server, Mr. Roberts, have also been included in the new catalogue. (*Astronomical Journal*, No. 347.)

THE TEMPERATURE OF THE SUN.—A new method of determining the temperature of the sun has been employed by H. Ebert (*Astrophysical Journal*, June). With the aid of data supplied by Langley's investigations, Rubens deduced the law that the wave-length of the maximum energy is inversely proportional to the square root of the absolute temperature of the radiating body. Experiments on the radiation of blackened bodies between absolute temperatures 373° and 1088° indicated the relation

$$\lambda\sqrt{T} = 123,$$

T being the absolute temperature, and λ being expressed in microns (μ = ·001 mm.). Langley has shown that the maximum energy of the continuous background of the solar spectrum is very nearly at 0·6 μ, and assuming that the incandescent particles in the sun which yield the continuous spectrum are comparable to a black body as regards their total radiating capacity, the application of the above formula gives a temperature of about 40,000° C. The parts of the sun to which this temperature applies are stated to belong to the interior regions, below the photosphere.

Dr. Ebert enters into a discussion of the electromagnetic nature of the solar radiation, in order to justify the application of the formula in the case of the sun. This leads him incidentally to suppose that the continuous background of the solar spectrum is mainly due to hydrogen in a strongly compressed state.

THE ROTATION OF SATURN.—In 1893 Mr. Stanley Williams announced some highly interesting facts with reference to the period of rotation of Saturn, as deduced from observations of spots on different parts of the surface of the planet (NATURE, vol. l. p. 32). The observations were continued during the opposition of 1894, and similar striking results have been arrived at. (*Monthly Notices*, vol. lv. p. 354). It was again found that the spots indicated widely different rotation periods in the same latitude, but in different longitudes, as shown in the following table:—

	Range in longitude.	Mean period. h.	m.	s.
Dark spots (17°–37° N.)	30°–130°	10	14	57·29
	140–200		14	44·23
	240–360		15	47·97
Bright spots (6° S.–6° N.)	0–80		13	1·69
	80–160		12	40·03
	160–360	10	12	25·83

The average rotation periods of the whole equatorial spot zone during the four years of observation were as follows:—

	h.	m.	s.		s.
1891	10	14	21·8	Diff.	43·6
1892		13	38·2	”	45·8
1893		12	52·4	”	16·6
1894	10	12	35·8		

The extreme difference of 1m. 46s. observed since 1891 "means a very considerable increase in the velocity of motion of the surface material, amounting to 66 miles per hour. In other words, the great equatorial atmospheric current of Saturn was flowing 66 miles an hour more quickly in 1894 than it was in 1891."

Taken as a whole, the observations indicate a more rapid rotation of the planet in the equatorial regions than in the northern zone of spots, and they appear to establish that there are great differences of velocity in different longitudes.

To Prof. Darwin, these results "suggest a rather wild consideration" (*Observatory*, June). He considers it possible that sections of the planet parallel to the equator may not be circular, and suggests that it might be worth trying to detect systematic differences between the various equatorial diameters by micrometric measurements.

THE VISIBILITY OF SHIPS' LIGHTS.

IT may be remembered that in 1890, the German Marine Observatory tested some three thousand running lights in use on board ships, and found two-thirds of them defective. Further tests of the visibility of lights of known candle-power were made by the German Committee last year, and some of the results obtained are noted in a leaflet just distributed to seamen by the U.S. Weather Bureau. The law of emission for a white light is that its visibility is proportional to the square root of its candle-power, and the results of the experiments by the Committee closely follow the law, the departures being no greater than the estimated errors of position of the vessel. The mean of a large number of observations gave as the distance at which a white light of one candle-power became visible 1·40 miles for a dark clear night, and 1·00 mile for a rainy one. Experiments undertaken in America, after the International Maritime Congress in 1889, gave the following results in very clear weather: A light of 1 candle-power was plainly visible at 1 nautical mile, and one of 3 candle-power at 2 miles. A 10 candle-power light was visible with an ordinary binocular at 4 miles; one of 29 candles faintly at 5, and one of 33 candles visible without difficulty at the same distance. On a second evening, exceptionally clear, a white light of 3·2 candle-power could readily be distinguished at 3, one of 5·6 at 4, and one of 17·2 at 5 miles. The Dutch governmental experiments, conducted at Amsterdam, gave the following results: A light of 1 candle-power was visible at 1 nautical mile; 3·5 at 2, and 16 at 5 miles. Experiments with green lights gave 0·80 as the distance in miles at which a green light of a single candle-power is just visible. The candle-power required for a green light to be visible at 1, 2, 3, and 4 nautical miles was 2, 15, 51, and 106, respectively. The American experiments before referred to give for green light: 3·2 candle-power fairly visible at 1 mile, and 28·5 clearly at 2 miles, these results being, however, from a limited number of experiments. The German trials were much more numerous. The extraordinarily rapid diminution of the visibility of the green light with the distance, even in good observing weather, and the still more rapid decrease in rainy weather of a character which will but slightly diminish the intensity of a white light, show that it is of the utmost importance to select for the glass a shade of colour which will interfere with the intensity of the light as little as possible. The shade recommended is a clear blue-green. Yellow-green and grass-green should not be employed, as they become indistinguishable from white at a very short distance. For the red, a considerably wider range is allowable, but a coppery-red is said to be the best.

THE RELATIVE POWERS OF LARGE AND SMALL TELESCOPES IN SHOWING PLANETARY DETAIL.

IT is to be hoped that a definite understanding will soon be arrived at regarding the differences between large and small telescopes in revealing delicate surface-markings on Mars, Jupiter, and Saturn. The subject of relative efficiency was discussed about ten years ago, and some interesting evidence was evoked as to the different forms and sizes of telescopes, but no settlement of the question was possible in the face of the diversity of opinion existing. The time seems to have come when the subject may be suitably referred to, and the facts considered apart from mere prejudice or preference for any kind or size of instrument.

The phenomenal results recently claimed for certain small telescopes are almost of a character to shake even the faith of those disposed to acknowledge their great utility on several classes of objects, for our confidence cannot go beyond reasonable limits. In individual cases a good though small instrument, an acute well-trained eye, acting in combination with the best atmospheric conditions, will yield surprising results; but some of those lately published border upon romance, and henceforth it would seem that if all the data derived with such means are to be absolutely accepted, then large telescopes are grossly incapable on certain important objects, and may as well be packed away in the lumber rooms of our observatories.

This is the more surprising when we consider the opinions expressed during the discussion which previously took place on the same subject. Prof. C. A. Young, who has charge of the 23-inch refractor at Princeton, said: "I can almost always see with the 23-inch everything I see with the 9½-inch under the same atmospheric conditions, and see it better—if the seeing is bad only a little better, if good immensely better." Other observers having the means of comparing large and small instruments, side by side, furnished similar evidence, except in the case of M. Wolf, of Paris, who said: "I have observed a great deal with two instruments (both reflectors) of 15·7 and 47·2 inches aperture. I have rarely found any advantage in using the larger one when the object was sufficiently luminous." Prof. Asaph Hall, whose valuable work with the 25·8-inch refractor at Washington is so well known, once said: "The large telescope does not show enough detail." The testimony was not, therefore, unanimously in favour of big telescopes.

More recently the 36-inch at Mount Hamilton has been eulogised for its fine performance. Mr. Keeler, in January 1888, said that the minutest details of Saturn's surface were visible with wonderful distinctness with this instrument. The 12-inch and 6-inch refractors at the same observatory were found far inferior in capacity to the 36-inch. Prof. Barnard has also stated: "Let the conditions be the best for observing, with the air steady, and the 36-inch is far ahead of the 12-inch." The same observer has also remarked: "350 is the most useful power on Jupiter and Mars, 520 on Saturn." For planetary work he prefers using the full aperture and low powers.

We have it on the authority of most of those who have employed both large and small telescopes, and are therefore in the best position to speak as to their relative merits, that large instruments in good air will reveal more than small ones. The observer would in preference use the largest instrument for any critical purpose; and this being so, how shall we explain their apparent failure in regard to planetary details? Is it that the big telescopes show too little, or that the small instruments exhibit too much?

And here it may be noted that only in exceptional cases do we find phenomenal results accruing from the use of small apertures. It is not every one who has a telescope of 6 or 8 inches diameter who can discover the various spots and numerous belts on Saturn, or trace the double and often interlacing canals of Mars.

During the last few years numerous dark and light spots have been detected on the ball of Saturn by Mr. A. S. Williams, who used a 6-inch reflector. These have been distinguished when Saturn was nearing conjunction with the sun, and in spite of two unfavourable circumstances—namely, the small diameter of the planet, and its proximity to the horizon. The spots have been seen so distinctly, that the observer has been enabled to describe them individually as bright or faint, small or large, round or oval, &c. These observations have not, perhaps, been fully corroborated, though several observers appear to have glimpsed the markings alluded to. When we consider that many hundreds of amateurs have been employing their telescopes upon Saturn without seeing the spots, the affirmative evidence of a few isolated persons can hardly be regarded as conclusive. It is a fact that, if any new feature on a planet, or an unknown companion to a star were confidently announced, a few of the many observers who looked for it would certainly assert they could see it though not really existing.

Prof. Hough, with the 18½-inch refractor, at Chicago, made a series of observations in 1884 and 1885 for the special purpose of detecting definite markings on Saturn and redetermining the rotation period, but he quite failed to get the necessary data. His statement was: "The belts on the disc of the planet were at times quite conspicuous and very sharply defined, but we were unable to find any spot or marking by which to observe rotation." Yet the *Monthly Notices* for June 1884 contain a drawing which gives a numerous array of condensations attached to the dark narrow belt bounding the equator on its southern side. This drawing was made with an 8¼-inch reflector, and at about the same period many other observers examined the planet with an entirely negative result as far as the existence of these condensations was concerned. A drawing was published in the *Journal* of the British Astronomical Association for July 1894, showing the planet as he appeared on March 26 of that year in a 12-inch reflector. A numerous assemblage of dark belts are shown, and many other observers appear to have seen several comparatively narrow belts. Prof. Barnard, however, using the 36-inch refractor in re-measuring the dimensions of Saturn and his rings in 1894, was led to pay some attention to the physical appearance of the planet, and significantly remarks: "But one dark narrow belt was seen upon the planet. The black and white spots recently reported with small telescopes were not seen at any time." It is certainly a remarkable circumstance that the belts and spots, if really existing, cannot be seen in the large instrument. Are the observers with small apertures suffering from some extraordinary hallucination, or must we consider that the brightness of the image in large telescopes and inferior definition are sufficient to obliterate very delicate markings? Is the glare sufficiently strong to overcome the slight contrasts of tone readily perceptible on a fainter image? Prof. Holden thus expressed himself in 1891: "There is no doubt that the belts on Saturn are often marked and mottled with brighter spots. I presume that such spots would be as easily seen in a small but perfect telescope as in a larger one. Seeing such faint markings is entirely a matter of detecting faint contrasts, and these should be detected as readily in a small instrument as in ours, if not more readily, except that the large size of our image helps us." On the other hand, Prof. Young has suggested that faint images are very encouraging to the imagination, and therefore often a source of observational errors.

Prof. Holden's remarks are tantamount to an admission that large instruments are ineffective on planetary details, for what are delicate markings but "faint contrasts"? Yet it would be conceived that the 36-inch had proved itself quite capable of dealing with such contrasts, for it is stated by Prof. Barnard, from observations of Jupiter in September–October 1894: "The red spot is fairly distinct in outline, though quite pale—a feeble red. The following end of the spot is quite dark. There are white regions on its surface. The belt south of it seems to be in contact with the spot, if it does not actually overlap it slightly."

The 36-inch is mounted in one of the finest localities for celestial observations, but shows nothing on Saturn but the dark narrow belt situated in the midst of the equatorial zone, while certain telescopes of small aperture reveal the disc furrowed with belts and mottled with spots. Nearly every small telescope shows more than one belt upon Saturn, but the delineations seldom agree as to the number or latitudes of these belts. We ought to expect approximately accordant positions; but the majority of drawings are hurriedly executed and based on rough estimations, so that they are often found inconsistent. The differences referred to are not, therefore, proof of the non-existence of the objects depicted, for the same disagreements are found with reference to well-assured formations. In some cases undoubtedly observers will, perhaps unconsciously, use their imaginatious, as the desire is always to put in as much detail as possible. When mere fancy assists the optical powers, the resulting drawings are often very pretty and attractive from the number and novelty of the features shown. We can fill in any number of dark belts and bright zones, beaded with spots of various forms and tints, and tone the whole to suit our ideas; but unfortunately such drawings, though pleasing to the eye, have a bad influence, since they pervert the truth, and lack that fidelity to nature which could, alone, make them really valuable.

Mr. Williams, the discoverer of the Saturnian spots, has made some hundreds of observations of them, and fully detailed his methods and his results in the *Monthly Notices* of the R.A.S., liv. p. 297, *et seq.* First detecting them in the spring of 1891, he has now followed them during five oppositions of Saturn. The bright equatorial spots apparently show a period of rotation decreasing with the time, for the mean period during 1891 was 10h. 14m. 22s., while in 1892 it decreased 44 seconds, in 1893 43 seconds, and in 1894 15 seconds. The care with which Mr. Williams proceeded in his work, and the plan he adopted to avoid bias or preconceived ideas, are explained in the paper alluded to, and every one reading his description must be favourably impressed with it. *If his results are fully confirmed*, they will deserve to be ranked among the best observational feats of modern times. To have been the first to discover these delicate objects in all their variety, to have traced out their individual motions with unwearying persistency year by year, and to have employed all the time a very small telescope, must be regarded as a remarkable attainment. It is to be hoped that the necessary corroboration will soon be forthcoming.

I have myself practically endeavoured to afford this, but failed. The spots on Saturn are certainly not visible under powers of 252 and 312 on my 10-inch reflector. The power of 252 is the eye-lens of a Huyghenian eyepiece, that of 312 is one of the "monocentric micrometer oculars" of ¼-inch equivalent focus by Steinheil of Munich. The latter has a distinct advantage over my Huyghenian eyepieces. I have sometimes used a Barlow lens in combination with it, increasing the power to about 450, but do not think any advantage has been gained. I have occasionally had impressions of white spots mottling the bright equatorial zone of Saturn, and occasionally also of faint condensations in the dark belts; but as to seeing these details outright, and obtaining their times of transit with all the certainty of a definite spot on Jupiter, I have quite failed. I am induced to believe, from a number of observations dedicated to the purpose, that my suspicions of spots were entirely illusory, and that such markings as objective features were invisible to my eye with the means employed. On the worst nights I could easily imagine a mottled aspect of the belts; but with good definition and a steady image, the tone of the belts and bright equator appeared perfectly even and free from noticeable irregularities. In a case of this kind the observer has to be severe with himself. There is a distinct line of demarcation between what is absolutely seen and what is possibly seen or suspected. An object may be only glimpsed, and yet it is certainly seen, for its impressions reach the eye now and then in a form not to be mistaken. But with some objects the experience is different. We fancy they are there, but cannot fix them with certainty; apparently they flit about like an *ignis fatuus*, and are intractable to our utmost efforts. Obviously in such a case the observer has but one alternative, and that is to regard the objects as imaginary.

On Mars, as well as Saturn, small instruments have done wonders. It is well known that the canals and their duplication were discovered by Schiaparelli with a refractor of only 8½ inches aperture. In 1892, during a favourable presentation of Mars, the large American telescopes showed very little either of the canals or of their duplication. During the opposition of 1894 the planet was better placed as regards altitude (but not so near to the earth as in 1892), and the results of observations have been more satisfactory. Mr. Williams with a 6½-inch reflector, and Mr. Brenner with a 7-inch refractor, have recovered many of the double canals of Schiaparelli. Mr. P. Lowell, with the 18-inch refractor at the observatory at Arizona, has also observed many remarkable and intricate details of the planet's topography. This observer remarks that in regard to the visible markings on the inner planets of the solar system up to and including Mars, size of instrument is quite secondary to quality of atmosphere. He draws the "oases" on Mars, and a large number of interlacing lines on the planet, in *Popular Astronomy* for April 1895, and the pictures are very effective. There are many of us who would like to obtain a view of Mars similar to what he has depicted. Mr. Lowell notes that with the 18-inch a power of 420 was as high as the atmosphere permitted to be used with advantage, though drawings were generally made with 370. On the 6-inch refractor 270 showed well, the dark and light markings being more contrasted than in the larger instrument. As affecting the comparative utility of large and small telescopes, Mr. Lowell remarks: "A large instrument is assumed to be necessarily superior to a small one, quite irrespective of what it is that is to be observed. Now the fact is that there are two quite different classes of celestial phenomena—those dependent on quantity of light, and those dependent on quality of definition for their visibility, and the two means to these ends go anything but hand in hand. For the one, the illumination, the size of the instrument is the prime requisite; for the other, the definition, the atmosphere is the first essential. As an object-lesson in this, it is worth noticing that the biggest instruments have not always given the best views of Mars. In matters of Martian detail it is amply evident from the results that observer, atmosphere, instrument, is the order of weight to be given as the factors of an observation."

I have referred to this subject without any desire to take up the cudgels on behalf of any class of instrument, but it is suggestive that the large ones will not bear powers commensurate with their size on planetary details. Thus with the 36-inch at Mount Hamilton a power of 350 has been found the most effective on Mars; a similar power can be used with advantage on glasses of only 8 or 10 inches diameter. It is difficult to understand, therefore, where the superiority of large instruments comes in, as the object is sufficiently bright in small telescopes, and the latter being more easily manipulated and less affected by atmospheric tremors, they obviously possess some distinct advantages. But this interesting and important question is scarcely to be settled by a mere discussion of this sort. It is only to be settled by careful trials of large and small instruments, side by side, upon the planets Mars, Jupiter, and Saturn. If observers having the appliances at command will institute some further comparisons of the kind suggested, the problem might be virtually solved in a short time. Relying upon evidence of fragmentary character is scarcely fair, since differences of eyesight and atmosphere come into play most prominently. The most valuable evidence would be that of an observer who used a number of telescopes of different apertures at one and the same station. Up to the present time it must be confessed that small instruments have somewhat the best of the argument; but if the unanimous testimony of our most trustworthy observers asserted the superiority of large telescopes on bright planets, it is hard to see how they could be disproved, as they alone have the effective means of judging the question on its merits.

W. F. DENNING.

SUBJECTIVE VISUAL SENSATIONS.[1]

THE activity of the cerebral centres which is independent of their common exciting causes, and which is termed "discharge," presents indications of the character and loss of their function which can be obtained from no other source. Foremost in interest and also in importance are the sensations of sight which occur without stimulation of the retina. Of these the most important are two. (1) Those which occur at the onset of epileptic fits, from the "discharge" in the brain influencing consciousness, through the visual centre, before loss takes place. (2) Those which occur as the precursory symptoms of the paroxysmal headaches which, from their one-sided distribution, have been called "hemicrania," "megraine" or "megrim," from the frequent vomiting, "sick headaches," and, from the inhibitory loss of sight, "blind headaches." These two classes form the subject of the lecture.

In what part of the brain does the process occur? The impulses from the retina reach the cortex of the brain first in the extremity of the occipital lobe, where, as Munk first showed, the half-fields are represented in strictly local definiteness. The left occipital lobe receives the impulses from the left half of each retina, produced by the rays of light from the right half of each field of vision. So, conversely, with the right occipital lobe. To each side, impulses proceed from a very minute area around the central point of the retina, the fixation point of the field. But we cannot conceive that the functional disturbance occurs in these centres, for the strict medial division in two halves is absolutely ignored by the subjective sensations. Moreover, the strange but certain facts of hysterical hemianæsthesia, in which there is inhibition of all the sensory centres of one hemisphere, present us with remarkable evidence of the higher visual function in each hemisphere. This is supported by some cases of organic disease, which cause an affection of sight similar to that of hysteria, and by more common cases of hemianopia from disease of the hemisphere, in which there is a precisely similar contraction of the remaining half-fields. The significance of all these is that the early conclusions of Ferrier are correct, and that, in addition to the lower, occipital half-vision centre, there is a higher centre in each hemisphere, situated in the region of the angular convolution. This theory of the double visual centres, consisting of a combination of the conclusions of Ferrier and Munk, was first stated by the lecturer in 1885, and has been confirmed by all the facts he has since met with. It is indispensable for the comprehension of morbid functional action, and, indeed, for that of normal vision, but is not yet recognised by physiologists, even as hypothetical.

The character of the function of this centre, so far as it can be discerned from the facts of its loss, are of great importance for the study of visual sensations. The two higher centres seem to be blended into one in function in a manner that is unique so far as our knowledge extends. If the centre on one side is functionless, there is loss of sight in the periphery of both visual fields; there is vision in the central third of the eye on the same side, and a far smaller central area on the opposite side. The only conclusion is the startling inference that either higher centre can subserve central vision in both eyes, but that peripheral vision depends on the co-operation of the function of both hemispheres. Between the central area for which either centre suffices and the peripheral area for which neither is competent but both are needed, there is an intermediate zone in which vision is subserved only by the opposite hemisphere when acting alone. This gradation of functional capacity enables some facts of subjective sensations to be comprehended which cannot otherwise be understood.

Moreover, the facts suggest that the function of these higher centres is quite different from that of the lower ones, and from that of other cerebral centres the action of which we can study. In the lower half-vision centres function is localised, so that destruction of part causes absolute loss of a part of the half-field, blindness of the corresponding part of the retina. But partial

[1] The Bowman Lecture, delivered before the Ophthalmological Society, by Dr. W. R. Gowers, F.R.S., June 14.