not admit of any great accuracy, some ionisation method appears preferable, such as is employed in Villard's X-ray counter, in which an electroscope is discharged a number of times. It then remains to measure the "hardness" of the rays, or their penetrating power, and this may be done by Benoist's "radiochromometer," consisting of a ring of aluminium strips of twelve different thicknesses. There is still, however, much room for improved methods of dosage.

MR. JAMES KEITH directs attention in the *Engineer* for June 11 to the use of cast-iron shells of fairly large calibre by the Germans. Mr. Keith suggests that, whether or not there be any particular reason for our keeping to expensive steel shells, there could surely be no harm in our having cast-iron ones as well to fill up the gaps, and so enable innumerable shells to be at the service of the armies of the Allies. The matter is taken up by our contemporary in a leading article, and the objections to the course suggested by Mr. Keith are discussed fully. In shrapnel cast-iron shells, the number of bullets is reduced because the walls of the shell must be made much thicker. In high-explosive shells there is such danger of a cast-iron shell developing cracks during manufacture that high explosives cannot safely be used in them. Further, projectiles must be perfectly in balance; the walls must be of uniform thickness all round, and must be of homogeneous material. Otherwise accuracy in shooting would be destroyed. Lastly, the methods of manufacture of steel shell have been so developed that such shell can actually be turned out more quickly than those of cast-iron of equal trustworthiness and accuracy. An 18-pounder shell can be completely machined from the bar in about forty minutes. The *Engineer* suggests that the use of cast-iron by the Germans indicates that they are finding their supplies of modern projectiles not inexhaustible under the tremendous drain that is being put upon them.

MESSRS. LONGMANS AND CO. announce for early publication "The House Fly: a Slayer of Men," by F. W. Fitzsimons, director of the Port Elizabeth Museum. The volume will be illustrated. The author has worked for several years at the destruction of the house-fly in South Africa.

OUR ASTRONOMICAL COLUMN.

BEHAVIOUR OF SPECTRUM LINES OF THE SAME SERIES.—The lines in a series are generally assumed to behave alike (omitting reversals), even under varying experimental conditions. In fact, their sharpness, diffuseness, or direction of unsymmetrical widening have been used as criteria in the detection of series relationships. Thus if the strong lines of a series were unsymmetrically widened towards the red the remaining lines of the series would be expected to be widened in the same direction. This, however, is not the case, and an investigation bearing on these points is communicated by Dr. Royds to the forty-third Bulletin of the Kodaikanal Observatory (see also the *Astrophysical Journal*, March, vol. xli., No. 2, p. 155). In the case of the barium lines he finds that all the first members of the first subordinate series are displaced to the red, and the second members to the violet. In the case of the calcium series he finds this not so extreme a case as that of barium, but still a noteworthy exception to the general run of series. The strontium series, on the other hand, is stated to be quite normal if the infra-red lines the character of which is unknown are excepted. Dr. Royds directs attention to the whole question of the relationship between pressure shifts and series, since the pressure shift may even be in opposite directions for lines of the same series. He points out, further, the importance of isolating the pressure effect from the density effect, the elimination of the latter in order to obtain true pressure shifts being "one of the most pressing problems for those interested in the displacements in the sun's spectrum."

THE FISHER, POLK COUNTY, MINNESOTA, METEORITE.—In the *American Geologist* for December, 1894, brief mention was made of the finding near Fisher, Polk County, Minnesota, of a meteoric stone weighing nine and a half pounds. This stone, the first found within the State limits, was assumed to be a representative of a reported fall which took place on the 9th of the preceding April. In a subsequent number of the *Geologist* a petrographic description of the stone was begun by Prof. N. H. Winchell, but this was neither completed nor was a satisfactory chemical analysis made. In view of these facts and also because more parts have been subsequently found, a complete review of the whole matter has been undertaken by Prof. G. P. Merrill, and the results are published in No. 2084 Proceedings of the United States National Museum (vol. xlviii., pp. 503–6, May, 1915). It seems that specimens of this fall are distributed in eight different collections, the four largest portions being in institutions in Minneapolis, Washington, New York, and Hamburg; the total weight of all the known portions amounts to 9900 grams. The author has been offered facilities for examining and taking samples for the purposes of identification and chemical analysis, and in this paper he publishes the results of his inquiry. Following Brezina's classification he places the stone in the group of intermediate chrondites Ci, or perhaps Cia, as one cut surface shows a small thread-like black vein.

THE NANTUCKET MARIA MITCHELL ASSOCIATION.—In the thirteenth annual report of the Nantucket Maria Mitchell Association, an account is given of the astronomical work accomplished during the past year. This association completed in 1911 the Astronomical Fellowship Endowment Fund, and the first fellow was appointed in the following year; the second has just been nominated. This fellowship enables the holder to avail herself of the entire year for study and research in an observatory of her own selection. Miss Annie J. Cannon, the chairman of this special committee, describes briefly the work of the association with the new $7\frac{1}{2}$ in. photographic telescope. After the adjustments were completed numerous photographs were taken, chief of which were of the minor planet Eros. These plates are now being measured by the first fellow, Miss Harwood, at the Harvard Observatory, together with the plates of the same asteroid taken at that observatory. The chief research will be the photographing of each asteroid once a month for as long a period as possible, the selected objects being those for which the ephemeris at opposition is given in the Berlin *Jahrbuch*.

RECENT BULLETINS OF THE ASTRONOMICAL SOCIETY OF FRANCE.—The April and May numbers of the valuable Bulletin of the Astronomical Society of France have come to hand in spite of the difficulties under which

such a publication is produced. The publishers, in a special note, direct attention to these difficulties, and say that the Astronomical Society of France, confident in the triumph of right and of civilisation, pursues, by the publication of this monthly Bulletin, its work of instruction and scientific propagation with untiring energy, and counts on its adherents to forward at once their subscriptions for the current year. The two issues mentioned above contain numerous communications of interest, among which may be mentioned the first observations of the transit of Mercury, an episode in the life of François Arago, an address by Monsieur C. Flammarion, delivered at the annual general meeting of the Society on April 11 of the present year, and a summary by Comte de la Baume Pluvinel, at the same meeting, of recent discoveries in astronomy. The application of selected filters to the study of Comet Delavan is described by Mentore Maggini, being a summary of a research he undertook in the year 1913.

IRON, CARBON, AND PHOSPHORUS.

DR. J. E. STEAD'S knowledge of iron-carbon-phosphorus compounds is so remarkable, and indeed so unique, that the recent meeting of the Iron and Steel Institute in London was rendered memorable by his presentation of a most illuminating paper on this subject. As a matter of fact, the word "paper" is an inadequate description of the publication, which is very composite in character and deals with some ten aspects of the iron-carbon-phosphorus equilibrium; most of them practical, some of them purely scientific.

The constitutional diagram of the iron-carbon-phosphorus alloys is not yet completely known. The studies of Stead, Wüst, and Goerens have established with sufficient accuracy the liquidus fields of that part of the triangular diagram the corners of which are represented by iron, iron phosphide, Te_3P, and iron carbide, Te_3C. The compositions of the three "binary eutectics" are known, as is also that of the ternary eutectic, which contains 91·19 per cent. of iron, 1·92 per cent. of carbon, and 6·89 per cent. of phosphorus, and freezes at about 950° C. But, in spite of the fact that the paper under notice contains much new and interesting information about some of the solid phases and their relations between the solidus and the ordinary temperature, we are still without accurate knowledge of the composition of most of them and their variation with varying temperature. The constitutional diagram below the solidus has still, for the most part, to be determined, and until this has been done the interpretation of a good many of Dr. Stead's results can only be provisional.

In some earlier experiments Dr. Stead squeezed a portion of the ternary eutectic out of grey Cleveland iron by pressure. The amount extruded, however, was only a small fraction of the total quantity present, for the mould was not maintained, as it would have had to have been, at a temperature just above the freezing-point of the eutectic. It appears, however, that the requisite temperature and pressure conditions are realised in the formation and very slow cooling of the so-called "blast furnace bears." These are accumulations of grey iron which gradually form underground below the well or crucible of the furnace, and sometimes attain an enormous size. One of these dug out from beneath one of the Skinningrove furnaces weighed between 500 and 600 tons. The circumferential contraction of this large mass on cooling compressed the central portion, which was the last to freeze. According to Dr. Stead, "the effect of this enormous pressure caused the central plastic mass to assume a vertical column, an arrangement closely resembling on a small scale the basalt of Giants' Causeway." These columns could be separated from one another. Chemical analyses indicate that about 90 per cent. of the phosphorus originally present had been extruded vertically between the columns during the period of intense compression. A "bear" with a similar columnar structure has also been found in the hearth of a Cleveland furnace of Messrs. Bolckow, Vaughan and Co. at Eston. Here, too, the columns were all vertical, and varied from $\frac{1}{8}$ to $\frac{1}{4}$ in. in diameter, and in some places were so loosely attached to each other that they could be separated by hand. These also were found to be low in phosphorus. In the case of a bear under an Ormesby furnace which had been in blast some thirty-eight years, about two-thirds of the original phosphorus had been removed, but there were no indications of columnar structure. On the other hand, the metal found in the hearth of one of the furnaces at Ferryhill consisted of columnar crystals of iron saturated with iron phosphide, with walls of iron phosphide, but entirely free from carbon and silicon. Here, therefore, the conditions must have been much more oxidising, and no ternary eutectic was present. It is, however, abundantly clear that by far the greater part of the phosphorus in highly carbonised iron is concentrated in the last portions which freeze.

Two photographs reproduced in Dr. Stead's paper illustrate the structure and mode of occurrence of the ternary eutectic extremely well. Both were developed by heat-tinting, iron phosphide appearing blue or purple, iron carbide red, and iron saturated with phosphide white. No. 1 is termed by Dr. Stead the "normal" structure, and is clearly lamellar, recalling the well-known pearlite in its form; No. 2 is evidently that of a very slowly cooled specimen, the lamellæ having coalesced to an appreciable extent.

The equilibrium relations between iron, iron carbide, and iron phosphide in the range of temperature 1000° C. to 700° C. are of the utmost importance in the light they shed on the so-called "ghosts" or "phantoms," which are very liable to occur in large forgings of mild or medium steel. These are lines or streaks which can only be detected after rough turning. As the names indicate, they are not deep-seated. They are completely removed by turning off a thin layer of the steel, but are liable to reappear in other places. It is clear, therefore, that they are very attenuated and irregularly distributed. The usual view held is that they are harmful, and forgings are sometimes rejected on account of their presence, in spite of the undoubted fact that some of them have proved satisfactory in service even though such ghost lines were present. Their occurrence, in Dr. Stead's view, is due to the fact that "in steels containing 0·45 per cent. and less carbon, although the carbon may be equally distributed when the steel is at 1000° C., on very slow cooling the ferrite first appears in the parts richest in phosphorus. The portions which are partially saturated with phosphorus cannot so readily hold in solid solution at certain temperatures as much carbon as the surrounding portions which contain little or no phosphorus; consequently, when in cooling it reaches these temperatures, the carbon diffuses out of the phosphorised parts into the surrounding pure metal." These areas of phosphide concentration constitute the ghosts, and, as sulphides and phosphides segregate together, sulphides are generally present in them as well.

Dr. Stead has succeeded in producing typical ghost lines synthetically by heating to 1000° C. strips of soft