Vol. III. No. 4.

The Journal

of the

Astronomical Society of South Africa

Edited by:

J. JACKSON, M.A., D.Sc., F.R.A.S.

Contents.

THE TRANSLUCENCY OF SATURN'S RINGS 139
By D. G. McIntyre, F.R.A.S.

REVIEWS 162

OBITUARY 165

REPORT OF COUNCIL FOR 1933-34 168

SECTIONAL REPORTS—
Comet Section 169
Variable Star Section 170
Mathematical Section 173

REPORT OF CAPE CENTRE 174

REPORT OF NATAL CENTRE 176

LIST OF OFFICE BEARERS 178

Published by the Society, P.O. Box 2061, Cape Town.
Price to Members and Associates — One Shilling.
Price to Non-Members — Two Shillings.

APRIL, 1935.

The Journal of the Astronomical Society of South Africa.

Vol. III. APRIL, 1935. No. 4.

THE TRANSLUCENCY OF SATURN'S RINGS.

By D. G. McIntyre, F.R.A.S.

(Presidential Address, Session 1933-1934.)

Introduction.

Material substances may be broadly segregated into two classes: those which transmit light—the transparent, and those which intercept the light falling upon them—the opaque. None of them, it is true, is either absolutely transparent or absolutely opaque. Light is intercepted, to some degree, by air, water and glass, while it will penetrate thin layers of metal. Some substances occupy, indeed, a midway position; they are penetrable to a greater or less extent by light, though an object cannot be seen distinctly through them. Such substances are named "translucent."

The idea that this property of translucency might be manifested in Saturn's rings is recent. The appendages to Saturn, the ansae or "handles," as they were called, which so puzzled Galileo, were not resolved into an encircling ring by Huygens until 1655. Huygens showed how his explanation fitted all the appearances of Saturn; for the ring would shrink, disappear, reappear and open out as the earth passed from North to South and from South to North through its plane.

At first the ring was thought to be a homogeneous unit—solid, rigid, opaque. But in 1675, Cassini saw "the breadth of the ring . . . divided by a dark line into two equal parts, of which the interior and nearer one to the globe was very bright, and the exterior part slightly dark." His impression was that the ring was "a double ring."

Cassini's belief that his "dark line" was a division was not generally accepted until the elder Herschel had seen and measured it upon both the northern and southern planes of the ring. From this and other observations, Herschel concluded that the planet had two concentric rings of unequal dimensions and breadth, situated in one plane, and at a considerable distance from each other. Two rings, however, were the most Herschel would allow. Observations of other divisions by Cassini, Short, Hadley, and by himself, he set aside as "wanting more confirmation."

Confirmation was to come from such skilled observers as Encke, the Struves, Kater, Jacob, Dawes, Perrotin, Lockyer, Antoniadi and Lowell. None of the divisions observed by these observers appears to have the permanence of Cassini's, with the possible exception of a division in the outer ring known as Encke's Division.

The next important telescopic discovery was—as will be seen later—really a rediscovery, and was made independently by Bond in America and Dawes in England in 1850. They observed a third dusky ring extending about half-way between the inner bright ring and the globe of Saturn. It was described by Lassell, to whom Dawes showed it, as "something like a crape veil covering a part of the sky within the inner ring"

While the telescopic observers were busy disintegrating the homogeneous, rigid and opaque ring of early theory, the mathematicians were also investigating. Robertval in the 17th century and Cassini in 1715 had suggested that the rings were composed of small satellites, a hypothesis which was independently advanced by Thomas Wright thirty-five years later in his book "An Original Theory of the Universe." Bond revived the idea to account for the dusky transparency of the crape ring. Hypothesis became established theory when in 1859 Clerk Maxwell showed by a mathematical investigation that if the rings were solid they would form an unstable system in which the smallest disturbing force would cause a catastrophic break-up. He showed, too, that the rings could not be fluid, but that the system would be stable if the rings consisted of a swarm of separate particles moving in orbits nearly circular and in one plane. "The final result, therefore, of the mechanical theory," Maxwell concluded, "is that the only system of rings which can exist is one composed of an indefinite number of particles, revolving round the planet with different velocities according to their respective distances." He also said that these particles could be solid or liquid, but that they must be independent.

In 1895 Keeler obtained spectroscopic proof of Maxwell's conclusion. He photographed the spectrum of Saturn with the slit parallel to the major axis of the ring. After this exposure, the spectrum of the moon was photographed on each side of the spectrum of Saturn and nearly in contact with it. These photographs showed very clearly the relative displacement of the lines in the spectrum of the ring due to its motion in opposite directions on the eastern and western sides of the globe; they also showed displacements which indicated that the inner edge of the bright ring is revolving 2½ miles a second faster than the outside of the outer ring. This, of course, is in accordance with Kepler's third law, and may be regarded as proof that the rings are an aggregation of separate particles revolving around Saturn.

Because the rings are such an aggregation, it has been very generally held that the brightness or duskiness of different portions of the ring system is due to differences in the density and thickness of the distribution of the component particles. This assumes a fairly uniform albedo throughout the particles.

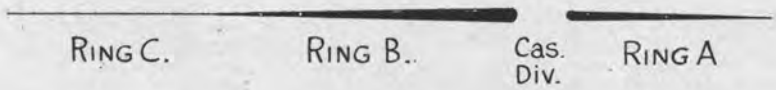

Fig. 1

If this premise is correct, it follows that a section through the ring system would appear something like Fig. 1, in which, however, the proportionate thickness of the rings is enormously exaggerated. In this diagram the rings are designated according to Struve's nomenclature, which will be followed from now on; the outer ring will be called Ring A, the division between the ring and the bright central ring will be called Cassini's Division, the central ring will be called Ring B, and the inner (or crape) ring will be called Ring C.

Of the divisions, only Cassini's is shown in the diagram. The divisions seen by Dawes, Lowell and others seem to be of a transitory nature. This is probably to be expected; for if the rings consist of streams of small particles, perturbations would very likely cause divisions to appear from time to time and to close up again.

Non-Obscuration in the Saturnian System.

That the space between the globe of the planet and Ring C is actually the background of the heavens, and that Cassini's Division is an actual division between Rings A and B, are facts which have been verified by direct telescopic observations. These observations are cogent to the evidence that the rings are translucent, and so are included here.

About the year 1707 or 1708, Dr. Samuel Clarke and the elder Whiston, observing with a 17-ft. refractor, saw a star between the rings and the globe. Proctor remarks of this observation that "such an occurrence is not infrequent with modern telescopes, especially when Saturn is transversing the constellations Taurus and Gemini in the one part, Scorpio and Sagittarius in the opposite part of the Zodiac." It would be interesting to learn on what authority Proctor based this statement. Research by Webb and others failed to find a parallel to Clarke and Whiston's observation, which is very possibly unique. As we shall see presently, there is, however, other telescopic evidence that the space between the planet and its rings is free, or nearly free, of obscuring matter.

That the Cassini Division is relatively free of such matter was first suspected by Lassell in 1852, some years before theory had demonstrated the nature of the rings and the cause of the division. Writing from Valetta on November 1 of that year he says, in discussing the appearance of the planet and rings:—"There is evidently also a sudden paleness of the main division of the rings where it crosses the ball as if, in some degree at least, *the ball were seen through the division.*"

Lassell's observation was forgotten, but thirty-one years later, almost to the day, a similar observation was made by Professors C. A. Young and Hall, observing with the 23-inch equatorial of the Halstead Observatory in America. Not only were the observers using a superlative instrument, but—in Professor Young's own words—"the seeing was very fine at the time," and there can be no doubt that these two skilled observers did see the globe of Saturn through the Cassini Division in the ring system.

Similar observations were made in 1913 by G. and V. Fournier, using a refractor of 19.69 inches aperture in the clear atmosphere of Setif, Northern Algeria. These observers saw "easily" the surface of Saturn through Cassini's Division.

For an observation of this nature to be possible it is necessary for the ring system to be widely opened and for the earth and sun to be equally, or very nearly equally, elevated

above its plane. It is noteworthy that in the three years, 1852, 1883 and 1913, when astronomers succeeded in peering through the division, the part of the planet's surface seen was in the northern hemisphere. Attempts made when the surface, if seen, would have been in the southern hemisphere have so far failed. A particularly favourable opportunity of seeing the southern surface occurred on July 17, 1902. The planet was observed in England and Australia without success. Is this because the two hemispheres have different albedoes, or because the seeing was superior in the years of success?

The Translucency of Ring C.

None will question the translucency of Ring C—the Crape Ring. It is more than translucent; it is all but transparent. As a consequence, its discovery was missed for years, although many observers unconsciously detected it and drew it where it crossed the globe of the planet, believing it to be a belt. Thus traces of Ring C have been found in a drawing executed by Campani so long ago as 1664. Picard drew it as a belt in 1673, Hadley in 1720. A magnificent drawing of Saturn by the elder Herschel is reproduced in the Philosophical Transactions of the Royal Society for 1794; it shows Saturn as Herschel saw it on the night of November 11, 1793. Anyone studying this drawing closely cannot but admit that Herschel would have discovered the Crape Ring on that occasion had his attention not been concentrated on the several belts on the globe. He has drawn it across the globe. He shows the extremities of a belt protruding from beneath it and there is a significant darkening on the inner edge of Ring B, particularly in the ansae.

Not until 1828 was Ring C seen as a ring and traced in the ansae and across the globe by an assistant in the Rome Observatory. This observation was reported to Secchi at the time, but, strangely, it was accorded no further notice. Ten years later Galle of Berlin detected and measured Ring C very accurately, but again no notice was taken of the observation. Proctor says that "it was only through the neglect of Encke, the Director of the Berlin Observatory, that Galle's observations were shelved"; but this is hard on Encke, for the observations were communicated at the time to the Berlin Academy of Sciences. Whatever the reason, Galle's discovery was forgotten, and not till 1850 was the ring rediscovered independently by Bond in America and Dawes in England. Since then, it has been under constant observation.

Since its rediscovery the semi-transparent nature of this ring has been obvious to observers, for the ball of the planet

has consistently been seen through it. True, this semi-transparency is variable; sometimes the ring is semi-transparent throughout, at other times—there is, for example, a classic observation by Trouvelot in 1876—the semi-transparency gradually diminishes from the inner edge of the ring and the limb of Saturn cannot be traced more than a portion of the way across. These changes may be due to a variety of causes; the angle which the ring subtends with the line of sight; the relative positions of Saturn, the sun and the earth; or fluctuations in the aggregation of particles in the observed portion of the ring.

The translucency of Ring C has also been investigated in a series of splendid observations by Professor E. E. Barnard. One possible method of testing for translucency would be to see if Saturn's satellites remained dimly visible when eclipsed in the shadow of the rings. Unfortunately, the inner satellites are all very nearly in the plane of the rings and so can never be occulted or eclipsed by them. The eighth satellite, Iapetus, however, has an orbit inclined at about 10 degrees to the ring plane. This means that in a certain rare combination of circumstances Iapetus will be eclipsed by the rings.

In Monthly Notices (Vol. xlix., p. 427) for June, 1889, Marth predicted that such an eclipse would occur on the night and morning of November 1 and 2, 1889. Barnard determined to observe this phenomenon, but unfortunately its earlier phases had occurred before Saturn rose above his horizon. Because of the planet's awkward position after rising, he was compelled to use the 12-inch telescope of the Lick Observatory, and did not observe with the 36-inch as stated in the latest edition of Webb's Celestial Objects. After the planet rose he watched for some time, and, "at 5h. 25m. sidereal time, the satellite Iapetus was faintly caught, and for at least one-half minute before this it was seen, but so faint and uncertain that it was not recorded. At the above time it was about as bright as Enceladus. Its light increased pretty rapidly and the idea at once occurred that it would be an excellent plan to test the shadow of the Crape Ring on the visibility of the satellite."

Fig. 2 is drawn after a diagram by Barnard and shows the variation he noted in the brightness of Iapetus. The method he employed in assessing this brightness was to compare it with the brightness of Tethys and Enceladus. Barnard assumed that these satellites differed from one another in brightness by a magnitude, as shown in the diagram, where the vertical scale corresponds to brightness (in 10ths of a magnitude) and the horizontal to time.

Barnard's observations show that after passing through the sunlight shining between the ball and the rings (another proof of the freedom of this portion of the system from obscuring matter) Iapetus entered the shadow of Ring C. As it passed deeper into this the absorption of the sunlight became more and more pronounced, until finally the satellite entered the shadow of Ring B and disappeared. Barnard remarked that his observations of "the disappearance of the satellite into the shadow of the bright ring shows that, so far as the penetration of the solar rays is concerned, the bright ring is fully as opaque as the globe of Saturn itself." He was to modify this opinion of the opacity of Ring B over seventeen years later.

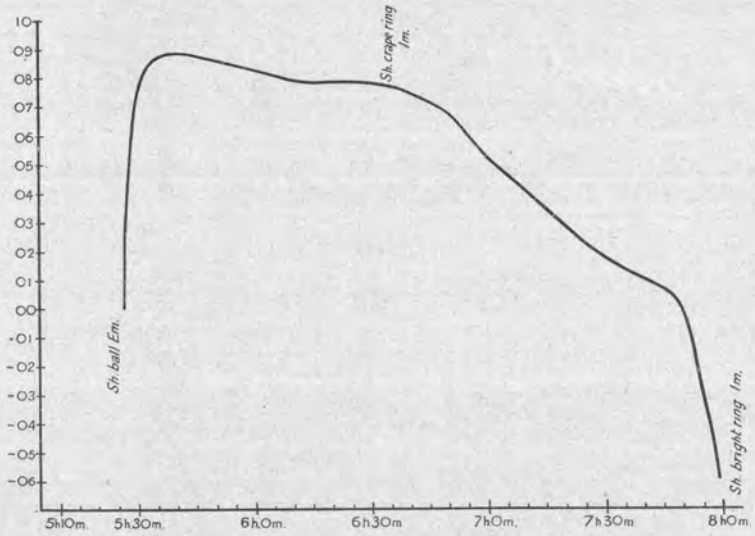

Fig. 2.

The importance of Barnard's observation is not that it teaches anything about the opacity of Ring B. It is (i) that it so clearly demonstrates that the space between the rings and the globe is free or nearly free of obscuring matter; and (ii) even more important, that it provides the only quantitative data on the transparency of Ring C.

So far as it affects the ring system as a whole, the full extent of Barnard's observation was that he watched the satellite throughout its passage through the shadow of Ring C and saw it disappear in the shadow of Ring B. It had not been long

obscured when the approach of daylight put an end to observation. This must be emphasised because extravagant accounts of the circumstances have been circulated. For example, a distinguished geophysicist, referring to Barnard's observation in Monthly Notices for December, 1916, wrote that it showed that Iapetus "is quite invisible when it passes into the shadow of either of the main rings, but visible behind Cassini's Division and the Crape Ring." Barnard looked for the satellite during only a portion of the time it was in the shadow of Ring B; he was not observing when it was eclipsed by Ring A; and it certainly was never visible to him in the sunlight shining through Cassini's Division. (Not until 1919, February 28, was Ellison to see Iapetus thus illuminated.) Error begets error, and the erroneous account of Barnard's observation has been adduced as evidence of the opacity of Rings A and B. The erroneous report that Barnard was observing with the big Lick refractor —a telescope of nearly nine times the light-grasp of the instrument employed—has lent additional weight to this "evidence."

In 1907 Barnard verified earlier observations of the rings with the earth and sun on opposite sides of the ring system. When this happens, the unlit side of the rings is, of course, turned towards the earth. Barnard's own description of the appearance of the rings at such a time may be quoted. On the night of 1907, July 2, "the entire surface of the ring was easily visible (in the Yerkes 40-inch telescope), though the sun was not then shining on its visible surface. Where it was projected on the sky, the ring appeared as a greyish hazy or nebulous strip, which was not well defined under the best conditions. It was about 1.5 times as broad as the trace of the ring on the ball. Nothing could be seen of the sunlit edge of the ring, which must have been too thin to be visible. There were two nebulous condensations of a greater brightness on the ring at each side of the planet. These were ill-defined and nebulous, and of a pale grey colour."

The curious phenomenon thus recorded by Barnard had been seen during the nineteenth century by a number of astronomers, each of whom seems to have thought he was observing something new. It had been interpreted in several ways. Dawes concluded that the rings must possess an atmosphere, particularly in the regions where the condensations occur. Professor G. A. Hirn believed them to be composed of separate satellites, each with an atmosphere of its own. Bond elaborated an ingenious hypothesis ascribing the condensations to the concurrent effect of light reflected by the edges, internal and external, of the rings. Lowell's explanation of the phenomenon was that the rings are not flat, but thickened rings or "tores."

The possibility of atmosphere in the ring system had been disposed of by Maxwell, who pointed out that, if there were any such medium in the vicinity of Ring C, the limb of Saturn would be distorted when viewed through it, whereas no distortion was observed. The existence of an atmosphere is also negatived by photographs taken through colour screens. These indicate that while there is an atmosphere about the globe, there is none about the rings.

The hypothesis of satellites with atmospheres of their own has to be abandoned because, to retain their atmospheres, the satellites would have to be of a size far in excess of that which both theory and observation allow.

Bond's hypothesis that the effect is due to reflection of light from the edges of the rings has been disposed of by Barnard's observations. Observing the rings on occasions when the earth was passing through their plane, first with the Lick and later with the Yerkes telescope, he could not detect a trace of the edge of the ring system. This indicates that in all probability the rings are so thin that the amount of reflection from their edges is negligible.

Nor does Lowell's hypothesis appear to be satisfactory. Dr. G. R. Goldsbrough, however, in discussing the divisions in the rings, demonstrates that they owe their existence to the gravitational attraction of the satellites, and adds that thickening of the rings near the divisions (Lowell's "tores") could be explained by oscillation, subject to this attraction taking place not only in the plane of the rings but at right angles to it. Barnard's observations of the invisibility of the rings "edge-on," however, seem to dispose of the existence of these thickened tores. Further, in a more recent investigation of the dynamics of the rings, Dr. H. Jeffreys demonstrates the probability that collisions between the constituent particles of the rings would be so frequent "that motion perpendicular to the plane of the ring must be annulled in a year or two, so that the thickness of the ring must be too small to be observed when seen edge-on."

This appears to dispose of Lowell. Barnard's own belief was that, because he had glimpsed the rings faintly between and beyond the condensations, the ring system was translucent throughout, but particularly in the regions of condensation. The rings, in fact, were made visible by sunlight filtering through them. This view was endorsed by Major P. H. Hepburn, but to many it does not seem an entirely satisfactory explanation.

One feature of the phenomenon which impressed Barnard was that the inner and outer condensations were symmetrical with respect to the centre of Saturn. His first idea was that the outer condensations were located upon the outer part of

Ring B and the inner condensations about the Crape Ring. To test this idea he submitted the condensations to careful microscopic measurement, and compared his results with measures of the rings taken when they were most fully open. The comparison apparently established that the condensations were connected with Cassini's Division and with Ring C, as the following figures show :—

Outer edge of outer condensation from centre of system	17″.48
Outer edge of Cassini's Division from centre of system	17″.52
Outer edge of inner condensation from centre of system	12″.90
Outer edge of Ring C from centre of system	12″.82

These measures, then, seem to connect the condensations directly with Ring C and with Cassini's Division. In Ring C it seems that the particles are so thinly and sparsely distributed that sunlight sifts through and they can be seen illuminated when viewed from beyond the unilluminated side of the rings. This is not unexpected when the tenuous nature of Ring C, as revealed by observations of Saturn's limb through it, is remembered.

The illumination in the region of Cassini's Division may indicate that the division is not entirely devoid of matter. The presence of some matter is, indeed, indicated by a number of observations. Observing Saturn in 1884, Pratt wrote: "Cassini's Division always appears very dark indeed, but under the most favourable conditions it is never a perfect black comparable with the shadow of the globe on the ring." Elger, an assiduous observer of Saturn, wrote in 1888 of the division: "This dark band has never impressed me as being perfectly black." Discussing a series of observations made with the Washington 26in., extending from 1875 to 1889, Asaph Hall remarks that Cassini's Division gave the impression "of not being a complete separation or that small particles of matter remain in this partly dark space." In 1900 Flammarion reported from the Juvisy Observatory that Cassini's Division appeared grey, not black. Years before, a spectacular observation had been made by Jacob, who, according to Webb, actually traced the shadow of Saturn's globe across the division in the rings. We may take it, therefore, that the outer condensations are possibly connected with the division, just as the inner are almost certainly with Ring C.

It is possible, however, that in the case of the outer condensations the effect is not due, or at least not entirely due, to sunlight sifting through, but to reflection of light from Saturn's globe to the surface of the rings. Professor Russell has calculated that the light received this way at the position of the outer condensations would be about 30 times our full moonlight —a very perceptible illumination. "We may therefore conclude," he writes, "that the outer condensations, and the general visibility

of the surface of the rings, may be accounted for by their illumination by light reflected from Saturn, while the inner condensations are due to sunlight transmitted through the practically transparent Crape Ring."

Possibly the phenomenon of the outer condensations and the general visibility of the surfaces of the rings is a combination of illumination by light penetrating as well as reflected light. In that event the effect might be enhanced by the presence of fine, widely-scattered dust which, Dr. L. Bell suggests, may envelope the ring system. This dust, he thinks, becomes "more and more tenuous away from the ring plane," and is everywhere "so thin a cloud that it reflects no visible light save when seen in great thickness edgewise."

At this stage it will be well to summarise what seems to be indicated by the evidence gleaned thus far—in effect, the views respecting the translucency of Saturn's rings generally current about twenty years ago:—

(i) The space between the globe and Ring C was thought to be clear of obscuring matter.

(ii) In Ring C the component particles were thought to be thinly and widely scattered so that the ring was all but transparent, and certainly translucent.

(iii) Ring B was believed to be opaque; this was borne out by observation and by the high albedo of the ring, which was comparable to the albedo of the globe, and suggested that the number of particles in Ring B was such that practically no light could get through owing to reflection, absorption and scattering. Opacity seemed further indicated by the fact that the ring cast a dark shadow on the globe of the planet and also intercepted the shadow of the globe.

(iv) Cassini's marking was an actual division between Rings B and A, but was possibly not entirely devoid of particles of ring matter.

(v) Ring A was thought to be probably opaque, for the same reasons as Ring B—but not so certainly, having a lower albedo.

The Translucency of Ring A.

The difference in albedo between Rings A and B had been first noted by Cassini when he discovered the division between these rings. In 1853 Lassell detected that sometimes there was also a difference in the intensity of the shadows cast by them. He found the shadow of Ring A on the globe of the planet not black, like the shadow cast by Ring B, but grey in at least its outer zone. The shadow, he wrote, was "blackest close up to the edge of the ring, and shaded off towards the northern

edge." Similar observations were made by Bond, Webb, Dawes and Huggins. At times there was no shadow visible, although theoretically there should have been. These observations, and a magnificent set of his own, were discussed by Trouvelot in a memoir entitled "Sur lu Variabilite des Anneaux de Saturn," published in the Bulletin Astronomique of November, 1884, and January, 1885. *The mutations of the shadow of Ring A from black to greyish and dusky tints compelled a reluctant inference that Ring A is occasionally partly transparent.* Trouvelot then discussed the possibility of seeing through Ring A, as in the case of Ring C, but concluded that there was no chance of seeing the surface of Saturn's globe through it owing to underlying shadow. "Rather," he wrote in a prophetic passage, "would the occultation of bright stars by the ring be what is required to indicate its transparency."

What the eye cannot see is sometimes detected by the camera. In 1914 Major Hepburn was engaged in measuring photographs of Saturn which had been taken with the 60-inch reflector at Mount Wilson. "The plate contains 12 images," wrote Hepburn, "the exposures being 10 to 12 seconds, but one of them was exposed for 40 seconds . . . Ring A as appearing on the photograph (of 40 seconds' exposure) is transparent, the globe of the planet being clearly visible through it, both limbs being fairly sharply defined. The combined effect of ring and ball is one of brightness—that is to say, the region where the one is superposed on the other is brighter than the adjacent parts of the ring and very much brighter than the north limb of the ball which projects beyond the ring."

Hepburn's interpretation of the appearance of Saturn on the Mount Wilson negative was accepted as correct by the majority of authorities. But it was strenuously controverted by a minority. And this despite an identical appearance being found on other negatives taken at the Lowell Observatory and elsewhere. Alternative explanations were offered; the appearance was a photographic effect; it was due to specular reflection from the outer ring. These explanations had, however, an artificiality that did not commend them.

But the correctness of Hepburn's deductions was soon to receive spectacular confirmation. From the days of Sir William Herschel the transit of the rings over a star had been eagerly awaited. At one time Herschel regarded such a transit as the crucial test of the nature of Cassini's Division. His son, Sir John, wrote: "The passage of Saturn across any considerable star would afford an admirable opportunity of testing the existence of fissures in the rings, as it would flash in succession through them. The opportunity of watching for such occultations—when Saturn crosses the Milky Way, for instance—should not be neglected."

Webb seems to have sensed even greater possibilities, for he remarks in the earliest edition of his Celestial Objects that the transit of the rings over a considerable star would perhaps give us further information as to the nature of the rings, and adds: "Dawes alone has seen, but under unfavourable circumstances, a star between 8 and 9 mag. pass behind the outer edge of A."

The next attempt at observing an occultation was equally unsuccessful. In 1893 Dr. Berberich predicted that on March 12 of that year a 9.5 magnitude star would be occulted by Saturn. Attempts to observe this phenomenon failed, though the Rev. A. Freeman succeeded in observing Saturn at the time predicted. He saw no sign of any occultation, but thought he glimpsed the star near the globe; "in which case," he wrote, "the place assigned by Dr. Berberich is only approximate."

Success came on the evening of February 9, 1917. At about 9 p.m. Mr. J. Knight, observing Saturn with a 5-inch refractor, "noticed a bright star which gave the peculiar optical effect of being projected on the ball. . . Soon after this," Mr. Knight adds, "I saw it apparently eat its way into the outer ring, and, apart from isolated moments when the air was particularly unsteady, it never seemed wholly to disappear. Sometimes it was exceedingly faint, and I was only conscious of a 'something extra' in the rings. A little before 10 p.m. it was plainly discernible through the Cassini Division, and I could easily trace it moving along this dark opening till about 10.25 p.m." After that, a rising wind made seeing conditions "hopeless" for Mr. Knight.

The star mentioned by Mr. Knight (B.D. 21°, 1714) had been seen a little earlier by Captain M. A. Ainslie, using a 9-inch silvered reflector, "north of and preceding the North Pole of Saturn." Captain Ainslie was prevented from observing again until after 10 p.m., but, as has been seen, by great good fortune Mr. Knight had witnessed the earlier part of the phenomenon.

Captain Ainslie did not see the star again until 10.15 p.m. He thus described his observation:—

> It (the star) appeared as a very conspicuous cream-white spot, very small, and apparently projected on the extreme edge of Ring B; it passed into the division and travelled along it, remaining very conspicuous and, as nearly as I could judge, as bright as when clear of the planet. It does not appear to have passed behind Ring B, as its brightness was so little affected; the appearance of its being projected on the ring was probably an effect of irradiation, the ring B being at its outer edge very bright.

At about 10.30 it was seen on the outer edge of the division, and (owing to bad seeing) disappeared for a few minutes; at about 10h. 35m., however, it was very easily seen, though greatly reduced in brightness, through Ring A.

It remained visible to the end of the observation, and traversed the ring with little or no variation in brightness, though at 11h. 3m. it increased very rapidly, not quite instantaneously, to perhaps double intensity, at which it remained for about 10 to 15 seconds, fading again as rapidly as it had brightened. A second brightening was observed at 11h. 8m., this time not more than for about 5 seconds.

The star finally appeared from behind Ring A at 11h. 10m., and was seen separated from the ring by a distinct black interval at 11h. 15m.

Captain Ainslie then proceeds to describe colour and magnitude phenomena; but these may be passed over for the present.

These beautiful observations confirmed absolutely that Ring A was translucent. They showed, too, as Captain Ainslie rightly pointed out, that the particles comprising the rings were considerably smaller than popularly supposed.

The success of the observers is all the more notable in that no prediction of the occultation had been published beforehand.

The Translucency of Ring B.

In 1919 (Monthly Notices, Vol. lxxx., No. 1) Mr. Arthur Burnet discussed briefly the occultation of a star, 1460 in C. G. Catalogue 1900, by Saturn, predicted for March 14, 1920. A fuller discussion by Dr. L. J. Comrie was published later in the B.A.A. Journal, xxx., No. 4.

According to Dr. Comrie's prediction, which was for the latitude of Greenwich, the star was not to be occulted by the rings of the planet, but only by its globe. Even so, the phenomenon was so unusual that many observers prepared to follow the star's occultation and emergence. Unfortunately bad weather prevailed at almost every station. An observation of the immergence was made, however, at Rondebosch by the late Mr. William Reid, the first amateur President of this Society, and others. These observers also observed the emergence under exceptionally fine seeing conditions.

That the full occultation was witnessed at only one southern station was extraordinarily unfortunate because, as seen from the latitude of Rondebosch, the star passed not only behind the globe of the planet, but behind Rings A and B as well.

So certain was Mr. Reid that the phenomenon would have been observed by many others that he did not communicate his observations to the scientific Press. He did, however, give

details to Mr. A. W. Long, who published them in the Astronomical Monthly Notes, April, 1920, in the "Cape Times" for the benefit of local readers.

Eventually it became apparent that bad weather had interrupted or prevented observation at nearly all stations. A few European observers reported that the star appeared to inpinge upon the planet very near to the point where the outer edge of the ring crosses the globe. From India, the star was reported to have been occulted by the ring for a short time before it reached the limb. From Mr. Reid's more southern station, thanks to parallax, the star traversed nearly the whole width of the rings before reaching the globe.

When it transpired that only at the Rondebosch station had a full observation of the occultation been made, Mr. Reid, at Major Hepburn's request, published an amplification of his account in the Journal of the British Astronomical Association for October, 1920. He wrote:—

> "The time, 6.46 G.M.T., which we decided upon as the moment when the star was in contact with the ring is the result of a compromise. It is the time when we were all positively certain that it was behind the ring. Personally I think that it touched the ring three minutes earlier, and at the time given was in the edge of Ring B.
>
> "At first there was little diminution of light, but as soon as it touched Ring B the light gradually faded for about half a magnitude. It remained like this for a few seconds, when it again fell a little further, and almost immediately the flicker took place—that is, it suddenly almost went out, but not quite. It rose again fairly suddenly; after that its light fluctuated very considerably, but never reached more than a magnitude less than its original brightness.
>
> "When it reached what we considered the limb of the planet it was about two-thirds across Ring B. Instead of disappearing it continued to traverse the ring until it was almost on the inner edge of Ring B. From the time it touched the limb of the planet its light did not fluctuate; it gradually got dimmer until it was two and a half magnitudes below its original brightness. The disappearance took place well within the limb of the planet, and although it was sudden, it was quite unlike the disappearance of a star in a lunar occultation. *It did not go out with a snap.*
>
> "Regarding change of colour. Before and after occultation the star was a beautiful bright orange; during the passage of the ring it faded to a dull orange, and before disappearance and at reappearance was a brownish orange.

"We had no difficulty in following the star during the whole time except when the flicker took place, but even then I do not think we lost it.

"I was fortunate to observe the star at the moment of reappearance. It was then about two magnitudes below its original value, and brownish orange in colour; it gradually brightened up until it emerged, and the time occupied until we saw it clear of the disc was almost three minutes.

"Cassini's Division was not visible at the spot where the star crossed, but it was clearly visible further out.

"There are one or two things to which I should like to call special attention, viz.:—

"*The seeing was perfect;* we could not have desired anything better.

"The instrument used (a 6-inch Cooke O.G.) gives beautiful definition . . .

"The star was a bright orange colour, contrasting well with the planet."

"In all probability we should have failed to see the star continuously when behind the ring, if it had been the same colour as the planet."

Finally, Mr. Reid calls particular attention to the "loss of light and change of colour when the star was *behind the limb* of the planet."

This observation of a star through Ring B, demonstrating the translucency of that ring, has not been generally accepted, particularly by American authorities.

While, for example, the evidence is accepted as proof of the translucency of Ring B by Hepburn (Report of the Saturn Section, Brit. Astro. Assn., xxx., 10) and Phillips (Enc. Britt., 14th Ed.), it is omitted in a manner which has almost the appearance of being deliberate in leading American text-books published since the date of the Rondebosch observation.

Professors Russell, Dugan and Stewart, in their well-known manual on astronomy published in 1926 state:—"Ring B, which has an apparent albedo fully as great as that of the planet, must be much more closely packed (with particles of ring matter) and is probably quite opaque."

Again, Professor R. H. Baker, in his admirable single-volumed Introduction to Astronomy, writes in 1930:—"The theoretical evidence that Saturn's rings are discontinuous is well supported by the observations. *The Rings A and C are transparent.* Barnard saw one of the satellites, still shining, though somewhat dimmed, within the shadow of the Crape Ring. More recently, two observers watched the outer ring pass over a star without entirely hiding it."

The italics are Professor Baker's. Note the careful emphasis that the evidence is in favour of the inner and outer rings only. There is no mention of the Rondebosch observation.

So late as February, 1934, Mr. T. L. MacDonald, lecturing to the West of Scotland Branch of the British Astronomical Association, said "That they (the rings) were made of discrete particles, had been directly confirmed by Ainslie and others who observed the passage of the outer portions over a star, which remained visible though flickering, and brightened up in the gap." Note again the implied exclusion of Ring B, by the use of the words "the outer portions."

This frequent insistence that Ring B is opaque, or that at least it has not been shown to be translucent, must be due to one of two reasons: either Mr. Reid's observation (corroborated by his three companions*) is not generally known, or it is not accepted by many authorities.

These authorities believe either that the reported observation was a figment, or that Mr. Reid and his companions were mistaken in what they thought they saw.

Those who think the report was a figment may be dismissed with the contumely they merit. The occultation had been predicted. Preparations for its observation had been made at many stations. If Mr. Reid (thinking that many others had witnessed the phenomenon) invented the account of what he saw, he would certainly have followed Dr. Comrie's prediction, and so report seeing the star occulted by the globe of the planet only, and not by the rings.

Others who think that Mr. Reid and his companions were deceived in what they thought they saw, do not doubt that the star was seen occulted by the rings. They do not even doubt that it was seen during its occultation, or part of its occultation, by Ring A. But they have grave difficulty in believing that it was seen through Ring B.

They base their doubts on three definite objections:—

(i) On the date of Mr. Reid's observation, the rings were inclined far more obliquely to the line of sight than on February 9, 1917, when Mr. Knight and Captain Ainslie were observing. On the evening upon which Mr. Reid was observing a star's light would have had to penetrate about eight times more ring matter.

(ii) Ring B, if albedo is a criterion, is much thicker and denser than Ring A, and would therefore further tend to obscure the light from a star behind it.

(*Mr. Reid's three companions were Messrs. D. G. McIntyre, C. L. O'B. Dutton and H. Reid.—Editor.)

(iii) Mr. Reid's estimates of the loss of light from the star during its occultation, compared with Captain Ainslie's estimates, do not seem consistent in view of the far greater amount of ring matter intervening.

Let us consider these three points one by one.

The screening effect of the rings when inclined at different angles will be more or less effective according as the rings are very thick or very thin, and according as the constituent particles are large or very discrete.

Visual estimates of thickness when the rings are seen edge-on have shown from the start a rapidly progressive decline. Here are some early attempts:—

Desejour (1789)	958 miles.
Herschel (W.) (1790)	856 ,,
Schroeter (1808)	539 ,,
Herschel (J.) (c1850)	less than 220 miles.
Bond (W.C. and G.P.) (1857)	,, ,, 43 ,,

It will be noted that the last two estimates are in the nature of approximate limits. All recent estimates are of this nature, and are generally very much lower than Bond's. Of recent estimates, that by H. N. Russell in the Astrophysical Journal, vol. xxvii., p. 233, appears to have found general acceptance. He estimates the thickness of the rings as "much thinner" than 13 miles (or 21 kms.). Through a curious error this figure has been quoted as 13 kms. in Monthly Notices, the B.A.A. Journal, our own Society's Journal, and elsewhere.

In a still more recent dissertation on Saturn's Rings in the Astrophysical Journal, vol. L., p. 1 et seq, Dr. L. Bell, after weighing all the evidence, concluded that "it seems highly probable that the substantial layer of Saturn's rings does not exceed 15 kms. in thickness"—an upper limit of under 10 miles.

Dr. H. Jeffreys in a paper on Meteoric Bodies in the Solar System (M.N. lxxvii., 2) discusses, *inter alia*, this problem of the ring's thickness. From purely theoretical considerations he concludes that "the ring must be very thin and practically confined to one plane."

If the rings are of tenuous thinness, the difficulty of seeing through them when they are more nearly edge-on is largely overcome. Particularly so, if the matter composing the rings is very finely divided, and owes it brightness, not to close packing, but to high albedo.

That the particles of ring matter are fairly widely scattered and very finely divided has been demonstrated by photometric observations. These observations are based on the fact that the light reflected from the rings falls off considerably as the

phase angle of the planet increases, while that from the globe does not. When the rings are widely open the combined light at quadrature is 79% of that at opposition (allowing, of course, for the effect of changes of distance). This shows that the light from the rings, which is a little more than half the total light, has diminished by 35%.

Seelinger has shown that this is a direct outcome of the ring being composed of separate particles. At different phases our line of sight penetrates to very different depths between the particles. The sun's rays do the same, and, naturally, the particles nearest the sun cast shadows on those further away. When the earth, the sun and Saturn are in line each particle hides its own shadow; consequently, the whole ring surface appears bright. But when the earth, the sun and Saturn are out of line, the effect of the shadows makes itself felt and thereby diminishes the total light. From observations at different phases Seelinger concludes that the particles occupy—on an average—about 1/16th of the whole volume of Rings A and B. A later investigation by Schonberg gives a much smaller fraction and he concludes that the larger particles are accompanied by much fine dust.

Dr. Jeffreys, in his paper, to which reference has already been made, reaches the same conclusions on theoretical grounds. He concludes that in the past frequent collisions have occurred between the ring particles, and indeed are still occurring. This must have " reduced their substance to powder and each of the new reflecting surfaces must add to the apparent albedo."

If this albedo is high the particles may be fairly widely scattered, even in Ring B.

This brings us to the second objection that Ring B is much thicker and denser than Ring A. This assertion is based on the assumption of a uniform, or fairly uniform, albedo of the material throughout the ring system. Why should such a uniformity exist? It would be at variance with all terrestrial analogy. Why should not the albedo of the particles in Ring B be considerably higher than that of the particles in Ring A? Dr. Jeffreys' investigations allow us to conclude that they are. Dr. Louis Bell, following other lines of investigation, remarks that the high albedo of Ring B may be accounted for if its composite material is more finely powdered, as Dr. Jeffreys tells us it is.

There is, in fact, no reason why Ring B should be very much thicker and denser than Ring A, though it does cast a deeper shadow. Increase in thickness does not mean, as seems to be generally imagined, a constantly increasing albedo. There comes a limit when the lower layers of particles would always be in shadow.

The difference in brightness between the rings may be due, then, almost entirely to differences in the albedo of the particles composing them.

The third objection arises largely from misunderstanding and misreport of what Mr. Reid said about the loss of light by the star when behind the rings. When he said, in the "Cape Times," that "the star seemed to shine with very little diminution of light, even when behind the ring," he was referring to the earlier portion of the occultation by the outside edge of Ring A. His estimate of loss of light behind the rings was, of course, very approximate, for there was no possible means of assessing the loss accurately and the attempt was further complicated by marked colour contrast. Possibly the loss was greater, judged by the criterion of Captain Ainslie's observation, when the star was considered to have lost 75% of its light. Mr. Reid held the star throughout its passage behind the rings more on account of its contrasting colour than because of its relative brightness.

I hope these arguments will meet, to some degree at least, the objections of those who have hitherto found difficulty in accepting Mr. Reid's observation.

An Outer Crape Ring?

So far we have discussed observations relating to the three generally recognised rings of Saturn, and adduced evidence to show that these rings, A, B and C, are translucent. But there are observations, neglected as Mr. Reid's, of a fourth ring, so translucent as to be at most times actually transparent and so invisible, beyond the outer bright ring.

There is evidence that towards its outer edge Ring A becomes extremely tenuous. Mr. Reid's difficulty in detecting any dimunition of light when the star first passed behind the outer edge of the ring was almost certainly due to this.

There is other evidence. On February 28, 1919, an eclipse of Iapetus by the rings, similar to that observed by Barnard, took place. Owing to bad weather only one observer, the Rev. W. F. A. Ellison, Director of Armagh Observatory, observed the eclipse, and he saw it only piecemeal. First he saw the satellite illuminated by sunlight shining through Cassini's Division. It then commenced to fade as it passed into the shadow of Ring A. Mr. Ellison was at this juncture called away from the telescope, a 10-inch Grubb refractor, and returned at 8.22 G.M.T., "at which time the satellite was visible but difficult." It increased in brightness till about 8.42, after which it was conspicuous. The prediction of the occultation and Mr. Ellison's observation may be set out thus:—

h.m.	*Prediction.*	*Observation.*
4.14	Satellite emerges from shadow of ball after occultation.	
4.50	Satellite enters shadow of Ring B.	
7.11	Satellite passes through gap in shadow corresponding to Cassini's Division.	
7.17		Satellite seen.
7.20		Satellite at maximum brightness.
7.25		Satellite commenced to fade.
7.32		Satellite "disappeared or nearly so."
7.50		Observer called away from telescope.
8.22		Observer returns to telescope. "Satellite visible but difficult."
8.29	Satellite emerges from shadow of Ring A.	
8.42		Satellite has increased in brightness from 8.22 and now becomes "conspicuous."

Although the predicted time of emergence must be considered as approximate owing to uncertainty as to the exact dimensions of the rings, Mr. Ellison's observation seems to show that the ring system extends further than is generally supposed. It certainly shows that it dwindles away into space, and does not end suddenly.

This is in accordance with the theory that the outer portion of the ring system is gradually spreading out into space. If this is so, it seems not unreasonable to suppose that there is an outer Crape Ring similar to the inner ring. Obviously, it must be a much more "difficult" object to detect. But, as a matter of fact, it has been detected.

In 1907 such a dusky outer ring was observed from several stations. It was first seen on September 5-7 by N. G. Fournier from the Jarry-Desloges Observatory, Mont Revard, Savoy. An independent observation on October 10 was reported from Geneva Observatory.

From October 10-30 this dusky ring was repeatedly observed from Greenwich. On October 10, for example, Bowyer saw it all round the outer bright ring. Lewis saw it on that date and

suspected it on the 12th. On October 15 Eddington saw it surrounding the bright ring, visible on the north side.

Three months later, in January 1908, Schaer, of Geneva Observatory, announced that the outer dusky ring was "more easily seen." Probably we shall have to wait for further attempts at observing this ring until Saturn is again well placed for observation in the northern hemisphere.

It seems possible, however, that there is evidence of this new ring on a photograph taken ten years after its discovery. In 1923 photographs of Saturn, taken at the Lowell Observatory in 1917, were exhibited at a meeting of the British Astronomical Association. Mr. E. W. Maunder, on examining them, found that in one photograph there was a distinct impression that the shadow of Saturn's globe extended out into space beyond the ring. This might well have been caused by the shadow falling on the outer dusky ring. Apparently, however, nobody at the meeting remembered the observations of 1907, and the appearance of shadow in space was attributed to "photographic effect."

Even without photographic testimony, the existence of an outer dusky ring is well substantiated.

Saturn's Outer Atmosphere.

This concludes the account of the observational data I have collected in support of the contention that Saturn's rings A, B and C are translucent, and that an outer ring exists so nearly transparent that it can only be seen in exceptional circumstances. Before closing, however, I would like to refer briefly to one feature of Mr. Reid's observation—the fact that at its emergence he saw the star *within* the disc of the planet.

Did he actually see the star through the outer atmosphere of the planet? Mr. Reid thought he had; so did the observers with him.

The appearance of the star within the disc may have been due, of course, to irradiation and diffraction.

But if the outer atmosphere of Saturn is very diffuse, there seems little reason why a star should not be seen through it any more than through the rings.

Perhaps Saturn's oblateness furnishes a clue. As you know, the amount of oblateness of a planet depends on the ratio of the centrifugal force to the acceleration of gravity at the equator. The oblateness depends also on the distribution of matter. If we denote the ratio referred to by m and the oblateness by ϵ then, theoretically, $\epsilon = 1.25\ m$ when the density of the planet is the same throughout, and $0.50\ m$ if the material is mostly concentrated at the centre. The distribution of material for the planets whose rates of rotation are accurately known is:—

For uniform distribution ..	$\epsilon/m = 1.25$
,, Mars	1.14
,, Earth	0.97
,, Jupiter	0.76
,, Saturn	0.72
,, very high central condensation	0.50

Evidently, Saturn's mass is very highly concentrated towards its centre. This surely enhances the probability of a very tenuous outer atmosphere.

It may be argued that as Jupiter's mass is also highly concentrated towards the centre, there should be observations, corresponding to Mr. Reid's Saturn observation, of stars and satellites seen through the outer atmosphere of Jupiter.

There are, in fact, many records of such observations, all well authenticated. Those interested will find a well-documented account of many instances in Vol. xliii. of the Monthly Notices. Further instances are cited in Proctor's Old and New Astronomy. The observations range from America to Australia, while there is one in the Greenwich Records, not mentioned in either of these accounts, which seems to have been generally overlooked. On November 28, 1880, no less a person than William Christie, afterwards Astronomer Royal, observing an occultation of Jupiter's third satellite, writes:—" The satellite was seen very distinctly through the edge of the planet's disc."

Sir William was well acquainted with the effects of irradiation. He sometimes reported seeing a satellite " projected on " the planet's disc.

Mr. Reid was also well acquainted with the effects of irradiation. Nevertheless he thought he saw the star through Saturn's disc. The Jupiter observations lend support to his belief.

If Saturn's upper atmosphere is indeed very tenuous, then the elder Herschel's otherwise puzzling observations of the satellites " clinging " to the limb of Saturn's globe before occultation can at once be explained.

In conclusion, may I say that I chose this subject for my Presidential Address, chiefly from a desire to obtain for Mr. Reid's observation a little of the general recognition it merits. But I also wished to draw attention to a line of investigation eminently suited to members of our Society who possess the necessary instrumental equipment. Occultations of Saturn's satellites, unfortunately, occur only at rare intervals. But the ring and the surface of the globe will at all time repay study.

REVIEWS.

"General Astronomy," by H. Spencer Jones, M.A., D.Sc., F.R.S., Astronomer Royal. Second Edition. London: Edward Arnold & Co.; 1934. 12s. 6d.

The Astronomer Royal is to be heartily congratulated on the second edition of his book on "General Astronomy" as an all-round up-to-date text book on astronomy, suitable for university students as well as amateurs who wish to have a book giving the fundamentals of astronomy without heavy mathematics. When the reviewer was studying astronomy some 25 years ago there were very few astronomical text books apart from mathematical works—the principal one being Young's General Astronomy. The study of the stars, as distinct from the solar system, was still in its infancy, and Newcomb, who brought out his well-known book on "The Stars" in 1904, admitted that it had involved a great deal of research for a non-mathematical work. During the last decade a considerable number of works suitable for university students, and others suitable for the educated layman, have appeared. Many of these are excellent, but few of them are as sound or as attractively written as that of Dr. Spencer Jones.

The first section of the book deals with the solar system and it might have been thought that there would be little to add to the information given in the edition of 1922. The following from the introduction shows some of the new matter dealt with "an account of the discovery of Pluto, interesting asteroids such as Amor and 1932 H D, the photography of the planets in light of different colours, the variability of the earth's rotation, the evidence of the age of the earth derived from radioactive materials and Bjerknes's theory of sun-spots." Clearly the possibilities for research in the solar system are not yet exhausted.

The principal alterations and additions to the book, however, are to be found in the section dealing with the sidereal system. The earlier edition had three chapters of 103 pages on "The Stars," "Double and Variable Stars," and "The Stellar Universe." The new edition has five chapters of 154 pages, the first two of these have the same headings as before, while the others are "The Galactic System," "Extra Galactic Systems," and "Stellar Constitution and Evolution." The additions show

the trend and extent of recent advances. South African readers will be specially interested in the references to Nova Pictoris, which appeared while Dr. Jones was H.M. Astronomer at the Cape, and to which he devoted a great deal of attention. In the course of time the more theoretical portions of these chapters (especially the last) will probably require very considerable revision, although the observational parts should remain, but it is important for the student to have the latest ideas on the subject and for these he can confidently look to Dr. Spencer Jones' book.

By the employment of smaller type, so that the number of lines per page could be increased, the size of the book has not been altered in spite of the additional matter. The new type is very clear and legible. Several new illustrations from celestial photographs have been included. At the same time the price has been very considerably reduced. It is safe to predict that the new edition will be found a most attractive book.

Lohse Tafeln für numerische Rechnen mit Maschinen. Zweite Auflage Neubearbeitet von P. V. Neugebauer, Engelmann. Leipzig. 6 marks; bound.

Five Figure Tables for Numerical Calculation with Machines:—A new edition of Lohse's tables has just been published. The greater part has been reprinted photographically in a slightly smaller size than the original. The tables, which are generally of five figures, give reciprocals, natural values of the six trigonometric functions, and tables of square roots. The principal part of the volume concerns the trigonometric functions. The drawback of the tables for use to many people is the fact that the argument is given in hundredths of a degree and not in minutes of arc, although a special table is given for changing minutes and seconds of arc to decimals of a degree. It would look better if the table of reciprocals had a heading on each page to show what the figures were. The printing and arrangement are excellent and the tables can be highly recommended to those who wish the natural trigonometric functions in terms of decimals of the degree.

"Leaflets," Vol I., Nos. 1 to 50 [pp. vii. 206 with foreword by Dr. R. G. Aitken] (Astronomical Society of the Pacific, San Francisco.)

This attractive little volume contains a reprint of 50 leaflets issued at intervals during the years 1925 to 1933 by the Astronomical Society of the Pacific. They were originally circulated as short papers to be read in a few minutes and carried in one's pocket book. Each leaflet (nearly all of them illustrated) deals with a separate topic, a few of the titles being: "The Magellanic Clouds," "Temperature of the Moon," "The Pleiades," "Our Journey through Space," and they are written by such well-known professional astronomers as Aitken, Hubble, Trumpler, van Maanen, and Pettit.

One extract may be quoted: "The matter constituting our universe is evidently found in either of two states: In organized bodies like the Sun and the stars, which by their peculiar regular and symmetrical constitution have reached the stage of luminous radiation and cheer our eyes with their twinkling light; or in unorganized, chaotic masses of tiny particles irregularly scattered through vast spaces, mostly dark, only in few places becoming visible as nebulae. The latter would rather appear to be the primordial state and may in the scheme of the universe be of no less importance than the first." It is one of the characteristics of astronomy as a world-wide science that it appeals to people of all degrees of education and opportunity. The brilliant mathematician and the man in the street both find a fascination in its discoveries and problems, and the leaders in the army of investigation (suns and stars) are unfailing in passing along information to those (dark nebulae) who follow behind.

The book before us is marked "Volume 1," and those readers who have not the privilege of obtaining further leaflets as issued will look forward to seeing the next volume.

The Royal Astronomical Society is prepared to issue (provided sufficient support is forthcoming) a third edition of the Franklin-Adams Chart of the Sky, in 206 sheets, each covering an area 15° x 15°. The Chart is in three Sections: (1) N. Pole to Dec. + 22°; (2) Dec. + 22° to — 22°; (3) Dec. — 22° to S. Pole. The price of the complete set, in three cases, has been fixed at £27, including carriage. Should any desire one or two of the Sections only, subscriptions will be received for the part required at a corresponding rate.

Further particulars and application forms may be obtained from the Assistant Secretary, Royal Astronomical Society, Burlington House, London, W.1.

OBITUARY.

Prof. W. de Sitter.

The news of the death of Prof. W. de Sitter on 20th November, 1934, came as a shock to the astronomical world, for although he had a severe illness 20 years ago and was never of a robust nature he had of late years been in general good health. By his death the world loses one of its greatest scientists. His greatest contributions to astronomy were connected with the mathematical theory of the motion of Jupiter's satellites and the development of the theory of relativity. In the last connection he first of all brought to English readers a knowledge of Einstein's researches, he developed the theory of their observable astronomical consequences, and he did pioneer work on the nature of the physical universe and on its expansion. He was an excellent administrator, and from the time of his appointment as professor at Leiden he gradually developed the resources and equipment of the Observatory there till it became one of the greatest Observatories of the world. The value placed on his work by his colleagues is indicated by the award to him at various times of the Gold Medal of the Royal Astronomical Society, the Bruce Medal of the Astronomical Society of the Pacific and the Watson Medal of the National Academy of Sciences at Washington.

He was closely associated with South Africa and was an honorary member of our Society. When a student under Kapteyn he met Gill on one of his visits to Groningen in connection with the Cape Photographic Durchmusterung. The result of the meeting was that Gill invited de Sitter to come to South Africa to discuss the observations of Jupiter's satellites which had been made with the heliometer of the Cape Observatory. De Sitter spent over two years at the Cape, 1897—99, and throughout his life devoted much time to the improvement of the theory and the determination of the orbital elements of these satellites. He visited South Africa in 1905 and 1929 when the British Association for the Advancement of Science came to this country. He early realised the importance of increasing the number of astronomical observations in the southern hemisphere and the excellent observing conditions to be found in the high veld of South Africa. Active co-operation was commenced under his guidance between the observatories at Leiden and Johannesburg, and for more than ten years it has been the plan for one of the Leiden assistants to make observations, and particularly take photographic plates at Johannesburg for examination and discussion at Leiden. In

recent years de Sitter had the satisfaction of getting a grant from the Rockefeller Institution in the U.S.A. for the erection at Johannesburg of a large telescope to form part of the equipment of the Leiden Observatory. The telescope, consisting of two 40 cm. short-focus telescopes for photographic work on faint objects, is nearing completion. Astronomers in South Africa will regret that he has not lived to see the telescope erected.

D. L. Forbes.

David Lamont Forbes, who died in October, 1934, was a foundation member of the Natal Astronomical Association—now the Natal Centre of this Society. Having qualified in law at Edinburgh University, he shortly afterwards came to South Africa. From 1906 to 1931 Mr. Forbes practised in Durban. In 1931 he removed to Mtunzini, in Zululand, where he was practising at the time of his death.

Mr. Forbes' interest in astronomy was active and practical. He was largely responsible for the administration of the Natal Society, of which he was a Past President. He did much to procure a home for the derelict telescope of the old Natal Observatory, and to bring it once more into commission. He observed with it, and in collaboration with Mr. C. F. Wicks made several drawings of Mars, some of which were reproduced in this Journal. He was astronomical correspondent to the "Natal Mercury," and his well-informed monthly notes in that newspaper were always up to date. On his departure for Zululand, his fellow-members of the Natal Centre elected him Honorary Chairman of that Centre.

Mr. Forbes was a Fellow of The Royal Astronomical Society. He is survived by a widow, a son and a daughter.

T. B. Blathwayt.

Theodore Ballantyne Blathwayt died suddenly in Johannesburg on Friday, 12th October, 1934, at the age of 72.

After graduating at Oxford, Mr. Blathwayt came to South Africa and for many years resided at Cape Town. There he was an active and very successful coach of university students. He was also a vigorous writer in the Press, and his terrific trouncing of the careless or reckless motorist will still be fresh in the minds of many who joined issue with him. In those

years, too, Mr. Blathwayt was a frequent contributor to the "English Mechanic," in the columns of which he discussed a variety of astronomical subjects. He also addressed an occasional note to "Nature."

After the Great War Mr. Blathwayt went north to Johannesburg. There he spent many hours sweeping for comets. His search was rewarded by three discoveries—in 1926, 1927 and 1930. These discoveries were made with a four-inch refractor and an eight-inch reflecting telescope.

Mr. Blathwayt was awarded the Donohoe Comet Medal on each of these occasions, and in 1929 was elected a member of the British Astronomical Society.

ASTRONOMICAL SOCIETY OF SOUTH AFRICA.

Session 1933-1934.

STATEMENT OF INCOME AND EXPENDITURE FOR YEAR ENDED 30TH JUNE, 1934.

INCOME.	£	s.	d.	EXPENDITURE.	£	s.	d.
To Balance 30/6/33 ..	16	3	1	By Printing Journal, Vol. 3, No. 3 ..	28	15	0
„ 50% Subscriptions (Cape Centre) .	35	13	9	„ Printing and Stationery	4	2	6
„ 50% Subscriptions (Johannesburg Centre), 1932-33	5	10	0	„ Postages	7	15	2
„ 50% Subscriptions (Durban Centre)	4	14	6	„ Rent	2	5	0
„ Sale of Publications	3	10	4	„ Donation, Herschel Centenary	10	0	0
				„ Commission on Cheques	0	1	9
				„ Balance carried forward	12	12	3
	£65	11	8		£65	11	8

Examined and found correct:
E. J. STEER.
19th July, 1934.

W. H. SMITH,
Hon. Treasurer.
30th June, 1934.

THE ASTRONOMICAL SOCIETY OF SOUTH AFRICA.

Session 1933-1934.

Annual Report of the Council.

In presenting its Annual Report, the Council is again able to record a year of steady progress. The roll of the Society now includes 131 members and associates, 6 honorary members and 2 members emeriti.

The Council has met four times during the year, those members who are eligible under Article vii. (iii.) of the Constitution being represented by alternates. The Council has considered the report of the sub-committee which examined the Constitution with a view of amending it in such respects as now appear desirable. A draft new Constitution has been framed with the Council's recommendation that you should adopt it at this Annual Meeting.

In co-operation with the Royal Society of South Africa, a joint committee was formed to organise a programme of events to celebrate the centenary of Sir John Herschel's survey of the southern sky. With the co-operation of other interested bodies an exhibition of instruments, manuscripts, etc., was held at the Government Archives Department and was opened on 5th March, 1934, by His Excellency the Governor-General the Earl of Clarendon. Thereafter a series of meetings was held, at which lectures were delivered by the following: Dr. J. Jackson (H.M. Astronomer), Mr. C. Graham Botha (Chief Archivist), Dr. A. W. Roberts, Prof. Roseveare, Prof. M. C. Botha (Superintendent-General of Education), Prof. L. Crawford, Mr. H. Horrocks, and the President, Mr. D. G. McIntyre. The following gentlemen occupied the chair at these meetings: General the Rt. Hon. J. C. Smuts, Dr. W. de Vos Malan, Dr. S. H. Skaife, Sir Carruthers Beattie, Prof. R. W. Wilcocks and Inspector H. Z. van der Merwe.

On 7th March a ceremony was held at the Herschel Obelisk, Feldhausen, Claremont, under the chairmanship of Dr. Bennie Hewat, at which the Deputy Mayor of Cape Town and Dr. J. Jackson gave addresses.

During the year Vol. III, No. 3 of the Society's Journal has been published. This, together with the cost of printing the new Constitution, and the financial support required by the Herschel Centenary Committee, has been a heavy drain on the Society's resources.

The official opening of the Boyden Station of the Harvard Observatory erected at Mazelspoort, near Bloemfontein, took place on 25th November, 1933. The ceremony was performed by the Mayor of Bloemfontein (Mr. J. B. Dersley), who traced the history of the removal of the Observatory from Peru, and said that the instruments with which the Observatory was equipped cost £75,000; the largest one, which was recently put in commission, had a clear diameter of 60 inches and was the most powerful instrument south of the Equator. Dr. J. S. Paraskevopoulos, the Director, stated that the cost of construction and erection amounted to over £35,000 and the work was not yet finished; funds would shortly be available for further construction and equipment.

The work of the Observing Sections, which has been steadily continued throughout the year, will be found recorded in the reports of the Directors of Sections.

The Council is pleased to record that Mr. A. F. I. Forbes has undertaken to organise a section for the observation of the Zodiacal Light and the Gegenschein; members who are willing to make observations are requested to communicate with Mr. Forbes at his address "Blairythan," Hermanus, C.P.

REPORTS OF SECTIONS.

For the Year ended 30th June, 1934.

COMET SECTION.

This has been a very quiet year in the realm of cometary discovery; only one return (Comet Wolf 1933*e*) and one new comet (Whipple 1933*f*) come to be recorded.

Comet 1933*f* (Whipple) was discovered at Harvard by Dr. Whipple on 15th October. It was of magnitude 13 at discovery and never became a bright object. It has a period of 7.77 years.

The prediction by Dr. Crommelin (mentioned in our last report) of a meteor display on 9th October, owing to the earth crossing the orbit of the recently passed comet Giacobini—Zinner was amply fulfilled. A memorable display was seen in Europe that evening. The radiant was about 266° + 56° and the effective duration of the shower was about 4½ hours. The shower was reported from as far South as the Gold Coast Colony. At the Cape, more than the usual number of meteors was seen that evening, but unfortunately we have no record of the radiant of any of them.

This is the second time we have not been able to record a new comet discovery by a member of our Society. But this negative result should have some value because a good deal of careful searching has been done. We thing that it is hardly likely that a comet brighter than the 10th magnitude can have passed across our skies without being seen. In this, however, we cannot be too positive; nature is full of movement and the quality of seeing was not always good, but one can judge more or less correctly whether the sweeping is thorough, by the known nebulae, as they come up in their order and pass across the field. An experienced comet searcher soon feels he is not careful enough if he passes any of his "old friends" without noticing them.

In reviewing what has been done in cometary research during recent years, we have been much impressed by the progress made by the mathematicians. No longer can comets be called the "crazy" wanderers of the sky. Ample demonstration has been brought to show that their motions are capable of being predicted with wonderful exactness.

If we do not yet quite understand all the physical forces concerned in their display we are encouraged to continue observing and recording.

A. F. I. Forbes.

VARIABLE STAR SECTION.

In presenting his Annual Report, your Director is pleased to be able to record very satisfactory progress during the Session.

3,992 observations of 130 variables were received, the largest total recorded during any year up to the present. Mr. H. E. Houghton's fine contribution of 2,313 observations constitutes a record that has never been surpassed by any South African observer.

Mr. R. P. de Kock, of Noorder Paarl, joined the Section during the Session, and is already doing very good work. The Rev. S. Solberg, of Eshowe, Natal, an old member of the Section, will probably resume active work during the new Session.

The observations received during the year were divided between the members of the Section as follows:—

H. E. Houghton, F.R.A.S.	2,313	observations	of 89	stars.
G. E. Ensor	1,527	,,	,, 128	,,
R. P. de Kock	136	,,	,, 11	,,
The Rev. S. Solberg	16	,,	,, 5	,,

Your Director's thanks are due to the Union Astronomer, Mr. H. E. Wood, and Dr. van den Bos, the Chief Assistant at the Union Observatory, for the measures of Nova Pictoris and its companions; also to the A.A.V.S.O. and Harvard College Observatory for variable star charts and circulars; and to the Director of the Variable Star Section of the new Zealand Astronomical Society, for their variable star reports.

Notes.

Nova Pictoris.—This nova decreased in brightness less than 0.3 magn. during the present apparition. Dr. van den Bos considers that the fading of the companions A and B would account for most of the decrease in the combined brightness as observed by the variable star observers, so that the central star appears to have remained nearly constant for more than six years.

The following measures of the nova and its companions have been supplied by Dr. van den Bos, by kind permission of the Union Astronomer:—

Mr. Finsen obtained measures on three nights, and Dr. van den Bos on one night, the following measure:—

AB	1934.008	75°.5	1″.63	9.5 — 13.0

C was glimpsed south preceding, closer to A than B, and fainter (about 14th magn.), but could not be measured.

There was hardly any trace of nebulous character left, the star image appearing almost normal.

Finsen has—

AB	1934.090	77°.4	1″.55	8.5 — 12.0	
	.099	73°.4	1″.75	9.0 — 12.5	
	.118	74°.7	1″.45	8.5 — 12.0	
mean	1934.102	74°.2	1″.58	8.7 — 12.2	3 nights
AC	1934.090	glimpsed			
	.099	232°.2	1″.31	14.0	
	.118	234°.9	1″.15	13.5	
mean	1934.108	233°.6	1″.23	13.8	2 nights

D never seen. And he remarks:—

B was fairly easy, well separated from the remaining slight nebulosity of A. C was very difficult, no more than a glimpse object.

On the whole the evidence seems to be that the distance is still increasing and the companions keep on fading, whereas no change has taken place in the directions—the variations in our measured angles may easily be explained as unavoidable errors of observation in such an unusual object.

The following particulars in connection with the spectral changes in Nova Pictoris have been taken from a paper by Dr. H. Spencer-Jones, F.R.S., "The Spectrum of Nova RR Pictoris," appearing in the monthly notices of the R.A.S., 1933, November. The changes as compared with previous years are summarised as follows:—

(1) The continuous spectrum has become stronger, relatively to the bright lines. It can be traced on the negatives from about λ 3800 to λ 6300, with a maximum intensity at about λ 4250. The spectra of several B type stars appear on the negative; these have maxima of intensity at about the same wave-length. Comparing the spectra of various stars on the 1933 negative with the corresponding spectra on the 1932 negative it is clear that the increase in the intensity of the continuous spectrum of Nova Pictoris since 1932 is real.

(2) The $He+$, λ 4686, line has become the brightest line in the spectrum. It may be recalled that in 1932 and 1931 the brightest line was the line of unknown origin at λ 6088, the next most intense lines being Hα and λ 4686, which were of equal intensity. In 1928 λ 4686 had been the most intense line, but during the year the λ 6088 line had increased considerably in intensity, and in October of 1928 it was not much inferior to λ 4686.

(3) The relative intensities of the two strong unknown lines λ 5723 and λ 6088 have changed, as they did in 1928, indicating that these two lines do not have a common origin. The relative intensities of the strongest lines in 1932 and 1933 are as follows:—

	Hγ	4686	Hβ	4944	5723	6088	Hα
1932	12	40	15	8	30	75	40
1933	9	50	10	5	16	20	25

(4) There appears to be a small increase in the Balmer decrement; relative to Hβ as a unit, Hα appears somewhat less intense in 1933 than in 1931, whilst Hγ and Hδ appear somewhat more intense.

RY Sagittarii.—This irregular variable remained at an average maximum magnitude of about magn. 7.3 between March 1932 and March 1933. There was a drop to magn. 11.4 in April 1933 followed by a rise to magn. 8.5 in August 1933.

A very rapid drop from magn. 9.2 to $<$ 12.5 took place during the last 15 days of September 1933.

When last observed in December 1933 the variable was too faint to be seen in small telescopes. During the latter part of December and in January 1934 it was too near the sun to be observed.

When picked up again in February 1934 RY Sagittarii had risen to magn. 12.0, and in June 1934 to magn. 8.4. The present magnitude is 8.8.

S. Apodis.—This variable has remained fairly constant in brightness for the last eighteen months. Its present magnitude is about 10.1.

G. E. Ensor, *Director.*

MATHEMATICAL SECTION.

In presenting his report for the 1933-1934 Session, your Director is pleased to be able to state that the activities of the Section have justified its formation.

Membership.

The Section has attracted a number of new members to the Society, and some of these have shown an interest in the other activities of the Society.

It is to be regretted that the Section has not received greater support from the teaching profession, but some advance has been made, and still more is to be expected next year.

Meetings.

During the year seven meetings have been held, and the following papers have been read:—

"The Educational Value of Mathematics": Mr. D. C. Alletson.
"Prime Numbers": Prof. L. T. Crawford.
"Mortality Tables": Mr. A. Murray.
"Henry Ford Methods in Elementary Mathematics": Mr. R. H. Dick.
"Cosmic Ray Calculations and Correlations": Mr. T. Dilatizky.
"Number—its Origin and Development": Mr. M. J. Pollard.
"Mathematics applied to the Psychology of Education": Dr. J. A. van Rensburg.

D. C. Alletson, *Director.*

CAPE CENTRE.

Twentieth Annual Report, 1933-1934.

Membership.

Sixteen additions have been made to the roll of membership during the year. There has been one loss through death, and six members have resigned. The total membership is now 101, consisting of 89 ordinary members, 2 members Emeriti, and 10 Associates.

Meetings.

During the Session there have been nine Ordinary Meetings. The first seven were held in the Mountain Club Room at 111, St. George's Street, and the last two in the new room of the Mountain Club at 38, Strand Street, which the Committee considers more suitable than the previous room as a place of meeting. By kind permission of His Majesty's Astronomer, the Annual Observational Meeting in February was held at the Royal Observatory, where members were able to view the heavens through the 6-inch Grubb telescope. In spite of a blustering south-east wind, there was a good attendance.

Addresses and Papers.

Addresses and papers presented at the meetings included the following:—

"An Arithmetical Curiosity": Mr. D. G. McIntyre, F.R.A.S.
"The Phases of the Moon": Mr. H. Horrocks, M.A., F.R.A.S.
"Double Stars": Mr. H. E. Houghton, F.R.A.S.
"Astronomical Mysteries": Mr. W. Andrews.
"Time": Dr. J. Jackson, M.A., D.Sc., F.R.A.S.
"The History of Cosmology": Miss C. Orpen, B.A., F.R.A.S.
"The Modern Telescope": Instr.-Capt. M. A. Ainslie, B.A., F.R.A.S.
"The Life of Sir John Herschel": Written by Miss M. Hardcastle; read by Miss C. Orpen, B.A., F.R.A.S.
An article on "The Possibilities of Inter-Planetary Travel": Read by Mr. R. R. Pratt, B.Sc., A.M.I.C.E.
"Astronomical Teamwork": Mr. H. E. Houghton, F.R.A.S.
"Cosmic Dust and Luminous Night Clouds": Mr. D. C. Burrell.
"The Proper Motions of Stars": Mr. A. Menzies.

Finance.

The Committee is pleased to be able to report an improved financial position, the balance on the 30th June being £10 16s. 11d.; as against a small debit balance at the end of the previous year.

Articles in the Press.

Articles detailing predicted astronomical phenomena have been published monthly in the "Cape Times," together with charts and diagrams of the sky. Articles in Afrikaans were also published in "Die Burger." Both series of articles were contributed by members of the Centre, and are greatly appreciated by members and the public.

R. Watson, *Chairman.*

A. Menzies, *Hon. Secretary.*

Committee of Cape Centre.

Chairman: Mr. H. W. Schonegevel.
Vice-Chairman: Mr. W. Andrews.
Hon. Secretary: Mr. A. Menzies.
Hon. Treasurer: Mr. R. R. Pratt.
Librarian: Mr. D. C. Burrell.
Hon. Auditor: Mr. E. J. Steer.
Committee: Messrs. D. G. McIntyre, A. W. Long, R. Watson, D. C. Alletson and H. E. Houghton.

Financial Statement for the Year ended 30th June, 1934.

RECEIPTS.	£	s.	d.	£	s.	d.
Subscriptions:						
Arrears ..	13	18	3			
Current Year	54	6	3			
In Advance	3	3	0			
				71	7	6
Commission on Cheques				0	3	6
Subscriptions to "Cape Times"				0	18	0
				£72	9	0

PAYMENTS.	£	s.	d.
Debit Balance at 30th June, 1933	1	10	5
Contributions under Article IX. of Constitution	35	13	9
Rent of Meeting Room	7	10	0
Rent of P.O. Box	1	5	0
Subscription to Astronomical Society of the Pacific	1	1	0
Typewriting and Stationery	4	2	3
"Cape Times" and Postage to Country Members	4	9	9
Secretary's Expenses ..	3	2	2
Treasurer's Expenses ..	1	4	0
Bank Charges	1	13	9
Credit Balance	10	16	11
	£72	9	0

Audited and found correct:
E. J. STEER.
13th July, 1934.

R. R. PRATT,
Hon. Treasurer.

NATAL CENTRE.

This, the twelfth year of our existence, has been remarkable in many ways. At the last Annual Meeting we were favoured with a visit from Sir Frank Dyson, late Astronomer Royal, who gave us a most interesting address on the history of Greenwich Observatory. At a lecture given by Sir Frank the following week, in the Art Gallery, under the auspices of the Library Group, our Chairman had the honour of presiding, and we also supplied Sir Frank with the lantern slides for his lecture.

The following is a list of our lectures for the Session:—

"The Spectroscope," with demonstrations: Mr. D. B. Hodges.
"The Moon": Mr. H. J. Roadknight.
"Star Clusters and Nebulae": Mr. H. J. S. Bell.
"Celestial Motions": Mr. J. Bennett Mumford.
"Space and Time": Mr. J. Willis.
"Some Recent Advances in Astronomy": Mr. D. L. Forbes, F.R.A.S.
"Solar Electrics": Capt. C. S. Hewlett, F.R.G.S.

The Observatory has been placed almost in a complete state of repair by the Technical College Council; we say "almost," because the floor of the dome still requires a certain amount of attention; but the whole place has been thoroughly cleaned out, and we have arranged with the Union Health Department to have the sweeping done regularly. Electric light has been installed and we have a number of suitable chairs in the computing room. More of the public are now using the Observatory, and they always find some of the Society's officials only too pleased to guide them on clear evenings.

We have to thank the local Press for publicity given to our work, the Natal Technical College Council for their valuable help in at all times placing a room at our disposal for our meetings, and also for the repairs they have carried out at the Observatory.

We now have better opportunities of doing useful work. We are not professional astronomers, so the man in the street need not fear to approach any of us. We want the public to make use of what we can offer them, and it is gratifying to find that they are now responding in fuller measure to our offers. Scouts, Guides, Rangers and Rovers are all asking our help, and we are happy to render any assistance in our power.

The Observatory, though erected more than 50 years ago, has not outlived its usefulness. The southern sky contains countless objects of interest and it is our pleasure to know just a little about a very few of them, but any who come to the Temple of Knowledge will find a ready welcome and much to interest them. Many of the youth of to-day come to us and find real pleasure in the mental entertainment we can offer them.

J. WILLIS.

LIST OF OFFICERS FOR 1934-1935.

Chairman: J. Bennett Mumford.

Vice-Chairmen: H. J. S. Bell and H. J. Roadknight.

Secretary and Treasurer: J. Willis.

Committee: Mrs. Grix, Messrs. F. T. Fox and H. Swanson.

REVENUE AND EXPENDITURE ACCOUNT FOR TWELVE MONTHS ENDED 31ST MAY, 1934.

REVENUE.	£	s.	d.	EXPENDITURE.	£	s.	d.
June 1, 1933:				By Caretaker Technical College	0	10	6
To Balance in Hand	7	18	11	„ Stamps, Stationery, & Petty Expenses	2	11	11
May 31, 1934:				„ Sweeping Observatory, 5 months at 2/6	0	12	6
To Subscriptions	12	11	6	„ Advertising	3	8	0
„ Donations	12	17	6	„ Contributions to Headquarters	4	14	6
„ Visitors	0	14	0	„ Chairs	8	10	0
				„ Elec. Lt. Connecting Fee	4	0	0
				„ Refreshments	2	0	0
				„ Bank Charges	0	8	6
				„ Balance	7	6	0
	£34	1	11		£34	1	11

Examined and found correct: (Sgd.) C. HARTSHORNE.

(Sgd.) J. BENNETT MUMFORD, Chairman.

26th June, 1934.

ASTRONOMICAL SOCIETY OF SOUTH AFRICA.

Officers and Council, 1934-35.

President: J. K. E. Halm, Ph.D.
Vice-Presidents: H. E. Wood, M.Sc., F.R.A.S.; D. G. McIntyre, F.R.A.S.; C. L. O'Brien Dutton.
Secretary: H. W. Schonegevel, 48, Lower Wrensch Road, Observatory, C.P.
Treasurer: W. H. Smith, Arum Villa, Plumstead, C.P.
Council: H. E. Houghton, F.R.A.S.; J. Jackson, M.A., D.Sc., F.R.A.S.; A. W. Long, F.R.A.S.; J. Bennett-Mumford; J. Willis.
Alternate Members of Council: Capt. D. Cameron-Swan, F.R.A.S., F.R.P.S., F.S.A.(Scot.); W. G. Andrews; A. Menzies; C. E. Peers; R. R. Pratt, B.Sc., A.M.I.C.E.
Hon. Auditor: E. J. Steer.
Hon. Editor: J. Jackson, M.A., D.Sc., F.R.A.S.
Hon. Librarian: W. G. Andrews.

Directors of Observing Sections.

Comet: A. F. I. Forbes, M.I.A., "Blairythan," Main Road, Hermanus, C.P.
Zodiacal Light: A. F. I. Forbes, M.I.A.
Variable Stars: G. E. Ensor, 43, Maple Avenue, Pretoria.
Mathematical: D. C. Alletson, B.A., Diocesan College, Rondebosch.

Hon. Editor: J. Jackson, M.A., D.Sc., F.R.A.S., Royal Observatory, Cape of Good Hope.
Hon. Librarian: W. G. Andrews, "Tircreevan," Clifton Road, Mowbray.
Hon. Auditor: E. J. Steer.

The Society acknowledges the receipt of publications, etc., from the following:—

University Observatory, Babelsberg, Berlin; Harvard College Observatory; Lick Observatory; University Observatory, Kasan; Union Observatory, Johannesburg; British Astronomical Association, Glasgow Branch of the British Astronomical Association, Sydney Branch of the British Astronomical Association; New Zealand Astronomical Society; Argentine Astronomical Society; Argentine Association of Friends of Astronomy; Antwerp Astronomical Society; Dr. L. J. Comrie; Yale Observatory; University Observatory, Bonn; Vereinigung von Freunden der Astronomie und Kosmischen Physik; Radcliff Observatory.