SOME NOTES ON JUPITER DURING HIS OPPOSITION OF 1876.

BY G. D. HIRST.

[Read before the Royal Society of N.S.W., 2 August, 1876.]

I suppose that of all the members of our solar system, with the exception perhaps of our satellite, the Moon, there is no object that so soon engages the interest or more readily yields to the scrutiny of the amateur astronomer, when, with his newly-acquired telescope before him, he sets himself to investigate some of the wonders of the heavens of which he has been hitherto altogether heedless, or which at best have excited his idle curiosity as they have met his gaze, than the giant of our planet-neighbours, Jupiter; and the reason of this a slight inquiry will, I think, make obvious.

Mercury, as far as we at present know the closest of our Sun's attendants, is an almost hopeless object for even the possessor of the finest telescope. His minute size, and in consequence of his position his intense luminosity, prevent anything like details ever being seen. Moreover, when in his most favourable position for observation, which is when he is furthest from the Sun, we, from his orbit being interior to the Earth's, see but half his disk illuminated. Therefore, to these unfavourable circumstances we must attribute the title Mr. Webb has given him in his "Celestial Objects" of a neglected subject.

To Venus much the same arguments apply. Being larger than Mercury, and also nearer to the Earth, we certainly do see somewhat more of her; but her brilliance baffles all satisfactory definition, and I think no well-accredited markings or details of any sort have ever yet been accorded of this, to the eye most beautiful, but in the telescope most disappointing, planet.

Passing now to Mars, the first exterior planet to the Earth, we see what neither of the interior two can ever show us—a full round disk illuminated by the solar light; and we have the further advantage of our object being brought at favourable oppositions very near the Earth. Here we can see marks which no very great stretch of imagination or analogy may lead us to suppose as representing land and water, more especially as adequate optical means enable us to discern white spots at his
poles, which, by their diminishing during the Martial summer and increasing in his winter, convince us to be ice. Still, with the possessors of small telescopes, Mars is not I think a prime favourite. The period during which we can advantageously observe him is short—a few weeks before and after opposition; after which he rapidly recedes from us, and his orbit carries him so far off that his disk dwindles down to most uninteresting proportions, and his markings are lost to all small glasses. Besides, even at opposition it requires a really good and powerful telescope to do satisfactory work on Mars. In the best drawings that I have seen there is a strange haziness about details, and different observers appear to me to disagree most woefully in their delineations.

Saturn has for many I must confess, including myself, a large number of attractions. I cannot well dwell at present on the subject, as it is foreign to the object of this paper; and even a short account of his wondrous details would require a paper by itself. Still, confining myself to the premise that I am speaking almost exclusively of amateurs, and as such possessing only moderately powerful telescopes, Saturn, from his enormous distance, presents difficulties which Jupiter does not; his ring, with Ball's division, perhaps a belt, and three or four of his satellites, are as much as most small telescopes show; what has been discovered besides are details of great delicacy, and some points connected with Saturn remain tests for the largest and most perfect telescopes of the present day.

So there remain but Uranus and Neptune; and I wonder, out of all that have ever lived on the earth, how many have ever seen these at all. Indeed, a very few. They might, I fancy, be counted on your fingers; and, should an ordinary observer get one of these outside wanderers by accident into the field of his glass, he would probably pass them by as fixed stars.

We return therefore to the subject which brings me before you—Jupiter. How readily his noble disk shows out in even the smallest glass, many of you—and I suppose that there are few here who at some time or other have not seen him through a telescope—are well aware. An aperture of even a couple of inches will show some signs of streaks on his disk, and his moons quite brilliantly. As we increase our aperture and power, more and more detail comes into view, the belts assume definite form, traces of colour are seen, and his four satellites turn out very respectable-sized disks of their own. Their shadows, their occultations, and their eclipses present a scene of ever-varying interest and beauty; and this, with the extreme facility with which it can be seen in even what are now considered small telescopes, makes Jupiter, as I said before, a most interesting object for all amateur observers.
About the beginning of May the following circular from the Royal Astronomical Society, London, was handed to me:

"Royal Astronomical Society,
Burlington House, London, W.,
March, 1876.

"The periodicity of changes in the colour and markings upon the planet Jupiter, and the connection that has been suggested between them and the solar phenomena, render it most desirable that a general system of observation of the planet should be organized. To this end, Dr. Lohse, in the year 1873, appealed to astronomers in the Northern hemisphere, and a response was made which has enabled him to collect and put on record many valuable descriptions and drawings of the planet's appearance since that time.

"The Royal Astronomical Society of London is deeply impressed with the importance of the question; and to assist in carrying out the plan of international observation suggested by Dr. Lohse, it has appointed us as a committee to endeavour to enlist the sympathies of observers generally, so as to obtain as extensive a series of observations as possible.

"The Southern declination of the planet will for a few years prevent satisfactory results being obtained in Europe, and we therefore desire to appeal to Southern observers to continue the work already begun.

"Drawings of the planet's appearance should be made as frequently as possible, giving in all cases the local or Greenwich meantime of the sketch, with particulars of the instrument and power employed, and the state of atmospheric definition.

"Careful notes of the tints and colours of the belts are most important.

"Particular attention is requested to the occurrence of the small bright spots, first observed by Mr. Lassell, and to the approximate Jovianentric latitudes in which these spots appear; also to small black spots which are occasionally seen in the equatorial zone.

"The phenomena presented by the satellites in transit, and their varying brightness considered with respect to their orbital position, are matters on which accurate observations are much desired.

"To ensure uniformity, we beg to send you some forms on which drawings can be made. These have a polar flattening of one-sixteenth. In all cases the north and south poles of the planet should be indicated in the drawing.

"All drawings and communications should be sent to 'The Secretary of the Jupiter Committee,' Royal Astronomical Society, Burlington House, London, W.

"Your obedient servants,
WILLIAM HUGGINS.
E. B. KNOBEL.
LINDSAY.
OSW. LOHSE.
A. C. RANYARD.
ROSSÉ.
F. TERBY.
T. W. WEBB."

Having at the time the use of a fine 10½-inch silvered glass reflector, the property of Mr. J. U. C. Colyer, who has for these and other observations kindly placed it at my disposal, I determined immediately on receipt of this circular, to commence and carry out, as far as lay in my power, a systematic course of observations, accompanying them by sketches made at the telescope, and the results up to the present are now before you. In making these
drawings I have been aided by a most efficient driving-clock, which keeping the object in the centre of the field of the telescope leaves both the hands free for other work, the advantage of which can only be appreciated by those who, in their attempts to delineate the heavenly bodies, are obliged to have one hand constantly employed in screwing away at a handle, to follow the motion of the object as it rapidly flits through the field.

The construction also of the Newtonian reflector is peculiarly adapted for drawing purposes, as the erect position of the observer is easy and natural; and with your desk at your elbow, you can rapidly transfer your eyes from the telescope to the paper before you.

On the whole I must say that the weather we have been favoured with since I commenced these observations has not been eminently adapted to telescope-work. We have had a rather more than fair allowance of cloudy evenings, and many of the most brilliant nights have been utterly worthless, from their blurred and tremulous definition; moreover, there appears to be at all times present a considerable amount of vapour in the higher regions of the atmosphere, so that even when definition is most steady, you have a consciousness that you are looking at the object under a veil, the field of the telescope not appearing perfectly dark as it should do. This is more especially tantalizing, as even on some of the most inferior nights you get moments—they only last for a second—of most startling definition, when the planet seems to be brought to within half its usual distance, and details start out before you so numerous, and so complex, that the eye in that evanescent moment totally fails to grasp them, and the next second they are gone, and you are left with a dazed impression that you have seen something that would tax the skill of a far more accomplished artist than yourself to do the slightest justice to. I have at times—but only, as I said before, for a second—seen the whole of the disk of Jupiter covered with fine lines; even the white belts, which ordinarily present not a trace of marking, are scored by them all over; and the darker equatorial zone appears a mass of flocculent, cloudy matter; but to attempt to put this on paper during the fleeting moment it is visible is an impossibility.

While on this part of my subject I may mention that one of the first things that attracted my attention, when looking up the observations recorded of Jupiter during the last ten or fifteen years, was the remarkable paucity, I might almost say the entire absence, of any reliable or well-executed drawing of the planet. I must, of course, confine this assertion to any published drawings for there may be, and probably are, many fine delineations in the hands of those who drew them, which will never see the light; but speaking of those pictures which have been given to
the scientific world through the medium of the papers of astronomical societies, periodicals, or books, I must confess it a matter of great surprise, that so few and such crude attempts have yet been made to give to the general astronomical reading public an idea of the telescopic appearance of this, the most magnificent of our planets; and the reason I am at a loss to see; for as I have before said, Jupiter is certainly, excepting our Moon, the easiest of all telescopic objects, and after a little practice, any one I am sure, with a decent notion of using his pencil or chalks, may give a far more accurate representation of the planet than he will find in the most elaborate and expensive astronomical work he can lay his hands on. Very few drawings ever represent colours at all; in a very extensively got up work I have in my library the belts are represented as straight lines—as if, to save trouble, they had been drawn with a ruler; in others there is an attempt at a ragged, cloudy appearance, but the artists who represented them evidently drew from what they had heard rather than from what they had seen. Messrs. De La Rue and Lassell have both furnished what have been said to be remarkably fine drawings, and probably the originals may be; but if this is the case a lithograph copy of one of them that I have seen must be a most woeful libel. Mr. Browning, of London, has one or two coloured representations of Jupiter; his most recent, I think, is that in the fifth volume of the "Student and Intellectual Observer." The volume is now before you, and I should be glad if any member present would tell me if it represents anything like what he has ever seen of the planet. In making these remarks, be it understood, I am not claiming for my own attempts any superiority; nobody can be more conscious than I am myself of their shortcomings, and much that I have seen has baffled all my endeavours to pourtray—as for instance, I have again and again, on favourable opportunities, seen a perfectly metallic appearance on some parts of the equatorial zone, which I cannot even describe, much less draw; so what I have said is not so much to depreciate what has already been done, but to express a surprise that more has not been done in this class of astronomical work, by those who have the skill, the time, and the instrumental means.

You will notice that the circular of the Royal Astronomical Society expresses that a connection has been supposed to exist between some of the phenomena observed on Jupiter and the maximum and minimum of the solar spots. From the evidence as yet adduced it cannot be said at present to amount to more than a supposition; still, as Mr. Russell very pertinently observed on the first meeting of our Astronomical Section, speaking on this subject—"We may not but believe that any disturbance affecting our ruler (the Sun), must pulsate through the whole retinue of
his dependents, bound together inseparably as they are by the law of gravitation."

Whether these influences, as in the case of Jupiter, make themselves manifest to us by what our telescopes show us to be going on on his disk cannot yet however be placed among astronomical facts. It is to obtain evidence on this point that they are so anxious in the Northern hemisphere that Southern observers should fill the gap which, in consequence of the great Southern declination of Jupiter, would otherwise exist in the records on which this theory is to be built.

Turning our attention now to the minute white spots mentioned in the circular, let us see what records we can find of their previous appearance, and what connection we can trace between their apparition and the maximum of the solar spots. I think we shall find there are some striking coincidences.

The first account that I can lay my hand on is one by Cassini, in the "Mémoires de l'Académie" for 1692, where there is a paper in which he notices great changes and bright spots on Jupiter. I find there was a sun-spot maximum for the year 1693.

There are some observations of Sir William Herschel of white spots and irregular bands in 1778, 1779, and 1780. He also observes what he calls a similar appearance in 1790. Two very considerable solar and magnetic maxima occurred—the one in 1779, and the other in 1789.

In the year 1848 the Rev. W. R. Dawes perceived some very remarkable white spots in Jupiter, which he likened to the circular craters on the Moon, and on the 27th March of the following year, Mr. Lassell saw them in his 20-feet equatorial reflector. Again, in May of the same year, Professor Schumacker, of Altona, observed four or five of these features on one of the belts, which he thus describes:—"They are white spots, and are all perfectly round, distinct, and bright. The largest of them is as distinct and well-defined as the disk of a satellite appears in a 9-feet reflector. They are striking phenomena, keeping their relative positions, as they are carried along by Jupiter’s rotation, and there are no other similar spots on his disk." A sun-spot maximum occurred just at this time. De La Rue, in 1856, very near a sun-spot minimum, with 13 inches of aperture, makes a drawing showing no traces of white spots, and another drawing made at the same time by Piazzi Smyth, on Tenneriffe, agrees almost entirely with his. Lassell again, in 1859, approaching a spot maximum, figures the white markings, and says he "had failed to see these spots for many years, but latterly they had appeared again." In 1861, Sir W. Keith Murray contributed some drawings with a 9-inch refractor showing the spots, and other observers confirmed his observations with telescopes of 5 inches and upwards. At the same time the report of the
Greenwich Observatory states that, with the great equatorial, Jupiter presented appearances not previously recorded, and drawings made from that telescope by Mr. Carpenter coincided entirely with Sir W. Keith Murray’s. The next maximum of 1871 I find comparatively bare of records; but there are accounts scattered here and there among the notices of the Royal Astronomical Society, of bright spots and patches observed on the equatorial belt; and if my own negative evidence goes for anything, I may state that during this year, which is just after a spot minimum, though I have attentively watched for these phenomena, I cannot record a single sign of them.

Testimony so far appears to point to a strong probability of the connection of these remarkable features with our eleven-year solar disturbances; but more is needed before we accept the theory as a fact. If the Earth were viewed from a distance, the auroras most prevalent about the maximum period might give a perceptible tint to parts, but they would be near the poles; there might be similar phenomena producing similar changes on Jupiter.

The small black spots mentioned in the circular appear to be a class of objects of somewhat more recent observation, and, so far as we can judge from the few observations recorded of them, they seem to coincide with the solar minimum of spots, as the bright spots do with the maximum. They are somewhat minute objects, and might be easily overlooked unless the observer possessed a good glass of large aperture, and an eye used to this particular work; but granting these conditions—and they become on favourable nights very conspicuous and remarkable phenomena—I have at times seen these spots so intensely black that I could scarcely persuade myself that they were not the shadows of satellites crossing the disk of the planet; but that this is not the truth becomes apparent if we watch them, for they retain their relative position with the other markings, and rotate with them, which of course the shadows of satellites do not do. It is difficult not to believe that these spots have a different nature from the well-known shadings and belts: they are so hard in their outline, and so very much blacker than any of the other markings. It has been I believe suggested that they may be the tops of mountains protruding through the cloudy envelope surrounding Jupiter; but, if this is the case, they must possess extraordinarily feeble powers of reflection, to appear so dark by contrast with their surroundings.

I have prepared a diagram on a large scale of the disk of Jupiter, which I hope my astronomical friends present will not laugh at. It is not intended to present the appearance represented by Jupiter at any one time, but rather as a map combining some of the more remarkable and persistent features I have
observed on his disk. I hope by its aid to make some of my remarks more intelligible, and have purposely exaggerated both colours and markings, in order that they may at a distance make themselves more readily seen. The black spots, you will observe, make their appearance principally on the darker bands; in fact, I have only recorded one occasion on which I noticed a black spot on the brighter portion of the planet, but that was a very remarkable one; it was quite as black as the shadow of No. 1 satellite, and was connected with the equatorial belt by a thin ligament. The next thing I would direct your attention to is the colour of the various portions of the disk; and here we open Pandora's box of trouble; for different eyes, different telescopes, and different states of our atmosphere, combine to give most conflicting statements. There is matter enough in this portion of my subject to form a treatise by itself, but time will not permit me to do more than give a brief statement of facts, and leave theorizing on the matter for some other occasion. I would, however, first give you a short account of what I have been able to find recorded of previous observations of the colours of Jupiter, in order that you may compare them with my own, as illustrated in the drawings before you.

Sir William Herschel, in “The Philosophical Transactions, 1794,” says—“I viewed Jupiter with a 40-feet reflector. There are two very dark, broad belts, divided by an equatorial zone or space, the colour of which is of a yellow cast.” To take more recent observations, I note that on 7th November, 1869, Mr. T. Elger, of Bedford, says—“I noticed the space between the central belts was peculiarly ruddy.” Mr. Salter, of Manchester, says, on the same date—“The colour of the equatorial streak was rich tawny.” Mr. Gledhill, F.R.S., same date, says—“Whenever the air was good the ruddy tinge of the equatorial belt was easily seen.” A photograph of the planet taken in this year shows the equatorial belt absolutely transparent, the light from the ruddy belt having failed to act upon the sensitive plate; yet, speaking of this particular photograph, Mr. Browning says, he has seen photographs taken at other times when this belt exerted the most action. In the year 1871 Mr. John Browning devoted some attention to the planet, and his drawings show the equatorial belt to be of a bright yellow colour. Towards the end of 1871 there appears from various records to have been a general diminution in the intensity of the colours, and more especially in that of the equatorial belt, which had lost much of its yellowish hue. In 1872 Mr. Birmingham describes the equatorial belt as rose-coloured. In the same year Mr. Browning again draws the planet, and his views show a reddish yellow. The colour generally of the planet in this year, from various records, seems to have been particularly vivid, and Mr. Lassell appears especially struck with it. I will quote his
remarks, for perhaps some may think I may in my draw-
ing have been inclined somewhat to exaggerate the colours—
a fault I have most carefully tried to avoid. On the 2nd June,
1872, he says, using a 24-inch reflector—"I acknowledge that I
have been hitherto inclined to think that there might be some
exaggeration in the coloured views of the planet; but this pro-
erty of the disk on the occasion I speak of was so unmistakable
that my scepticism is at last beginning to yield. I have attempted
in the accompanying drawing to represent the colours as faith-
fully as I can, and to convey something like a general notion of
the distribution and intensity of the various lights and shades
scattered over the planet, but to give anything like a faithful
outline of the individual phenomena is far more than I can pre-
tend to." These words of Lassell have come home forcibly to
myself, again and again, when in moments of magnificent defini-
tion, such a wealth of detail has been presented to my sight that
my pencil has lain idly by, and I have been content to gaze in
almost open-mouthed wonder.

After 1872 the planet appears to have for some time shown no
remarkable amount of colour—at least I have not been able to
put my hand upon any observation in which the equatorial belt
has been especially noticed as presenting anything particularly
unusual in this respect. And Mr. Browning says, in June, 1873—
"The colour of the equatorial belt of Jupiter was fading during
the last weeks of the previous opposition; during the present
opposition the colour has been scarcely, if at all, perceptible."
In the same year Dr. Lohse, as you will have noticed in the cir-
cular, made an appeal to astronomers generally in the Northern
hemisphere, that drawings should be systematically taken of the
planet. One of the results of this request, and the only one that
I am able to show you, was a series of drawings made by Dr.
Copeland, using the great Lord Rosse telescope of 6-feet aperture.
A lithographic reproduction of these is now on the table. I believe
these drawings were thought a great deal of at the time, and they
were specially mentioned at a meeting of the Royal Astronomical
Society, as showing an immense amount of detail; but I may
mention that I have repeatedly observed more detail in the
10½-inch reflector on an ordinary night than is shown in any one
of them. You will observe moreover, that there is a reddish
tinge in all of them, pervading the whole of the disk. This I
cannot fancy really belongs to the planet, but is communicated
by the metallic reflector; for it is a known fact that these old
metallic reflectors gave all objects a ruddy hue, and it is believed
that this explains the appearance of so many red stars in the
elder Herschel's catalogue.

The most noticeable feature in these drawings of Lord Rosse
is the great loss of colour sustained by the equatorial belt. This
belt, which in 1870 was so red that, according to a naked eye observation of Dr. Copeland in September of that year, the general colour of the planet's light was affected by it, shows in nearly all these illustrations very little (if any) colour at all.

In the year 1874 there appears to have been an increase of colour, for Mr. E. B. Knobel says—"The colours of Jupiter this year have been far more conspicuous than in 1873. A marked change in the tint of the equatorial zone has taken place. In May 1873 it was observed of a decided brick-red tint. On no occasion this year has that tint been remarked, but a bronze yellow or sienna has prevailed for the whole period of observation, though perhaps on one or two nights it approached more to a rich yellow."

After remaining at a minimum of colour for two or three years, Jupiter seems now to be regaining his tints; but in many cases I have noticed a marked difference between what I now observe and what has been previously recorded. On first directing the telescope to this planet, at the beginning of May last, I was immediately struck with the bright orange-yellow of the equatorial zone. This was most conspicuous with all powers from 50 to 500, and could still be traced with the aperture reduced to 4 inches—the colour was of course much affected by bad definition—when the air was unsteady it required almost the full aperture to show its existence, and the reduction then required to give a clear perception of the dark streaks would render it almost invisible; but on a steady night, when a magnifying power of (say) 200 could be used with the full aperture, the equatorial zone has appeared almost invariably, with one or two exceptions which I shall mention by-and-by, of a rich orange. Shortly after I commenced the present series of drawings, I had occasion to show some of them to Mr. H. C. Russell, of the Observatory, who was himself engaged in similar observations. The first thing he said when he saw them was—"Why, you don't use the same colours that I do at all." A short time subsequently I went to the Observatory for the sake of comparing the telescopes, and to my utter surprise the equatorial belt that I had invariably observed with the reflector to be a tawny orange or yellow appeared in the 11-inch refractor of a bright rose-pink. That this was no sudden change in the planet has since been amply confirmed, for Mr. Russell's drawings and my own on the same nights show each the different colour. Moreover, I have on other occasions compared the glasses, and the same distinction still exists: the reflector continues to show the equatorial belt yellow, and the refractor pink. The same pinkish tint has been observed by me, though in a less degree, on account of the smaller aperture, in a fine 4-inch refractor, the property of Mr. Alfred Fairfax, of Double Bay. Mr. Russell has recently erected an 11-inch silvered glass reflector of his own manufacture at the Observatory, and he confirms my
opinion as to the tawny yellow of the equatorial zone, as seen in that description of telescope.

Now I must confess I am at present totally at a loss for a theory to account for these contradictions. The refractor showing, as the best object-glasses do, a fringe of uncorrected purple or violet light round a bright object such as Jupiter, ought according to theory, to give the planet if anything a yellow tint, that being the complementary colour; but this is exactly what it does not do. The refractor, on the contrary, ought to give a reddish cast, as the reflection from silver is slightly tinged with that hue; but this is just the colour that it refuses to show. There is some unexplained mystery here, which I cannot now stay to inquire into, but content myself with putting just the bare facts before you.

The great equatorial belt of Jupiter appears at times to be the seat of sudden and violent disturbances, taking place on a scale of which we can scarcely form any conception. I have seen the whole appearance of this belt alter during the interval of from one night to another, so that though the same portion of the disk was presented to the eye, not a single feature in this part of the planet could be recognized in the drawing of the previous night. One notable example of this occurred on the 24th May. The equatorial belt had presented a particularly quiescent appearance for some time before, occupying not more than a third or a fourth of Jupiter's diameter. On the evening of the 24th of that month I noticed that it had suddenly spread over fully one-half of the disk, and seemed to be the seat of the wildest commotion, being torn and twisted in the strangest manner. Curious to say, this only applied to one side of the planet, for the opposite side preserved the calm appearance before referred to, the equatorial zone being exceedingly narrow. This outbreak lasted for some two weeks, and then gradually appeared to calm down. On the 23rd June there was another similar outbreak, accompanied as before by another extension of the equatorial belt, and also—and this is why I particularly mention it in this part of my notes—by an almost total loss of the yellow colour so remarkably predominant before in this part of the planet. This loss of colour seems to arise from the spreading over the yellow belt of the dark-gray or chocolate-coloured bands with which it is usually streaked; during these out-breaks they appear to extend as it were laterally, and to colour almost completely the yellow, which is only then seen between them in thin streaks. A strange feature noticed by me on the 4th July was that one of these dusky bands was bordered by a narrow edge of crimson lake; it could not have been more than a second or two of arc in diameter, but was most vivid; and it gave me almost the impression as if I were looking at a scarlet or crimson flame.

The polar portions of Jupiter, to which I will next direct your
SOME NOTES ON JUPITER DURING HIS OPPOSITION OF 1876.

attention, do not present the same ever-varying character of the equatorial belt; the causes which produce such tremendous disturbances at the equator do not appear to affect in anything like the same degree the northern and southern latitudes. You will observe in the large diagram, that I have coloured the north pole a decidedly brownish green, and this is the almost uniform tint that it has presented to me. On evenings of bad definition the green is scarcely visible; but when the air is sufficiently steady it is most conspicuous, and is a very beautiful feature: it requires a certain amount of magnifying power and considerable aperture to bring it out well; it is scarcely apparent with anything under 100, and a power of not less than 200 is by far the best, if the air will bear it. The reflector seems to possess a decided advantage over the refractor in showing the green tint; in the large Observatory achromatic it appears to me more of a smoky brown. The only record I can find of a green tint being observed at the poles is one in the “Transactions of the Royal Astronomical Society,” by Miss Hirst, a lady residing in Auckland, who observed Jupiter during his opposition in 1875 with an 8½-inch reflector. She says—“On February 20th I noticed a small oval patch of a decided sea-green at the south pole, which on the following morning was more elongated and a shade darker in the centre. It remained thus for three days, and has not since been seen.” The south pole has on all occasions been tinted with a warm gray. The most remarkable feature on this portion of the planet has been the persistent appearance of a cloudy mottling, which I have attempted to represent in the diagram. This was first noticed on the 3rd May, and it has continued to appear at intervals up to the present date.

Of the markings generally on the planet there are one or two which I will mention as being particularly characteristic and persistent. The strangest-looking of them is the one Mr. Russell and myself called the “Fish,” on account of its presenting something of that form. It first made its appearance during the great outbreak about the 24th May; and it existed, though somewhat altered in shape, until the 4th July; there were always one or two black spots on the southern edge of it. The next peculiar marking was one I called the “Tuning-fork.” I have represented it here on the diagram. On the north rim of the equatorial belt there appeared from the beginning of May to the middle of June a succession of remarkable breaks, the dark band on the following side being as it were cut short off, and on the preceding side it is thrown suddenly up, and extends right across the disk in a thin streak.

We have been accustomed to talk of the belts and clouds of Jupiter as if they were in their nature somewhat analogous to the clouds of watery vapour in our own atmosphere, or as perhaps
exhalations from molten matter constituting the body of the planet. But there is sometimes a strange persistency in these features, which seems incompatible with a vaporous nature only; and I think that those who have had the best opportunities for observation in this particular subject will be the last to hazard an opinion as to their origin. Unfortunately, too, the spectroscope fails to help us here: for Jupiter, shining as he does by reflected light, gives back the solar spectrum, with the addition of a few lines somewhat similar to those added when the sun is low down, and, consequently, shining through a considerable extent of our atmosphere. The spectrum, too, of Jupiter is, contrary to what many would suppose, exceedingly faint, being only about equal to that of a third magnitude star; the brilliant aspect that he presents to the eye being occasioned by the immense size of his disk, and not by its intrinsic luminosity. When I say that Jupiter shines only by reflected light I am aware that amongst some eminent authorities it is believed that he does emit somewhat more light than he receives; and Proctor, writing on this subject, says—"If Jupiter does not shine somewhat by native light, his surface must possess reflective powers nearly equal to white paper, which is scarcely credible." But this excess of brilliance, if it does exist, is too small to make any difference in the spectrum.

I feel the limits that I can fairly allow myself for occupying your attention will not permit of my entering into half of the many features which this interesting planet has presented during the present opposition, and of which I am persuaded much is new, and has in consequence never been recorded before. I will not, therefore, dwell now on the phenomena connected with the satellites, their transits, their shadows, and many other details of which more than enough remain for another discussion. Still less would I detain you by any attempt of my own to theorize on these wonderful and complex operations taking place on such a mighty scale—a scale of which the inhabitants of our little globe, 8,000 miles in diameter, can form no adequate idea. What, for instance, should we think if we saw, supposing that we could see, a black mass of vapour, or it may be of some far more solid substance, 22,000 miles in extent, suddenly break up and disappear in the course of a few minutes; and yet this very phenomenon was recorded by Sir James South to have taken place on one occasion when he was observing Jupiter.

There is, however, one theory of Proctor's in reference to the condition of Jupiter as affecting his colour which I will mention, as it seems to me to be one of the most reasonable yet broached, and moreover appears to accord well with observation. He thinks at a first view that nothing could appear more surprising than a change affecting the colour of a zone-shaped region whose surface is many times greater than the surface of our earth.
A brief change might be readily explained as due to such causes as affect our own air. Large regions of the Earth are at one time cloud-covered, and at another time free from clouds; such regions seen from Venus or Mercury would at one time appear white, and at another would show whatever colour the actual surface of the ground might possess when viewed as a whole. But it seems altogether impossible to explain in this way a change or series of changes occupying many years, as in the case of the colour changes of Jupiter's belt. It is one of the strongest arguments against the theory that solar action has to do with these changes, that any changes produced by solar influence would be so slight as to be in effect scarcely perceptible. If, however, Jupiter's whole mass be in a state of intense heat, we can understand any changes, however amazing; we can see that enormous quantities of vapour must be continually generated in the lower regions, to be condensed in the upper; and although we may not be able to indicate the precise reason why at one time the mid-zone or any other belt on Jupiter's surface should exhibit the whiteness which would seem to indicate the presence of clouds, and at another should show a colouring which appears to indicate that the glowing mass below is partly disclosed, we remember that the difficulty corresponds in character to that which is presented by the phenomena of solar spots. The most probable hypothesis appears to be that the ruddy glow of Jupiter's equatorial belt is due to the inherent light of glowing matter underneath his deep and cloud-laden atmosphere.

This seems, as I said before, to be about the best theory yet advanced in this matter; but the human mind craves for something more substantial than mere supposition. And the questions that naturally arise when concluding a series of observations like the present are—Shall we ever in our present state know any more of the real nature and purpose of these magnificent orbs; shall this opposition of 1876 ever furnish a link in the chain that is to lift the veil that hangs on all outside; or are we but accumulating a pile of facts, a mass of observations, which, like the scattered necklace-beads, want the connecting string to form them into one harmonious whole? Are we, like the benighted wanderer in the desert, travelling in a circle, to find ourselves back at the point whence we started? Is it ever with the telescope and spectroscope to be "thus far and no farther"?

No! I cannot but believe that the time will come, though it be generations hence, when the fruit of many years of patient watching shall be,—the reversal of the complex pattern on the underside of which we have so long toiled, tracing with anxious care its numberless perplexing threads, and then the design of the Creator in the solar system will stand revealed in all its symmetry and beauty.
DISCUSSION.

Mr. H. C. Russell said, that Mr. Hirst had done a valuable work in watching so closely the changes which had taken place in the planet Jupiter during the present winter. A great many curious things had appeared.

Mr. Hirst had tried to collect the observations made upon the white spots, and to show that they had some connexion with the periods of the maximum sun-spots. If such a connexion could be shown satisfactorily, it would have much interest; but in 1863 he (Mr. Russell) saw the white spots on Jupiter most distinctly. He had never seen them so well since, and 1860 was the maximum sun-spot period before 1870.

The black spots were similar in form to the white spots. A theory had been hazarded that perhaps they were cyclones opening up the cloud envelope which is supposed to reflect the sun's light to us. If so, the persistence they maintain in their relative distances is very curious. He (Mr. Russell) had not been able to detect any difference in their position for a considerable time. Jupiter is 1,300 or 1,400 times the size of the earth, yet his revolution only takes 10 hours. If these cloud accumulations are produced by the revolution of the planet, the velocity of the currents must, therefore, be something enormous. Some of the markings on the planet Jupiter have been seen to recur years after, and we cannot conceive of any peculiar cloud-form recurring after a number of years. It seems probable that something solid has been seen on these occasions. We cannot expect cloud-forms to have that definite character and to retain it. His own opinion was that the great changes which had occurred within short intervals were simply changes in the state of definition, not changes on the planet, but changes in our power to see it. He had lost sight of certain features one night, and seen them another night.

In June, when we had a great change in the state of our atmosphere, the colour of the planet was altered. He thought the colour of the planet depended on the state of the air over our heads. The colours of the stars depend on something very mysterious. Being struck with the differences of colour observed through different telescopes, he had put a graduated scale of colours, varying from green to red, through yellow and orange. Through the telescope there came to view a definite point at which the yellow changed to pink—a point not visible to the naked eye at all. With a silver-glass reflecting telescope he observed the same phenomenon. He could only explain this by supposing that the pink had been put over the yellow.
Mr. Hirst said that, as to the sudden disappearance of some of the markings, the remark of Mr. Russell was hardly borne out by some existing observations. Sir James South mentioned that a black patch on Jupiter, representing a space on the planet 22,000 miles in diameter, totally disappeared in the course of a few minutes. Such a conspicuous marking could scarcely be blotted out in a moment by bad definition.