficient reasons for considering the districts producing either oil or gas exclusively (?) one in a geological sense.

Gas-wells are not entirely confined to narrow belts (one-fourth to one mile wide) along the crests of anticlinal folds, nor are those which have apparently been found in synclines necessarily in the vicinity of subordinate crumples or anticlinal rolls which are so frequently found in extensive basins. The "dip of the gas-sand and the position of the anticlines and synclines" is the third of the five principal geological and physical conditions, which I have already enumerated (*Science*, July 17), which seem to influence the occurrence of natural gas, and in special cases would seem to be the most important consideration. Most of the saddles and basins in western Pennsylvania have a progressive dip along their axial line toward the south-west; and a well, drilled half a mile to the north-west or south-east of a given point on the crest of an anticline, will encounter any given stratum at the same elevation as a well drilled immediately on the crest of the same anticline at a distance south-west from the given point, the distance in each case being dependent upon the intensity of the dip in the three directions. The anticline along which the famous Murraysville gas-wells in Westmoreland county have been drilled is an instance.

About ten miles north-east of the village of Murraysville, two large gas-wells have been obtained about three miles apart (north-west and south-east), one on Beaver Run, the other on Pine Run. The total dip of the Upper Freeport coal-bed, from the Beaver-run well to the Pine-run well, is two hundred and fifteen feet, or at the rate of seventy feet per mile toward the north-west. The former well is found in close proximity to the anticlinal axis along which the great Murraysville wells are obtained, farther to the south-west; while the latter well is near the synclinal axis. The extension of the general direction of this anticlinal line to the north-east of the Beaver-run well crosses the Conemaugh River near the mouth of Roaring Run, where a well was drilled, evidently on account of the existence of the anticline at that point; but no gas was found. The Apollo well, about three miles north-east of the Pine-run well, along a line parallel to the structural lines of the district, found no gas. In the