sound. They do not vary as time goes on. The colours are scarcely ever the same in two individuals. This is very clearly shown in two coloured diagrams which accompany Dr. Colman's paper. The first diagram shows the tint excited by the spoken vowel sounds in twenty-one individuals, while the second shows the tints of the colour sensations excited by the letters of the alphabet in seven individuals. Dr. Colman does not, however, give the colour sensations excited by numbers. The writer has tested a boy at intervals within the past four years, and has found that each numeral is associated with a colour as follows:—1, black; 2, white; 3, yellow; 4, red; 5, green; 6, grey; 7, mauve; 8, light grey; 9, brown; 0, black. These associated colours have remained the same throughout the period.

A NEW monthly journal of mechanics and electricity for amateurs and students has just made its appearance under the title of *The Model Engineer*. The periodical is intended particularly for amateurs who take up mechanical or electrical work as a hobby.

THE additions to the Zoological Society's Gardens during the past week include a Sooty Mangabey (*Cercocebus fuliginosus*) from West Africa, presented by Mrs. R. H. Padbury; a Suricate (*Suricata tetradactyla*) from South Africa, presented by Mrs. Soames; a Spectacled Bear (*Ursus ornatus*, ♂) from Colombia, a Spotted Cavy (*Cœlogenys paca*) from South America, presented by Mr. William Crosley; three Brown Capuchins (*Cebus fatuellus*), a Blue and Yellow Macaw (*Ara ararauna*), a Red and Yellow Macaw (*Ara chloroptera*) from South America, deposited; a Naked-throated Bell-Bird (*Chasmorhynchus nudicollis*) from Brazil, two Noisy Pittas (*Pitta strepitans*) from Australia, purchased.

OUR ASTRONOMICAL COLUMN.

WINNECKE'S COMET.—As announced in this column a fortnight ago, Winnecke's periodic comet is shortly due at perihelion, and therefore might be expected to be picked up at any time. Such has been the case, for Prof. Perrine telegraphs from the Lick Observatory that it was found on January 1, being only feebly visible. Its position then was R.A. 15h. 19m. 42·5s., Decl. $-3^\circ 58' 34''$ S.

ARRIVAL OF ECLIPSE PARTIES AT BOMBAY.—Reuter's correspondent at Bombay states that Mr. E. W. Maunder, Mr. C. Thwaites, and the Rev. J. M. Bacon, with the parties under their direction sent by the British Astronomical Association for the observation of the total solar eclipse on the 22nd inst., have arrived there. The different observing stations will be as follows:—Mr. Maunder and Mr. Thwaites will be stationed at Talni, on the Great Indian Peninsula Railway, between Amraoti and Nagpur; the Rev. J. M. Bacon at Baxar. The Astronomer Royal and Prof. H. H. Turner, forming one of the official parties sent out by the joint committee of the Royal Society and the Royal Astronomical Society, will be stationed at Sahdol, between Katni and Bilaspur. The observing party from the Government Observatory at Madras, under the direction of Prof. Michie Smith, will be at Indapur.

MONT BLANC OBSERVATORY.—The closing of the year brings to hand the reports from many observatories, and not the least interesting is that by M. J. Janssen, in *Comptes rendus* No. 24, "On the work done in 1897 at the Mont Blanc Observatory."

During 1897 the principal work has been the determination of the quantity of heat received by the earth from the sun, or the *solar-constant*, as it is called.

The meteorological conditions have not been very favourable, and M. Janssen was compelled to direct observations and expeditions from Chamonix, only reaching there with difficulty, having seriously injured his left leg, which made an ascent of Mont Blanc quite impossible for him. The observations were, therefore, made by M. Hansky—first at Brévent, again at the Grands Mulets, and finally at the summit of Mont Blanc, at the observatory.

From these observations a *solar-constant* of nearly 3·4 calories has been deduced; that is to say, a value notably higher than that obtained before. This, M. Janssen thinks, will be still further increased, for the more deeply the question is studied the more one ascertains the complexity of the elements which enter into it. For instance, of the radiations which strike the earth, it is those having wave-lengths of large and small periods that undergo the greatest absorption in the atmosphere; those with a mean wave-length corresponding to the most luminous part of the spectrum are propagated with the least relative loss. As a result of this, if the transmission of heat in a zenithal direction be deduced from observations made through a great thickness of the atmosphere, it will give a value much too high, and hence one much too small for the solar radiations outside the limits of our atmosphere, which value is the solar-constant. Again, the presence of water vapour and dust particles, whether of snow or other matter, all give rise to disturbing effects which influence the results. To obtain precise indications of water vapour the spectroscope has been used, and for the dust particles and snow clouds M. Cornu's form of polariscope has been employed with success.

From these results it can be seen that it is desirable the observations should be made with as little atmosphere intervening as possible; that is, at high altitudes—in balloons even, if sufficiently precise instruments could be used in these regions of the atmosphere. Nevertheless, if stations such as that of Mont Blanc do not offer comparable altitudes with those which balloons can reach, in return they permit the use of instruments more delicate and precise, giving trustworthy results.

PHOTOGRAPHY OF UNSEEN MOVING CELESTIAL BODIES.—Quite recently Prof. Barnard showed in *Astr. Nach.*, 3453, how it might be possible to photograph an "unseen moving but known celestial body," as, for example, unseen comets, or the swarm of meteorites giving rise to the November shower. The method, it may be remembered, was to watch with a guiding telescope and keep an adjacent star on cross wires moving in the correct position angle at the proper rate, the movement to be produced by an arrangement of watch-work. In *Astr. Nach.*, 3467, Herr Josef Jan Fric, of Prague, gives an account of a somewhat similar method in which the photographic plate or object glass is moved in the requisite direction. The holder is driven by a fine screw, which derives its motion from the intermittent action of a ratchet wheel moved by a "powel," which in turn is actuated at will by an electro-magnet. The length of stroke can easily be altered so as to give any varying motion which may be necessary, but of course, in consequence of the discontinuity of the movement produced in this way, the change in the position of the plate must be so small as not to interfere with the perfectness of the image photographed.

ASTRONOMICAL ANNUALS.—Perhaps the most useful annuals for use, either in a well-established observatory or by amateurs, are: the *Companion to the Observatory* and the *Annuaire Astronomique et Meteorologique;* and if these two could be compounded together, they would form a most desirable and complete compendium of astronomical data. The former confines itself chiefly to tabular matter giving data for finding the planets and their satellites with their respective phenomena, occultations, and eclipses. In addition to these, and perhaps the most important section, as it is not readily found elsewhere, is the ephemeris for physical observations of the sun, mean places, and maxima and minima of variable stars of all periods, and also the radiant points of the principal meteor showers of the year.

The latter publication, by M. Camille Flammarion, is in its thirty-fourth year, and while treating of astronomical events in a popular way, it gives numerous diagrams, and has many interesting features. The calendar, detailing observations to be made for each day, has proved itself most useful, as also have the charts of the positions of the planets.

PHOTOGRAPHIC MEASUREMENT OF HORSES AND OTHER ANIMALS.

VALUABLE horses are habitually photographed by professionals and amateurs, and beautiful portraits of them appear in newspapers; notably in *Racing*, in the *Horseman* of the U.S.A., in *Le Sport Illustré*, and in other similar periodicals. I am informed that in shows of pedigree stock it is frequently required that the prize-winners should be photographed, it being of obvious importance that the appearance of the progenitors of animals should be known before selections are made for pairing. It seems, then, that if photographs of horses and other pedigree stock could be rendered available for strict scientific studies in heredity, the material is copious, and as it would in time extend through many generations, should far exceed in value anything that is now procurable for those purposes. But all depends on that "if." The basis of science is exact measurement, for which the existing photographs are unsuitable. My present object is to show that by paying strict regard to conditions of a simple kind, an ordinary photograph will be transformed from a mere picture into a record of real scientific value; so that if photographs should hereafter be habitually made of pedigree stock (not only of horses) under those conditions, and be afterwards published, a mass of material would quickly accumulate, sufficient to advance the science of breeding far beyond the point at which it now stands. Artistic photographs

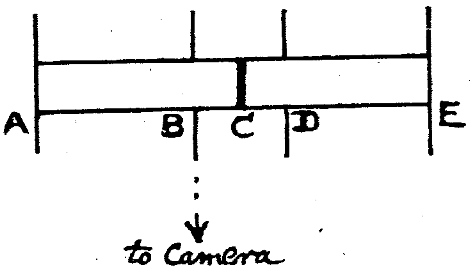

FIG. 1.

are not to be discouraged. Their object is to exhibit animals in their more attractive positions, as by inclining the fore part of their bodies to the camera when it is desired to make the shoulders look larger than they are. What I desire is that other and inexpensive photographs should be procurable, which shall be suitable for exact measurement.

All that is asked for is a strip of hard level ground, on which a rectangle is laid out of some 8 or 9 feet (say 100 inches) long and 20 inches wide, and otherwise marked, and that the camera shall be directed squarely towards a certain point in it, as shown by the diagram (Fig. 1). The horse is to be led to the rectangle, and kept in it, taking care that all his feet stand within its margins, that the cross-line at C lies clear of his front and

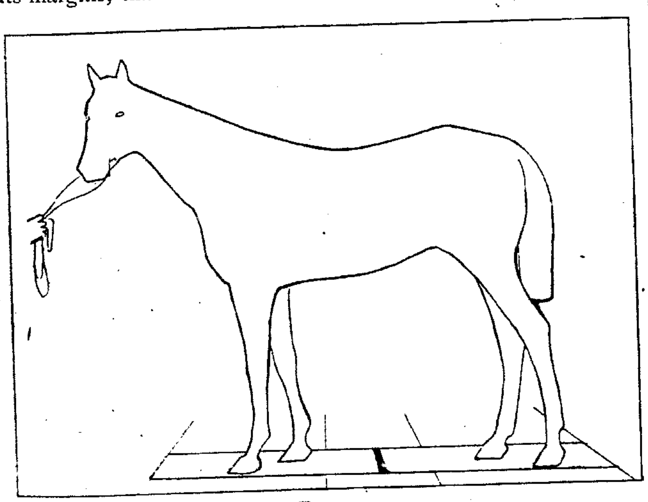

FIG. 2.

hind legs, and that the tip of every hoof and each corner of the rectangle is visible from the camera. The appearance of the horse standing upon the rectangle, as seen in the photograph, would be this (Fig. 2), but the lines should be much more delicate. The camera should be placed on a line strictly at right angles to the side A E of the rectangle. When the horse's head, as in Fig. 2, is on the side of A, the perpendicular in question should be drawn from B, a point about a foot distant from C, and on the same side as A. Then the image of the horse fits, laterally, well into the field of the camera. When the horse's head is intended to be on the side of E, a symmetrically situated point D must be selected for the foot of the perpendicular on which the camera is to stand. The distance of the latter from the rectangle should be fully 20 feet.

The camera having an adjustable back, must be slightly tilted downwards in order to get a good view of the feet, but its back must be kept *strictly vertical*. It would be a decided gain if the installation were so arranged, that the photograph should contain means of judging whether the plate in the camera had really been adjusted aright—that is, parallel to the vertical planes passing through the long sides of the rectangle. This can be accomplished by laying out the rectangle near the base of a wall, with its long sides parallel to it; then, driving two nails into the wall in the same horizontal line, hang a long string with weighted ends over them, the ends nearly touching the ground. If the two nails are well placed, the line will appear in the photograph, as running along the top and down the two sides of it, close to the margin. Then, if the plate has been rightly adjusted, the upper line in the picture will remain parallel to the long sides of the rectangle, and the two weighted ends will remain parallel to one another. Otherwise there will be convergence in one or both respects. The camera must be high, in order to show well the position of the horse's feet; 5 feet is perhaps the best height for it at a distance of 20 feet, then the perspective foreshortening of the width of the rectangle is such that its scale is one-quarter of that of its length.

Relative measurements can be made with accuracy on photographs taken under these conditions, between any visible points that are situated on the median plane, such as between the withers and the lower part of the chest below them, between the front and the back of the profile, and so on, but absolute measurements cannot be made because the distance between the camera and the median plane is not yet accurately determined. Much less can heights above the ground be measured, for in order to do so it is necessary first to determine the line at which the median plane of the horse intersects the ground, because it is to this line that the vertical measurements must be made. What is meant by "median plane," is the imaginary plane which passes lengthways and vertically through the spine of the animal, and which serves generally as a plane of reference. It cuts the ground half-way between the two pairs of hoofs, so that if the half-way position between the tips of the fore hoofs be called S, and that between those of the hind hoofs be T, then the intersection of the median plane with the ground lies along the line S T. For its accurate determination the animal should stand on hard ground, and the hoofs be so disposed that at least the tips of all four shall be visible from the camera, which must be well elevated so as to look down on them, as already described.

Beginning with the simplest case, namely that in which the median plane of the horse is parallel to the long sides of the rectangle, and also parallel to the plate in the camera, we are at once in a position to measure the height of the horse, its depth of body wherever desired, and its length. For by prolonging S T in the photograph until it cuts the ends of the rectangle in S′ and T′, a length equal to that of the line S′ T′ drawn on the median plane in any direction will correspond to the length of 100 inches objectively. We begin by measuring the lengths of S′ T′, and those of any other, say two, dimensions on the photograph. Call their several measurements s', a, and b, reckoning them according to the scale used throughout for that purpose, whatever the value of the units of that scale may be. Let x and y be the objective values of a and b, which have to be found;

$$\text{then } s' : 100 :: a : x \text{ and } :: b : y$$

$$x = \frac{100}{s'}a \qquad y = \frac{100}{s'}b,$$

so the coefficient $\frac{100}{s'}$ being determined, serves to convert these and all other measurements in this same median plane into their objective values. Those persons who possess Crelle's Multiplication Tables, can perform these little sums without effort and with great rapidity. In Fig. 2 the real length of the rectangle there represented happens to be only 80 inches. The measurements on the diagram are as follow:—(1) S′ = 21·6 mm.; (2) height of withers, 15·7; (3) height of lower side of chest, vertically below, 8·9; (4) height of rump, 16·2; (5) extreme length of body, 15·5. Whence the coefficient $= \frac{80}{21·6} = 3·7$, and the objective values are (2), 58·1 inch, (2-3) 25·1; (4) 59·9.

Before considering the effect of obliquity the following objec tion must be disposed of. It may be said that the protuberan sides of the animal will prevent its true outline being visible from the camera, for the reasons indicated by Fig. 3, which is an extreme case in which the camera, or eye, R is supposed to be very near to the side of an animal, so fat that his cross section has to be represented by a circle.

The summit of the outline as seen from R is H, giving the idea that the spine of the animal is as high as L, whereas it is really at K. The ratio of LO to KO is of course the same as that of LO/OR to KO/OR, that is to HO/OR; in other words as the tangent of L R O to the sine of the same angle. The values to be dealt with in reality, are very different from those in the diagram. OR is 240 inches and KO may be taken as 15 inches. It results that L R O is only 3° 35′. Now the tangent and sine of such a small angle are so nearly alike that LO : KO :: 100·00 : 99·85, which corresponds to a difference of less than 1/8th inch in a horse of 15 hands high, and is quite negligeable.

In some fat stock, however, the backs are flat like tables. Here some artifice would be necessary to obtain the true height, such as by fixing a stud of say 2 inches in height to a surcingle. The top of the stud would then be the point of measurement, and 2 inches would be subtracted from the result.

We now come to the effect of obliquity of the median plane of the horse to the long sides of the rectangle. The hoofs of a thoroughbred horse are some 4 inches wide, and 4 inches apart, so that the closest distance between either S or T, and the nearest side of the rectangle, is 6 inches; therefore the utmost cross distance between S and T is (20 − 12) or 8 inches, and the length of ST in a horse of 15 hands in height may be taken as 60 inches. Therefore the maximum obliquity within the strip is as 8 to 60, or 0·1333, which corresponds to an angle of 7° 39′.

The foreshortening of the length ST (= 60 inches) is such that its foreshortened value must be multiplied by the secant of 7° 39′

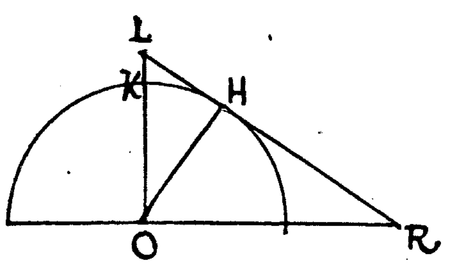

FIG. 3.

to obtain the unforeshortened value, that is by 1·009, which makes it nearly 1 per cent. longer. This is the greatest error to be feared under the conditions, and it is further much diminished by determining the actual obliquity. We can do this easily by measuring the distance lengthways between the points where ST produced cuts the opposite sides (not ends) of the rectangle. The further side of the rectangle affords the scale for reckoning distances from C along that line when produced; similarly the nearer side affords the scale for distances from C measured along and beyond itself. The cross distance between those points is known to be 20 inches, so the obliquity is easily found. The accompanying table may be found convenient. It applies with strictness only to objects viewed from a great distance, but is practically correct for much smaller ones.

Obliquity.		Multiplier to convert fore-shortened values.	Corrections to be added to foreshortened measurements of			
			10 ins.	30 ins.	50 ins.	70 ins.
	° ′		in.	in.	in.	in.
1 in 7	8 12	1·0103	0·100	0·20	0·50	0·70
,, 10	5 43	1·0050	·050	·15	·25	·35
,, 15	3 49	1·0022	·022	·07	·11	·15
,, 20	2 52	1·0012	·012	·04	·06	·09
,, 25	2 18	1·0008	·008	·02	·04	·06
,, 30	1 55	1·0006	·006	·02	·03	·04

The mean scale for the slightly oblique median plane is the perspective length of the rectangle at the point where a line drawn through the middle of ST cuts the perspectively viewed ends of the strip. It is unnecessary to attempt greater minuteness, as by determining the vanishing point (the position of which is given by prolonging two or more of the cross-lines upon the ground to their points of common intersection in the photograph), and then employing the further methods known to draughtsmen in perspective. Much could be written of which it is unnecessary to speak here, because it is a condition that the obliquity shall never be great. A strict attention to the elementary requirements laid down above, makes the problem of measurement extremely simple; otherwise it becomes complex and troublesome.

The next point to be considered is the method of measuring between points situated on the side of the horse, such as from the haunch bone to the shoulder. I shall speak of these in general terms only, because the most suitable points for measurement have yet to be determined. Whatever they be, it is a great assistance, before photographing the horse, to mark the points to be measured either by chalk, or more neatly by a disc of gummed paper, the size of a shilling, wetted and stuck on. Veterinary-Captain F. Smith has used both these plans. It is also an excellent plan to prick through these points in the photograph, and through a piece of paper laid below, and to measure between the prick holes. The general principle of dealing with these measurements is to find a *mean* correction suitable to each distance, when those distances have been calculated as if they were situated on the median plane. The lateral deviation from that plane of each one of these points, ranges within narrow limits, when the height of the horse is taken as unity. The mean deviation even of either protuberant haunch bone from the median plane between them, is much under 20 inches in a horse of 60 inches (15 hands in height). The mean range of this deviation in different horses of that height, judging from what occurs in anthropometric measurements, is probably very much under an inch, and its extreme range in ordinary cases would be under 2 inches. Extraordinary cases of massive or slender build would be betrayed by the photograph itself, and could be allowed for. It seems, then, that after the desirable points had been determined, between which measurements might be wanted, it would be a straightforward piece of work to make numerous measurements between them in different horses, and to draw up the suggested table of corrections for 2 or 3 different positions in the rectangle.

The head and neck can hardly be measured on the above principles, as it is very difficult to ensure that their median plane should be the same as that of the body. A strip of card chequered with inches, alternately white and black, and fastened to the head stall, affords a serviceable scale, and is by no means unsightly.

From measurements obligingly procured for me by Dr. MacFadyean, the Principal of the Royal Veterinary College at Holloway, the measurements being repeatedly made of the same horses by different pupils, I learnt two things. One was that horses of the same class vary among themselves as much as men. In short, they could be identified by a Bertillon method. The other was that the fallibility of a measurer was considerable. I think that measurements made on a half-plate photograph, under the conditions I have described, would on the whole be more trustworthy than direct measurements made with a tape or callipers, especially on fidgety horses.

FRANCIS GALTON.

THE MAGNETIC PROPERTIES AND ELECTRICAL RESISTANCE OF IRON AT HIGH TEMPERATURES.

THE magnetic properties of iron and, to a lesser extent, of the associated metals, nickel and cobalt, have always been a fascinating subject of study. Possessed by these three metals alone, these properties, so peculiar and so different from any of the other known properties of matter, have imparted to the study of these so-called magnetic metals a special charm and interest, apart from that excited by the vast industrial importance of at least one of them.

Among the very early inquiries into the nature of magnetism there were not neglected experiments on the effect produced by change of temperature. Three centuries ago, Gilbert recorded the observation that a piece of iron or steel, if heated more strongly than up to a full red heat, ceased to be attracted by a magnet, though it regained its previous magnetic qualities on cooling below that temperature.