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Astronomical Society of South Africa

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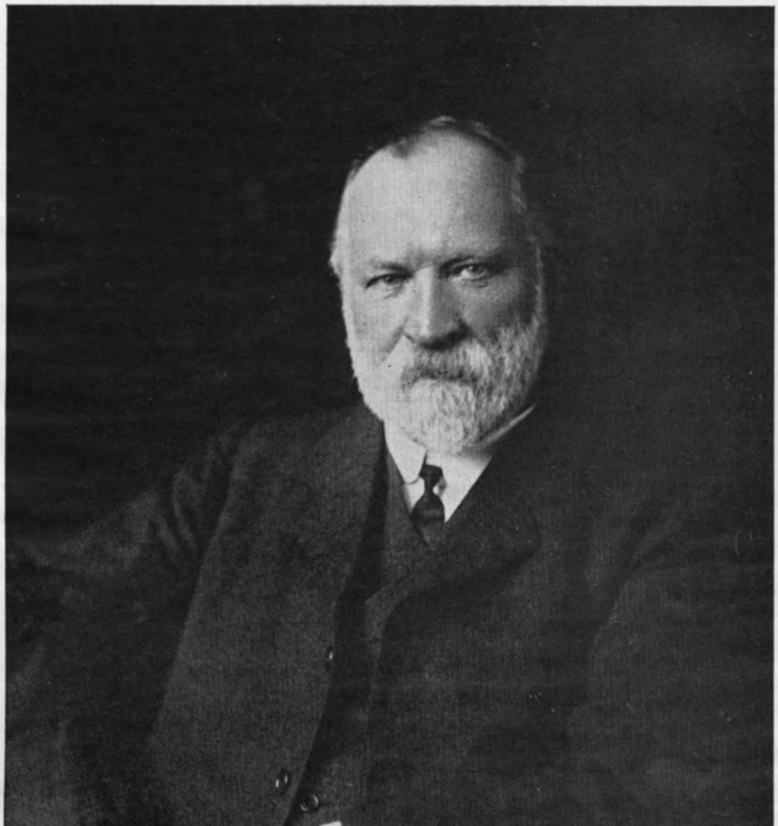
DR. A. W. ROBERTS.

By GENERAL THE RT. HON. J. C. SMUTS.

An extended notice in this issue attempts to do justice to the great services of the late Dr. Roberts to Science. I should like to add a brief reference to his outstanding human service. For in him the humanitarian and the scientist were happily blended together, and his name will be gratefully remembered in both respects. It is not only African skies that appealed to him, but also and equally that dark mass of African humanity which constitutes the major problem of this continent.

But first a word on his astronomical achievements. It is an intriguing thought that a schoolmaster, far away in the wilds of the native territories, should as an amateur have started a line of research which has contributed to the complete revolution of the science of astronomy, and even of our entire view of the physical nature and origin of this universe. Without specialist training, without equipment or apparatus, harassed and exhausted by the endless routine of teaching native children, without helpful stimulus from his fellows, and out of sheer love for his beloved hobby, he struck a vein which has proved the most fruitful in modern astronomical science, and pursued it with an insight and an ardour, and with a success, which have given him world-wide fame. It is truly an astonishing performance. After Roberts let no amateur despair, and let each cultivate his scientific hobby to the utmost limit of his powers and opportunities. Science in South Africa owes much to the amateur. Roberts was truly a prince among our scientific amateurs.



Astronomy was his hobby, native uplift was his work. He began as a teacher of native children, he ended a long career as a Senator for natives in the Union Parliament, as Chairman of the Native Affairs Commission, and as our foremost South African authority on all native questions. There was universal confidence in his impartiality, his sanity of outlook, his wide and wise sympathy in all matters of race and colour. Race and colour form perhaps the supreme human problem of the twentieth century. He specialised on that problem and became our greatest authority in that dangerous and difficult field. From teaching native children he rose to be the teacher of European South Africa in the biggest, most historic issue they have to face in this continent. And it was done all so quietly and modestly, with so much sympathy and tolerance for differing views, that his manifold activities provoked no resentment, and his voice was listened to with respect by all as that of a wise teacher and a great expert. Such men are rare in South Africa. They are rare anywhere. They are a priceless asset in a country where race issues tend to be pursued in a heated atmosphere. In the development of the native policies of this country his sage counsel and expert experience, at times his grave warnings, proved of inestimable value. And so one is justified in coming to the conclusion that his human service transcended his astronomical service and that he brought us nearer to the skies, not only in an astronomical, but even more so in a purely human humanitarian sense.

To me personally it will always be a pleasing recollection that when the opportunity came to me I took him from his exacting teaching duties and gave him wider scope of human service in the Senate, in the Native Affairs Commission, and in public life generally. Of the opportunities that thus came his way he made the fullest and best use, to the lasting benefit of the country.

Deeply rooted in religion, and in that love of God which is also love of man, he rendered a service to his country which we in gratitude shall never forget.

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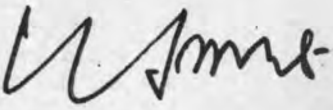

LONG-PERIOD VARIABLE STARS.

By H. E. Houghton, M.B.E., F.R.A.S.

(Presidential Address, Session 1936-37)

The President is generally allowed on the occasion of the Annual Meeting to say what he likes, and before coming to the subject of my Address I should like to make a few preliminary remarks.

We are, I think, fortunate in our choice of astronomy as a vocation or a hobby. The scientific worker now-a-days comes in for a good deal of blame from several quarters. The chemist is credited with the invention of poison gases, the engineer with dangerous machines and weapons, and the physicist with the desire to ruin everything by tampering with the atom. It has been pointed out on many occasions that the scientist has no malevolent aims in his work; it is the use to which his results, obtained in quite peaceful pursuits, are put, that leads to harm. Other people argue in a general way that science is responsible for the rush of modern life, the loosening of various ties and traditions, and the widespread unemployment and unrest. However that may be, we in this Society have no doubt that our branch of science is essentially harmless and peaceful—one might even say restful were there not some, no doubt present, both professional and amateur astronomers, who sometimes lose their night's rest in its pursuit. We invent and employ no destructive compounds or machines (perhaps one must except the discovery of helium, the gas used to fill dirigible airships, which was detected in the Sun by the astronomer before it was isolated on the Earth), and we are legitimately proud of the mathematical conceptions and processes which originated in the study of the stars, and the contributions of astronomy to the study of physics and chemistry.

In other directions astronomy points the way to peace; it leads in international co-operation. The International Astronomical Union is in its sphere more influential than the League of Nations, while its work is unhampered by the national rivalries, vested interests and trade secrets that beset other scientific unions.

I need not stress the goodwill between the professional and the amateur in astronomy—the only limits to a complete entry by the amateur into all the mysteries are lack of training, time and equipment. These, you will say, are serious drawbacks, but they can largely be overcome given an aptitude and sufficient application. One of the secrets is to specialize. It may seem ambitious for a beginner to think of specializing in one branch of astronomy, but the limitations of time and equipment can best be got round by so doing ; otherwise time is wasted and equipment imperfectly used.

This brings me to my subject : the observation of Long-Period Variable Stars. I was introduced to this branch of astronomy when I joined the Cape Astronomical Association, the forerunner of this Society, in 1921. Equipment and time were limited and training had to be acquired. Since that date I may say, for the encouragement of others of equally limited opportunity, that I have made some 20,800 observations of a list of stars now totalling 90 from which it has been possible to deduce about 760 maxima and 640 minima, say 14 observations were required to derive each one of those critical phases.

The first requirement in this study is a list of the stars to be observed and a sequence of magnitudes of comparison stars for each variable. Then from a photographic chart or one constructed from catalogues the observer identifies the variable star and the comparison stars in each case. The light of the variable is compared with that of the stars of known magnitude and its magnitude is estimated by the eye and recorded, with the date and time of the observation. The range of brightness that can be followed depends upon the aperture of the instrument employed. The stars selected should be those whose light will be visible with the instrument over a good portion of the period. In some cases the whole range can be observed with a 3″ telescope, but generally a larger aperture is necessary to obtain a complete series of observations from maximum to minimum. The observer of course follows the star as long as he can, and when it is invisible he records it as not seen, and fainter than the faintest comparison star that he can see.

The standard of accuracy with visual observations varies ; it depends on certain laws and also upon peculiarities in the observer's vision. When, as in our Variable Star Section, the observations of different people are combined, their own peculiarities of vision become apparent.

It has been found that a star near the edge of the field of view appears brighter than one in the middle, and accordingly the variable and the comparison stars should be placed at equal distances from the centre of the field. If this is not practicable each star should in turn be brought into the centre of the field and looked at steadily until a distinct impression of its brightness is obtained. Another source of error that can be overcome in the same way is due to the fact that in a field the lower of two equal stars will appear to be the brighter.

Then there are errors introduced owing to the colours of stars to be compared. The Purkinje phenomenon is apparent as follows : if the observer starts with two equal red and green lights and both are increased in brightness in the same degree, the red light will appear brighter than the green one, and if they are similarly decreased in brightness, the red light will grow faint more rapidly. Although green stars are uncommon, variable stars are usually reddish and their comparison stars whiter, and the same effect occurs as with red and green objects. In a similar manner, if two stars are observed with a small telescope and then with a larger aperture the light received from each is increased and the Purkinje phenomenon comes into play.

A further difficulty was discovered by Dove. The brightness of the background has an effect upon the relative brightness of different colours. When the background is bright, as in moonlight or twilight, a red star appears brighter, and when the background is dark a white star will appear brighter.

There are also differences between observers : of two observers who would find a faint star of equal brightness, one will see it redder as its brightness increases than the other.

Yet another law is Fechner's, which states that the least observable increase in a stimulus is proportional to the stimulus itself. In other words, if the light of a very faint star should increase by twenty-five per cent. the change would be observable and important, but the same actual amount of light added to that of a very bright star would be utterly insignificant and undetectable. Thus the light of a variable when it is bright is less easily estimated and more liable to discordant reports of its brightness than when it is faint.

In spite of the foregoing difficulties, however, changes of brightness in a variable star can be estimated and recorded and a light curve drawn to show the rise to brightness and the decline to a minimum. The observations of several observers can be combined into one series and the most probable curve drawn, though by such a combination of observations small but real divergencies from a smooth curve may be lost. It is soon found, when comparing the light curve of a star over several maxima and minima, that irregularities occur both in the length of the period and in the limits of brightness reached. These irregularities appear to be inherent in the star and not always due to errors of observation. But a mean curve can be obtained from a number of cycles, and such curves have been extensively studied. There are curves in which the intervals from maximum to minimum and from minimum to maximum are not very unequal, and others where there is a sharp rise to maximum followed by a long period of decline. Others show a long flat minimum phase with sharp peaks at the maxima, some have the maximum flat and the minimum sharp, while a few stars, particularly two southern stars observed by members of this Society, R Centauri and R Normae, show a double maximum, that is, from minimum phase they rise to a maximum, then decline to a bright minimum, then reach a maximum again, approximately equal to the previous one, and then drop to the real minimum.

In addition to the above classes, all of which exhibit a good measure of regularity, there are other long-period variables that are obviously irregular—those that remain bright for a period of months or years and then decline for a longer or shorter period, and those, which may include the so-called new stars, that are ordinarily faint but occasionally, after years of observation, become bright. Objects of both those classes are observed by us in the Southern Hemisphere.

A point that has attracted a good deal of attention is whether regularly varying stars show any lengthening or shortening of their periods over a long range of years. The following possible types have been found:

(1) The individual period may differ from the mean by a purely accidental fluctuation independent of previous fluctuations.

(2) The individual period may be correlated either positively or negatively to those preceding it.

(3) The irregularity may be a fluctuation of phase rather than of period. The effect of a perfectly regular cause may be delayed or accelerated by casual circumstances.

(4) The casual circumstances referred to in (3) may be long enduring so as to affect a succession of maxima.

(5) The irregularity may be due to periodic causes.

Two examples of a systematic change of length of period are known: R Hydrae decreased from about 500 days at the end of the 18th century to about 400 at the beginning of the 20th century, and R Aquilae shows a decline from 349 days in 1885 to 310 days in 1925. It has however been pointed out that no "change of period" can be accepted as being real, that is, not a statistical fluctuation, unless after a careful investigation of the standard deviation of individual cycles from the true period the change is found to be either too large, or if showing an apparent sine term, too regular, to be consistent with its being a statistical fluctuation.

The problem of the true length of period has been tackled in another way. Writing in 1932, Mr. Leon Campbell of Harvard observed that " Recent studies of the light curves of many variables over extended intervals of time appear to indicate that periods derived from phases *between* maximum and minimum magnitudes—for example, from points midway—are more uniform than those derived from maximum or minimum phases. This method of computing applies most successfully to the less symmetrical light curves, namely, to those with steep rises to maximum and with protracted duration of minimum light." Quite independently of this conclusion an interesting investigation was carried out by Mr. W. M. Lindley, now Honorary Secretary of the Variable Star Section of the B.A.A., into phase punctuality of long-period variable stars. Discussing the light curves of 19 stars which had been well observed through ten or more successive cycles he found that it was possible to determine a phase for which the period varied by not more than 2 per cent. from the mean; that this phase was in many cases not that of maximum, but subsequent to it; and that the greatest mean deviation from the mean period at any phase was about 6 per cent. and in all cases but two took place on the rise to brightness which was the portion of the light curve which showed the greatest general appearance of irregularity. His investigation was confined to the length of the periods, and did not include irregularities of range of brightness. By examining a long series of light curves it is possible to determine the average time taken by the star from say 9th magnitude on the rise to 9th magnitude on the next rise, and so on for other places on the curve, comparing each rise and each fall with the corresponding magnitudes at the next cycle. Although the maximum and minimum phases are probably the most valuable data, and determined with least doubt, it is found that an intermediate phase may be of more regular occurrence and that the period thus determined is of value. Generally speaking, Mr. Lindley found that points on the curve of decreasing brightness are reached with less irregularity of time than those on the rising curve. This may be due to psychological causes based on an observer's tendency to anticipate the maximum, though some stars undoubtedly show unexpected pauses and delays when their light should be varying with some regularity. But it is clear that all parts of a light curve are valuable, and observers should not crowd observations at maximum and neglect a star at other times.

Mr. Lindley dealt with 19 northern stars; two southern stars, T Pictoris and R Carinae, have been treated in the same way and his results generally confirmed.

Long-period variable stars have been known and studied for over two hundred years. A good deal of work has been done, mainly at Harvard, to bring together all the known data relating to such stars in an endeavour to compare the information available as to period, maximum brightness, range of variation and spectral class. The data regarding period and range are most complete as no star could be included without those details being reasonably well known. Out of 1,077 stars considered, nearly two-thirds (616) had periods of between 201 and 350 days, and the ranges varied from about one magnitude or less to 8.5 magnitudes. Of the same 1,077 stars, the spectral class was known for the brighter stars (537, or one-half the total). Of these 116 showed a non-emission spectrum of classes G, K, M, N, R, or S, 78 being of class M; and 421 showed an emission spectrum of classes Ke, Me, Re, and Se, 390 being of class Me.

The conclusions of the investigation are as follows: A maximum frequency of periods is evident at about 300 days for the variables of known spectrum, but for all the stars of known elements the mode of frequency occurs nearer to 280 days—perhaps because the apparently fainter variables tend to have shorter periods. The correlation between period and spectrum at maximum for Me stars is the most evident result of the discussion, that is, in class Me to which the majority of the stars belonged, the period increases as the spectral type advances from a mean of 150 days with classes M0e and M1e to a mean of 396 days with M7e. This implies roughly that the longer the period the redder the star; for example, of the 10 less red stars of spectral class G or K, 9 have periods of 150 days or less, and most of the longest periods known are those of stars of the very red spectral classes R and S. The correlation of range with period for Me stars is positive but low; the range, however, is systematically large when the period is long and the spectrum is advanced. The stars with observed spectra and known elements show no correlation between mean period and apparent magnitude; thus the length of period of a star which attains the 3rd magnitude at maximum may be little different from that of a star which reaches only the 11th magnitude at maximum. Of the 1,077 stars referred to, 305 had maxima between 8 and 8.9 with an average period of 281 days, and 267 had maxima between 9 and 9.9 with an average period of 294 days. Only two stars exceeded magnitude 3.9 at maximum, and their periods were 231 and 332 days respectively. For stars brighter than the 10th magnitude the period is not related to the absolute visual brightness.

The investigation shows the need for more information, particularly with regard to spectra. With many variable stars the spectrum changes as well as the magnitude: the spectrum of S Carinae varying for instance from K7e to M4e and M5, and many others show varying spectra in class M as their light varies.

This brings us to the question of the physical nature of long-period variables. Their light changes are little more than an advertisement that there is some instability in their make-up. We are still a long way from a complete knowledge of these bodies. Their behaviour and possibly their structure are different from those of other stars. The spectral type M to which most of them belong is distinguished by broad absorption bands of titanium oxide and calcium. The absorption lines have their greatest intensity towards the violet end. Those stars of the sub-class Me show in addition bright hydrogen lines. Type N have broad absorption lines which are more intense towards the red : the lines are due mostly to carbon dioxide and cyanogen. Much of the radiation of long-period variables is in the long, infra-red wave-lengths. In stars like the Sun about half the total radiation lies in that region, but long-period variables show more than ninety-five per cent of their total radiant energy in the infra-red region. They are therefore stars of low temperature, Mira for example varying from 2020° at minimum to 2540° at maximum. This range of temperature is such that a comparatively small increase in temperature throws a considerable increase of energy into the visual portion of the spectrum, and consequently an increase of light by a hundred-fold (five magnitudes) is not necessarily evidence of so great an increase of total energy.

But while the temperatures of these stars may be estimated as above the problem is complicated by the absorption effect of the bands of titanium oxide, and also by the intense bright hydrogen lines, which still remain a mystery.

Long-period variables are giant stars : the largest may be larger compared to the Sun than is the Sun compared to the Earth. The angular diameter of Mira has been measured with the interferometer and found to agree with its calculated diameter, about 0.05″. The density of such stars is extremely low, in fact in a laboratory it would be considered a vacuum.

What is the cause of the variation of light ? We can compare long-period variables with that other class of variable known as Cepheids. The theory with regard to that class is that periodic pulsations take place which cause changes in the rate of emission of light. At the moment when the radius of star has its minimum value, the gravitational forces, the gaseous pressure and temperature inside the star have their greatest values. The star expands until the gas pressure falls to such an extent that the star commences to contract again under the influence of its gravitation ; at or shortly before this stage, some of the greater interior heat at maximum compression has reached the surface and the surface temperature and the light reach a maximum. But the light range of these stars is small, their periods are generally a few days and the maxima and minima follow each other with a regularity of time which may be calculated and predicted to a nicety.

None of the above considerations appears to apply to long-period variables. Their light range may be large, and their periods uncertain to quite a considerable degree.

One of the earlier explanations of the variation of light of these stars was based on the analogy of the rotation of the Sun and the phenomenon of sun-spots. With an arbitrary arrangement of bright and dark areas, almost any light curve may be reproduced. but in a star of low density the necessary discontinuities could probably not exist for hundreds of cycles to account for the degree of regularity observed. Moreover the amplitude of the light curve would depend on the orientation of the axis of rotation with respect to the Earth, and the observed correlations with period, spectrum, and behaviour of bright lines would remain unexplained.

The idea of a general analogy between the cycles of variable stars and the eleven-year period in the frequency of sun-spots has often been mentioned. The conception of a crust forming on the surface of a cooling star, through which the imprisoned gases escape at intervals destroying the crust and giving a great increase of the star's light is attractive, but present data on the sizes and probable densities of long-period variables render that theory untenable.

Changes in temperature alone do not appear sufficient to account for light variations. A drop in temperature from 2350° to 1800° which is typical corresponds to a decrease of one magnitude in total radiation and three magnitudes in brightness, but a further three magnitudes in brightness would have to be accounted for. A periodical increase or decrease in the amount of absorption due to the dark bands in the spectrum may account for a good deal of the differences in brightness, while the theory of the veiling of the star's light by a cloud of liquid particles condensed at certain phases from gases of the upper atmosphere of the star seems at present the most attractive. The latter theories do not however account for bright emission lines of hydrogen seen in the spectra of the majority of long-period variables. Dr. P. Merrill has summarised a general theory as follows: "Because of the large size of these stars or the low density of their atmospheres, or for other reasons, various spectroscopic phenomena are not closely interrelated, but may proceed in partial independence of each other. The temperature of the photosphere, for example, appears not to have immediate control over the appearance and intensity of the bright lines. It seems rather as if the brightening of the photosphere were but one of a number of phenomena set going by a special occurrence at a certain phase. To illustrate the idea, let us postulate a release of energy in a certain level at intervals of time equal to the period of light-variation. These occur presumably just before minimum. The first visible result is the brightening of the continuous spectrum, caused either by an increase in the radiation of the photosphere or by a decrease in the absorption to which its light is subject. The aspect of the spectrum does not change materially for a time. A little later there appears the first of a sequence of bright lines which runs throughout the remainder of the cycle while the photospheric spectrum is increasing to a maximum intensity and then fading. These two effects from a common cause apparently proceed with but little interrelation. The intensities of the bright lines mark the phase unmistakably but they do not seem to bear a simple relationship to the apparent brightness of the photosphere. On the descending branch of the light curve, for example, the intensities of several bright lines differ decidedly from those at the same magnitude on the *ascending* branch. Among the bright lines to develop after maximum one or two persist for a time *after minimum,* thus overlapping the new cycle, indicating that the series of events started by some occurrence near minimum may last longer than a whole period. A similar phenomenon is furnished by the behaviour of sun-spots ; a given series of spots may remain visible for two or three years after the next cycle begins. This is another instance of periodic disturbances each having a chain of consequences longer than the period."

It has been remarked that members of this Society only observe variable stars and do not discover them. There is much truth in that statement. Some years ago, however, one observer, Mr. W. H. Smith, reported a new star in one of his fields but it turned out on investigation to be a known variable discovered at a later date than that of the preparation of the chart he was using.

The earliest long-period variable star to be discovered was the famous Mira Ceti. It is also the brightest known at maximum attaining magnitude 1.7 and declining to 9.6 with a period of about 332 days. It was first noticed by Fabricius, a German clergyman, in 1596, and was again seen by Holwarda in 1638. In December, 1638, it attracted his attention as being brighter than neighbouring stars of the 3rd magnitude. Some time later he was no longer able to find this star, and he believed it had disappeared ; but great was his astonishment when on the 7th November in the next year he perceived it in the same place and shining with a brightness sensibly the same. At this time the star was considered by astronomers as a new star, but Holwarda took particular pains to show that it had been known for a long time and that Bayer had catalogued it in 1603 as being of the 4th magnitude. In 1686 Chi Cygni was discovered by G. Kirch, and R Hydrae in 1704 by Maraldi. The first had been charted and lettered by Bayer, but R Hydrae though it attains an equal brightness (4th magnitude) was missed by Bayer but included by Hevelius in his catalogue as seen by him as a 6th magnitude star in 1662: Maraldi was the first to recognise its variable nature. Up to 1860, 56 long-period variables were known, R Hydrae still being the most southerly object of this class known.

As an example of what was accomplished by an amateur astronomer at a later date, I may quote from an obituary notice of the late Colonel E. E. Markwick. He was stationed in Gibraltar in 1893, and determined to survey the zone $27\frac{1}{2}°$ to 45° S. Declination. The survey consisted in identifying the stars on the maps of Gould's Uranometria Argentina with a pair of binoculars on one or two clear evenings each month, and in noting new or discordant objects, the observation of which was then pursued with a small refractor. In the course of five years he discovered four variable stars, two of which were new, and which are both actively observed by our members—T Centauri, which has the short period of 90 days, and RY Sagittarii, which is an irregular variable remaining at about 6th magnitude for many months and then suddenly and irregularly dropping to below 13th magnitude.

In our Society we remember with pride the great work of Dr. A. W. Roberts and the late Dr. R. T. A. Innes, who have done more than anyone for Southern variables both by their own labours and their assistance to other workers.

One of the earliest systematic discoverers and observers of variable stars was Argelander who was born in 1799. Towards the end of his life he appealed to the " Friends of Astronomy " to study the heavens, including variable stars. A translation of a portion of his appeal may be of interest. He says: " Therefore do I lay these hitherto sorely neglected variables most pressingly on the heart of all lovers of the starry heavens. May you become so grateful for the pleasure which has so often rewarded your looking upward, which has constantly been offered you anew, that you will contribute your little mite towards the more exact knowledge of these stars. . . . The observations may seem long and difficult on paper, but are in execution very simple, and may be so modified by each one's individuality as to become his own, and will become so bound up with his own experiences that unconsciously, as it were, they will soon be as essentials. As elsewhere, so the old saying holds here: 'Well begun is half done;' and I am thoroughly convinced that whoever carries on these observations for a few weeks will find so much interest therein that he will never cease. I have one request, and it is this; that the observations shall be made known each year. Observations buried in the desk are no observations. Should they be entrusted to me for reduction or even publication, I will undertake it with joy and thanks, and will answer all questions with care, and with the greatest pleasure."

Two other quotations will suffice to close this Address. The late Professor H. H. Turner said once: "Probably the time is long gone by when observers were tempted to think that they knew all about any star however regular, and need observe it no more. We have yet to find a variable star which is not capable of giving us a surprise at some time or another, and there need be nothing unwelcome in such surprises, for they may afford valuable clues to the physical causes of variation." And Professor H. N. Russell thinks: "If we really understood the causes of stellar variability, we should probably have advanced a long way towards the solution of the whole problem of stellar evolution."

Acknowledgments.—I am indebted for much information to "An Introduction to the Study of Variable Stars" by Caroline E. Furness, Ph.D. (1915).

A series of articles on Variable Stars by Dr. Paul W. Merrill in *Popular Astronomy*, 1929 to 1936.

Numerous publications of the British Astronomical Association and Harvard College Observatory.

OBSERVATORY DOME.

By A. F. I. Forbes, M.I.A.

The chief aspiration of an Amateur Astronomer after becoming the possessor of a good telescope is to have an observatory with a real, round, revolving dome. The observatory building itself is generally easy to come by but a hemispherical dome presents some practical difficulties to an amateur who has not got at hand the resources of a regular workshop. He generally falls back on some polygonal or octagonal shape in trying to realise his desire, But a polygonal shape does not seem to embody the desired concept; nor has it the easy elegance we associate with a hemispherical dome.

Amateurs often take to working in wood, or wood and canvas, but unfortunately wood does not lend itself easily to circular work, especially "circle upon circle." Not only is it difficult work but it also means forcing the material beyond its natural adaptability, and canvas needs a lot of painting.

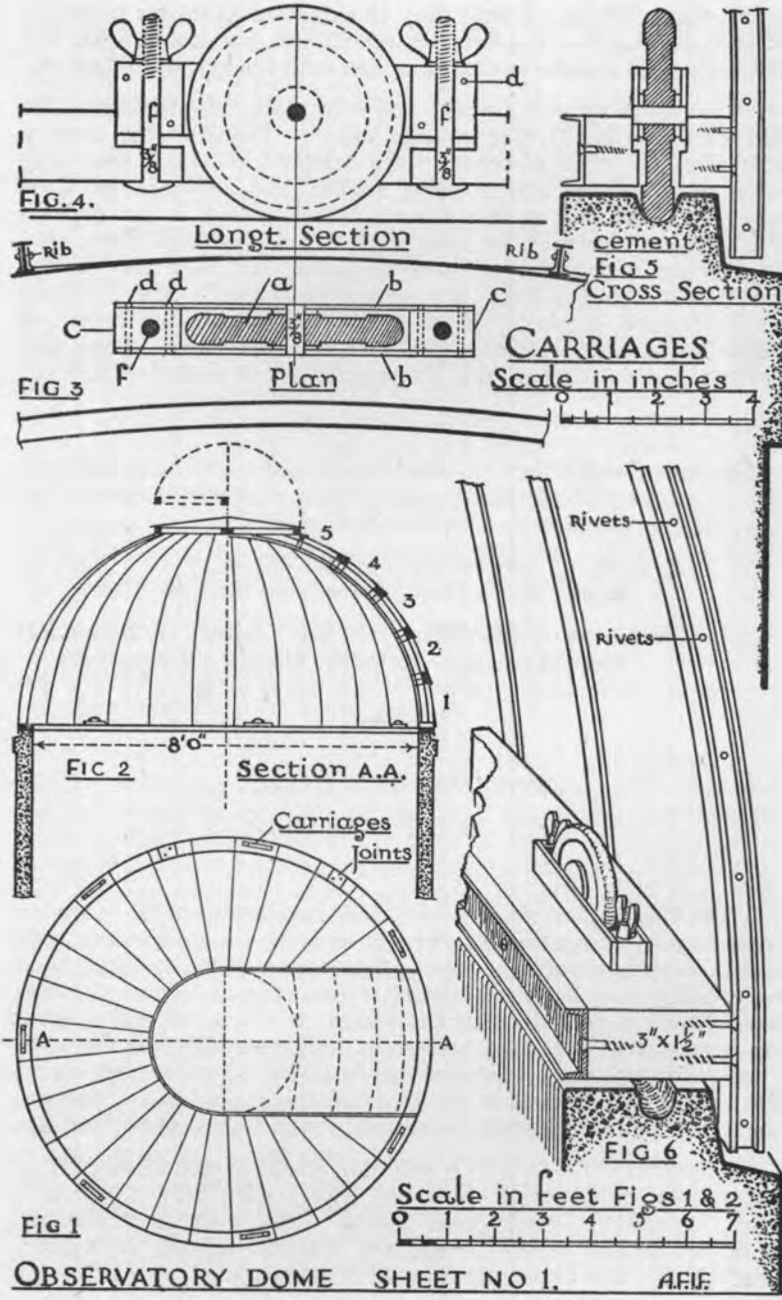
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Fig 5
Cross Section
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Plan
Fig 3
Carriages
Scale in inches
0 1 2 3 4
Rivets
Rivets
5
4
3
2
1
8'0"
Fic 2
Section A.A.
Carriages
Joints
A
A
3"x1½"
Fig 6
Scale in feet Figs 1 & 2
0 1 2 3 4 5 6 7
Fig 1
Observatory Dome
Sheet No 1.
A.F.I.F.

But many things can be made with light steel structural shapes such as angles, channels, beams, tees and galvanised sheet, etc. They can easily be bent when cold into the necessary shapes and only need holes drilled in them to join them together. Domes however do not promise mass production like motor cars but something might be done. Steel has an advantage over wood in circular work. With wood the circles have to be cut exactly ; that needs care. Steel can be bent to the desired circle by the trial and error method. If we bend it too far it can be bent back ; if too little, a knock or two may bring it right. If the worker can do some woodwork ; can use a hack saw ; has some simple facilities for drilling small holes in iron there are not many difficulties to surmount in constructing an excellent dome of steel, or steel and wood. The cost of the materials will be as cheap as it is possible to get by any other method and he can make the whole of it with his own hands.

The design illustrated in the accompanying drawings has been prepared specially for the amateur worker and shows an observatory 8 feet in diameter which is a convenient size for an 8 inch reflector or a small refractor. Without departing entirely from the polygonal form we can by an artifice, by using many sides and by letting the ribs project above the surface of the dome, get a form that will appear spherical when completed. It will be helpful if we think of the dome as consisting of three parts :—

1. The base ring with carriages which we might call the " chassis."
2. The body of the dome.
3. The opening doors.

The " chassis," Fig. 1, is a ring of red deal 3 in. by $1\frac{1}{2}$ in. ; the joints are made between the carriages. To strengthen the ring a band of $1\frac{1}{2}$ in. by $\frac{1}{2}$ in. by $\frac{1}{8}$ in. channel steel is bent and screwed around the inside, Fig. 6.

The carriages, Figs. 3 to 6 are sunk into pockets cut in the wood ring ; the wheels are turned out of hardwood and run in a groove of cement formed around top of wall of the observatory. Wood wheels run quietly and will last for years. The cheeks of the carriages are $1\frac{1}{2}$ in. by $\frac{1}{8}$ in. steel held together by the $\frac{1}{8}$ in. rivets d.d. with spacing blocks of hardwood c.c. The $\frac{3}{8}$ in. bolts with wing nuts are for adjusting to height. Spring washers may be put under the wing nuts. The cement groove is run in Portland cement from a centre ; care has to be taken to get it quite level all round. The ribs of the dome are to be formed of $\frac{3}{4}$ in. by $\frac{7}{16}$ in. steel I sections. With a hack saw cut the top ends to the shape as shown in Fig, 9. Bore all the holes before bending ; the holes in the web need not be spaced out exactly ; they should be drilled

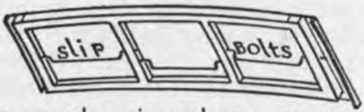
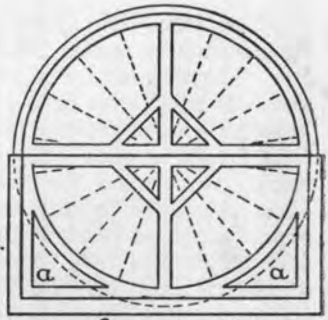
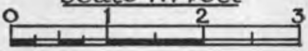


Fig 12 Showing doors No 1 to 5; to be made interchangeable



Cover of eye Looking up. Fig 11

Scale in feet



Steel Required

Ribs	3/4" x 7/8" I beams	24/5'6"	= 53 lbs.
Trimming around openings	1" x 3/16"	1/18'	= 21 "
Channel for inside of base ring	1½ x ½	2/13'	= 40 "
cheeks of carriages	1½" x 1/8" flat	1/10	= 7 "
Galvanised sheets 6' x 3' x No 26 guage		No 10	= 170
		Total	291 lbs.

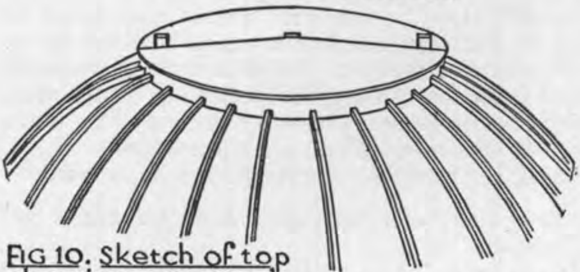


Fig 10. Sketch of top showing cap and projecting hinges

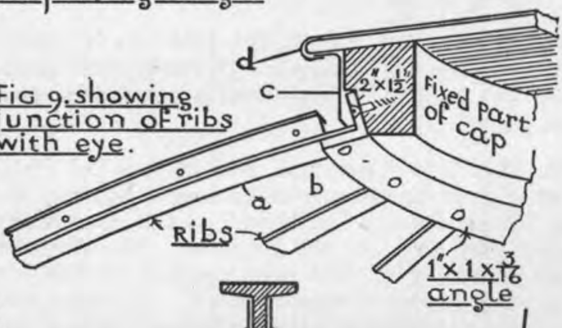
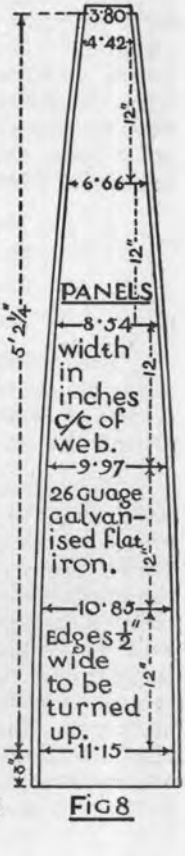


Fig 9. showing junction of ribs with eye.

Fig 7 showing rib approx + full size



OBSERVATORY DOME SHEET NO 2. A.F.I.F

Fig 8

$\frac{1}{16}$ in. larger than the diameter of the rivet we intend to use. Bend the ribs over any curved object that is near to the curve and test them with a templet. In making the templets make them carefully to the curve ; the templet used to form the base ring can be used for the ribs. A flat floor or table is needed to lay the ribs on and a small square to examine them for twist. If they are twisted they can be brought right with a twist by a wrench in the opposite direction.

The panels, Fig. 8, can be cut with shears from No. 26 gauge galvanised flat iron. To turn up the edges of the panels to form the flanges use two thick blocks of wood about 2 ft. long shaped to the curve ; clamp the sheet between them and hammer down the flange ; move the sheet along and repeat till all is complete. We will be delighted to find that, with the hammering on the flange and on account of the lateral curve of the sheet, the panel has now taken on a convex bend that is almost right for the curvature of the dome and that it will need very little more hammering to the flange on an anvil to draw it to the right curve to fit into the ribs.

In riveting the panels to the ribs use a pointed punch of the pliers type or a bear punch to make the holes in the flange. Place it over where the hole in the rib is and pierce the sheets on each side ; this is why the holes in the ribs should be slightly larger than the rivet. Insert rivet and clench.

In the history of domes we find the early builders nearly always left an " eye " at the top. We will be in good company if we do the same and being astronomers we can call the cover the polar cap. Around the eye, Fig. 9, and down the sides of the opening, bend and fix a trimming of 1 in. by 1 in. by $\frac{3}{16}$ in. angle iron. Angle iron is easy to bend cold; it has, however a "way" with it which we will find out as we proceed and delight to master. In setting out the positions of the ribs it is best to be careful about the number and the spacing. If there are 29 spaces in the circumference, there will be half that number in the half eye. We may find it better however not to drill the holes in the angle iron trimming until the ribs and panels are fixed ; the angle iron can then be put to its place and the position of the holes for the rivets marked.

The cap of the dome detailed in Figs. 9, 10, 11, is framed of deal, covered on top with $\frac{1}{2}$ in. radiating boarding and on top of that with No. 26 gauge galvanised iron. The sheet is cut to project $\frac{3}{4}$ in. beyond the wood ; this projecting edge is then hammered down and round the edge and up to clamp a piece of sheet iron C. that has previously been bent and fixed around the edge of the cap. This is a sheet metal workers job but is delightfully easy to do and makes a very neat and suitable finish.

The vertical piece C. has to be notched out afterwards to fit over the ribs as shown in Fig. 10. Only one half of the cap opens; it requires projecting hinges.

Fig. 12 is a detail of the opening doors 1 to 5, Fig. 1. They are best made to lift off and made interchangeable. In a fine evening they would be all off, but in a windy night it is very convenient if we need only to open the part we require. They are framed of deal, lined on top with thin wood and covered with thin iron or for lightness, aluminium. Fastening slip bolts are made of $\frac{3}{8}$ in. iron rods bent with a loop as shown. These loops are useful to an observer with a reflector who needs something to hold to while observing. Clamps to secure the dome in a gale must not be overlooked. They can be fixed inside to the concrete wall and have a projection over the base ring.

When all is complete and painted we should have a very convenient and comfortable observatory; it should look elegant both outside and inside and we need not be ashamed to see it rear its head amongst the most pretentious of roof forms.

BLINK FINDER FOR TELESCOPE.

By A. F. I. Forbes, M.I.A.

In working with a telescope we often invent different contrivances for assisting the work. These often turn out to be only another way of doing things, but sometimes we find that our idea, with practice, will develop of itself and we discover there is perhaps more in it than we originally anticipated.

A reflecting telescope has a small telescope mounted parallel with it as a finder. This finder more often than not gets into an inconvenient position and necessitates the observer moving away from the eyepiece of the telescope altogether in order to get into a position to get a sight. To facilitate observing, instead of using a telescopic finder, I find it much more convenient to use on my 8 in. reflector the device illustrated in the accompanying drawing.

A rigid frame *a*, Fig. I, 16 inches long by 7 inches high of metal or wood is pivotted at *b.b.* parallel to the telescope and is free to fold down on any side over the eyepiece. It has a clamp screw, and two sights *c.* and *d.* *C.* is an ordinary solid point like an inverted *V.* *d.* is a small flat mirror point less than $\frac{1}{8}$ in. in height, set to reflect a beam of light to *c.* from a 4 volt, concealed electric torch lamp at *e.* There is a push button contact at *f.* The light from *d.* should appear less than an ordinary 1st magnitude star.

In using the finder we look across the back sight to the " fore-light " and direct them on to the star we want; blinking the light on and off all the time until we get all in line. We may be surprised at what we see. The back sight is inverted, appears jet black against the small light disc of the foresight and we see the star shining through the black of the backsight as shown in Fig 2. The star will then be in the telescope.

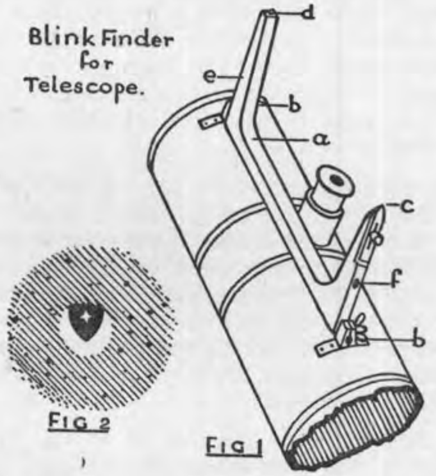


FIG 2

FIG 1

The great advantage of the device is that when we are directing the finder to the object, the eye is not up against an eyepiece which shuts out the surrounding stars; the field is clear nearly all round and we can place the finder not only on the star we want but we can place it on an unseen object which may be relative to the surrounding stars. *Vice versa,* if we see an object in the telescope we can locate its position relative to the surrounding stars much better than by looking through a telescope finder.

I find it facilitates observation greatly; an object can be found at once; we do not need to move from the eyepiece because the finder being pivotted can be brought into a convenient position for getting a sight.

There are other advantages which will become apparent with use. It might be possible to develop it to be a convenient magnitude gauge by having a gauged shutter to reduce the area of the mirror that forms the light disc.

THE PROBLEM OF SATELLITE IV. (CALLISTO) OF JUPITER.

By the REV. CANON E. B. FORD, M.A., F.R.A.S.

Satellite IV. exhibits phenomena which are not common to the other Galilean satellites. In volume it is about as large as III., and very much larger than II. or I., and it might reasonably be expected that it would take the second place in order of brightness, but its light is variable over more than a magnitude and it is normally the dimmest of the four. The three others, though possibly showing slight variation at times, can invariably be arranged in the order of brightness, III., I., II. In contrast to these, IV. varies almost from night to night both in colour and brightness, from a dull coppery state, in which it is about half as bright as II., to a bright bluish white, in which state it surpasses II. and approximates to III.

Of the physical condition of IV. little is known. In volume it is about twice the size of our moon, but its mass is far less. Its specific gravity is one of the lowest in the solar system, being only 0.6, about half that of Jupiter and one-fourth that of III. It is relatively nearer to its primary than our moon is to the earth, the proportion being about 26 : 60 in radii of Jupiter and the Earth respectively. Owing to its proximity to its primary and its relatively low mass its proper orbital motion is about eight times as rapid as that of our moon.

There are two opposing theories as to its physical nature. The first is that of the Astronomer Royal, Dr. Spencer Jones, which holds that it has no atmosphere and " probably consists of ice and solid carbon dioxide."*

There would seem to be rather strong objections to this theory :

(*a*) IV. would hardly show the extreme and irregular variations in light that it does if its surface consisted of two substances of high reflecting power.

(*b*) Even if these substances were overlaid by some substance of less reflecting power over part of the surface, the variation in light would be regular and accord with its diurnal motion. (We do not know certainly whether the diurnal and orbital motions of IV. have become synchronised as with our moon.)

(*c*) It is doubtful whether the cold and pressure necessary for the solidification of carbon dioxide are to be found on IV. If there is no atmosphere to absorb the heat-rays from the sun,

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* " Worlds without end," page 69.

the temperature of the surface would rise during the " day " and should be sufficient to cause the carbon dioxide to pass into the gaseous state.

(*d*) It is difficult to accept the existence of so large a body compounded mainly of but three elements, H, O, and C.

(*e*) The very low specific gravity of IV. is against its being a purely solid body.

The second theory, which is the one held by Sir James Jeans, holds on physical grounds, that Satellites IV. and III. with Titan of Saturn, may well have atmospheres. †

In this case, IV. would probably be similar to its primary in physical composition, a central rocky core, overlaid by a thick crust of ice, with a deep gaseous envelope surrounding it. In order to account for the low specific gravity of IV. it is necessary to postulate a relatively smaller core and a relatively deeper gaseous envelope. It is very doubtful whether IV. with its low velocity of escape, could retain free hydrogen, and its atmosphere would more probably consist mainly of ammonia, methane, and the neutral gases such as nitrogen.

Against this theory must be set the fact that, hitherto, gaseous elements have not been detected in spectroscopic observations of IV., but the difficulty of such observations of planetary bodies is well known. Otherwise this theory accounts well for the low specific gravity of IV. and permits of various possibilities to account for the light variations.

1. Surface disturbances of the gaseous envelope may bring into view layers of condensed gases which differ from one another in reflecting power.

2. The light reflected from the sun may be modified by incandescence of the gases forming the envelope, which may have the power of absorbing sunlight and returning it in a changed form.

3. There may be some quality in the light as reflected from IV. which is subject to modification by diffused light in the earth's atmosphere. This may account partly for the variations as, by observation, IV. certainly seems to be relatively brighter in a " dark " sky than in a " light " one.

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† " The Universe around us," page 193.

REVIEWS.

"Eclipses of the Sun and Moon," by Sir Frank Dyson and R. v. d. R. Woolley. Oxford: Clarendon Press. 15s.

In view of the total eclipse of the sun in South Africa on 1st October, 1940, the publication of a new book on eclipses at once attracts the attention of astronomers in this country. The fact that the senior author is the retired Astronomer Royal who played an important part in organising eclipse expeditions for 30 years and personally took part in many of them indicates at the outset that the book has been written by an expert. His collaborator is a younger astronomer versed in recent researches in the interpretation of spectra.

The book is one which cannot be read quickly. Its most striking feature is the amount of information crammed into less than 160 pages. The whole range of the subject is covered. The first few chapters deal with the geometrical principles governing eclipse phenomena including the calculation of all the circumstances. An account is given of the Saros and of Halley's discovery of the secular acceleration of the moon from data supplied by ancient records of eclipses, as well as the dynamical explanation of this phenomenon.

Those interested in the deflection of light in a strong gravitational field will find the results obtained at various eclipses critically discussed in Chapter VII. There is no doubt that this is one of the most difficult observations which an astronomer has to face. The quantities to be measured though small are much larger than those met with in parallax determinations, but to make the observations with the necessary accuracy under eclipse conditions is only possible when the field of stars round the sun is much richer than the average. The present state of the problem is summed up with these words: "The conclusion is that the displacement is at least as great as 1".75, and possibly a little greater but not more than 2".0. Possibly a slight excess over 1".75 may be attributed to atmospheric causes. But there is no doubt that Einstein's prediction has been verified."

Probably the most useful part of the book deals with the astrophysical results derived from eclipse observation in the last 50 years or so. Up till the middle of last century the principal results of eclipse observation related to the determination of the exact time of the different contacts of the limbs of the sun and moon. But the study of celestial spectra after 1860 gave new impetus to the observation of eclipses, and the rapid advance of photographic methods gave the means for making many valuable observations in the few minutes available. The chapter dealing with eclipse expeditions and instruments is shorter than would have been expected but much information which could be given under this heading is to be found in later chapters.

The second half of the book deals principally with the astrophysical data—spectra of the chromosphere and corona and the polarisation of the corona. These subjects are dealt with both from the standpoint of the observations which have been obtained by various eclipse expeditions and their theoretical interpretation.

The great interest attached to eclipse phenomena led to many efforts to get the observations independently of eclipses which can only be observed for a minute or two per annum. It was only in the last few years that any success has been obtained in this field and the book naturally includes an account of the striking achievements of Lyot in photographing the corona and investigating its spectrum (towards the red) without an eclipse.

There are very few results of importance connected with eclipses not dealt with in this work and for further information the original publications, to which references are given, may be consulted. The book is very well produced and there are a number of excellent plates reproducing eclipse photographs. It is indispensable for students of eclipses.

"Comets," by Mary Proctor and A. C. D. Crommelin. (The Technical Press, Ltd., 8/6.)

Every member of the Astronomical Society of South Africa should possess this book. It contains perhaps the fullest account ever published of the work of the Society's Comet Section. Both the late Mr. Wm. Reid and Mr. A. F. I. Forbes (the original and present directors of the Section) are accorded special sections, and lengthy quotations are made from the Society's publications.

Miss Proctor and Dr. Crommelin form an ideal combination to write about Comets. Miss Proctor combines a picturesque style with a thorough knowledge of her father's cometary theories while Dr. Crommelin is probably the greatest living authority on this subject. Their book is non-technical and is intended for the general reader. It is adequately illustrated with diagrams and photographs.

There are several obvious slips which will doubtless be corrected in a future edition. It may be pointed out, however, that Mr. Forbes discovered his first comet from Rosebank, Cape, and that the photograph is of his Rosebank, and not his Hermanus, Observatory.

OBITUARY.

Alexander William Roberts (1857-1938).

Alexander William Roberts, sixth President of the Astronomical Society of South Africa, was born at Farr in Sutherlandshire, Scotland, on 4th December, 1857. He died at Alice, near Lovedale, in the Cape Province, on 27th January, 1938.

At the age of twenty-five Roberts migrated from Scotland to South Africa to devote his life to educational work among the natives. Enduring as his fame will be as an astronomer—and after Sir John Herschel he is the foremost amateur who ever laboured in South Africa—his fame as friend and counsellor of the natives is greater and will endure among the native peoples longer still. " Roberts of Lovedale's " beginnings in the native field were humble. His and his wife's first quarters were so cramped that, for lack of space, they cooked in a tripod pot in the open. But from these humble beginnings sprang over fifty years of labour in the natives' cause. After many years, he was appointed a Senator to represent them ; and finally he became a member and then Chairman of the Native Affairs Commission, a post which, from a fine sense of duty, he persisted in holding long after failing health and strength might well have justified his leaving it. Dr. Roberts was also a member of the commission to inquire into the native riots at Port Elizabeth in 1920, and in 1922 was chairman of the commission to inquire into the Bondelswarts rebellion. In 1923 he was chairman of a commission on Native Churches, and in 1930 he was a member of the Native Economic Commission.

It is with Roberts as astronomer, however, that these notes deal. His days at Lovedale were very fully occupied ; nevertheless he made up his mind to devote his nights to astronomy. Possibly his friendship with Sir David Gill influenced this decision.

Having chosen astronomy as his hobby, Roberts was faced with the problem of what particular line to follow. He was well acquainted with Gould's work at Cordova in the Argentine. In 1880 Gould's *Uranometria Argentina* had been published giving the brightness of every star visible to the naked eye in the southern skies. In the course of Gould's work fourteen variable stars had been discovered. To quote Roberts' own words from his Presidential Address to the Astronomical Society of South Africa :—

> Gould's work opened up a very great field. My own thoughts, since early youth, had turned to astronomy, and so in 1888, after considerable correspondence with Gould and Pickering and in consultation with Gill . . . I determined to erect a small observatory at Lovedale for the single purpose of observing southern variable stars and other allied phenomena. I spent two years in getting my hand into the work, becoming skilful in determining differences of magnitude, acquainting myself with the labours of other observers.

Roberts had no charts of southern variables to guide him. There were, indeed, very few southern variables known, and the first task was to find variables to observe. Working for some years with only a second-hand theodolite and a pair of field-glasses, he would carefully chart a portion of the sky. Then he would mark all the stars appearing on his chart in descending order of magnitude. A few nights, a few weeks, a few months later he would return to this locality, re-chart and regrade the stars. If the regrading was not in agreement with earlier gradings an investigation was demanded ; some star might have advanced or declined in magnitude.

In this manner Roberts' early discoveries of new variables were made. There were then no photographic surveys of the southern skies, surveys which in later years were to reveal a ready crop of variables—to Dr. R. T. A. Innes in particular. *

After two years of probation, Roberts started work in earnest in 1891. From 1891 to 1894 he made an examination of the southern sky south of decl. 30° which resulted in the discovery of twenty new variables, four of which are of the Algol type. These need not be listed in detail here, for his fame does not rest upon the number of his discoveries. It rests upon the observations he made subsequently of his newly discovered variables and of southern variables discovered by others, and upon the interpretations he placed upon his observations.

Particularly, he devoted attention to the Algol type of variable. These stars, to quote Sir David Gill, " constitute a particularly interesting class of objects. For many days together the star shines with uniform light, suddenly at a particular moment the light of the star begins to wane, diminishing until a certain minimum is reached and again increasing in brightness till the normal magnitude is restored. These periodic fluctuations recur with great regularity. The obvious conclusion is that two stars revolve about each other nearly in a plane directed towards the sun, and consequently one star in the course of its revolution obliterates the other. When the stars are not in the same line with the sun we see as a single star their combined light, when in a line we see the light of only one *plus* such part of the light of the second as is not obscured by the first. Thus there are two kinds of minima, one when star No. 1 is in front of No. 2 and *vice versa*." Such variables, physcially connected double stars (or " binaries "), the components of which eclipse one another, are generally known as " eclipsing binaries."

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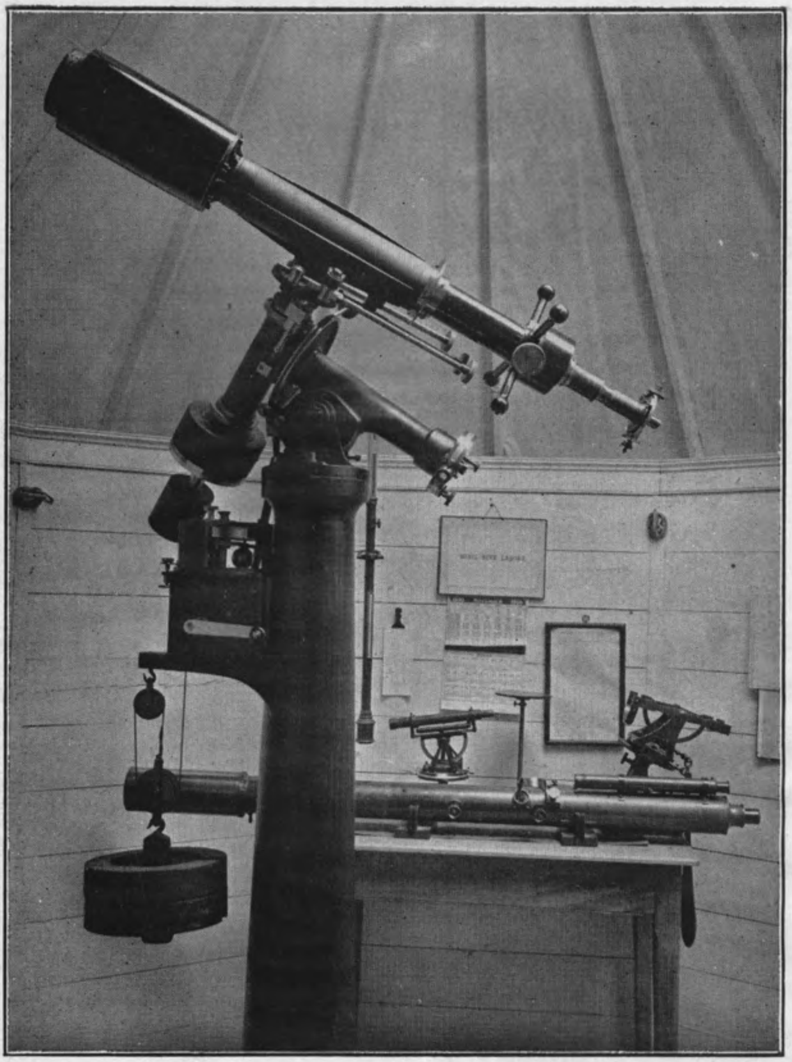
* Innes' discoveries were a matter of routine and not of intensive observational survey. Kapteyn who examined the Cape photographic plates found many anomalies between them and the earlier star catalogues. He listed these anomalies and Innes investigated them.



The Usher Telescope at Lovedale Observatory.

Observatory of Dr. A. W. Roberts at Lovedale.

To enable Roberts to study these stars, patrons of science, knowing his great worth, provided special instruments. Chief of these was a special form of telescope with a rotating prism in front of the object glass, presented by Sir John Usher in 1900. The Usher Telescope was made by Cooke of York to Sir David Gill's design. A system of rotating mirrors for bringing the images of distantly-situated stars into juxtaposition was another of Roberts' important instruments. With these specially constructed instruments Roberts' margin of error was two-hundredths of a magnitude—that is, the difference in brightness of a candle placed first at the distance of 100 and then of 101 yards!

Three examples from this phase of his work must suffice: his studies of the eclipsing binaries RS Sagittarii, RR Centauri and V Puppis.

RS Sagittarii had been discovered by Gould in 1874. Roberts subjected it to long and exact observation and inquiry. Upon the resultant period and character of variation observed by him, he brought to bear a skilful mathematical mind. He demonstrated from his photometric data that the component stars of the system are alike in size but not in brightness—the one giving more than twice as much light as the other. This is indicated in the light-curve by two unequal minima representing one revolution of the components. The minima are 7.6 and 6.9 magnitude respectively, the intervening maxima being a uniform 6.6. The minima, however, differ in duration, the first lasting 10 h. 40 m., the second only 7 h. Roberts deducted from these observations that this binary system has an eccentricity of 0.25, "the long, deep eclipse occurring at apastron, the slighter phase coinciding with the rapid sweep through periastron." The periods between successive minima are very nearly the same—2 days 10 hours. This means that the period of revolution for the system is 4 days 20 hrs. and that the major axis of its orbit is directed towards the earth. Roberts found, however, that the plane of the orbit is slightly inclined, though he had not sufficient data to determine the exact amount of its inclination.

If the story of RS Sagittarii, as unravelled by Roberts, is interesting, the story of RR Centauri and V Puppis can only be described as absorbing. These two stars may be considered together although the method of their observation was different: Roberts observed RR Centauri with the Usher Telescope, and V Puppis with the system of rotating mirrors.

RR Centauri was one of his own new variables. He discovered its variability in 1894—a notable discovery, for the range of its magnitude is only from 7.4 to 7.8. The period is remarkable—a mere 7 h. 16 m.—the shortest period until then found for any star outside a star cluster.

V Puppis (its variation had been detected in 1886 by Stanley Williams) Roberts found to vary from 4.1 to 4.9 magnitude. Its period he fixed after meticulous observation and labour at 17 h. 27 m. 13 s. This indicated, if the star was a binary, a period of revolution for the system of 1 day 10 h. 54½ m. But here the spectroscope stepped in. Spectrographs of V Puppis, taken by Bailey at Arequipa, showed that the star was certainly a binary, but from them was inferred a very different period—a period of 3 d. 2 h. 46 m. The spectroscope is usually regarded as the final authority in these matters—yet Roberts resolutely refused to abandon his period. " I have spoken my last word on the subject," he said. Early in the present century a re-examination of spectroscope observations, old and new, was made at Harvard and it was found that Roberts' period of 1 d. 10 h. 54½ m. satisfied all observations.

But period and variation are not what constitute the true interest of these two stars. To understand their significance it is necessary to digress for a moment. While Roberts was labouring at Lovedale (he worked night after night with a bare three hours sleep in the twenty-four, and sometimes with no sleep at all), Poincaré in France and Sir George Darwin in England were engaged upon a profound study of the form which two stars would take revolving in near or actual contact. Their work was of extraordinary interest, for it linked up fundamentally certain aspects of the theory of stellar evolution. These aspects cannot be touched on here ; it suffices to say that Roberts was able to prove from his photometric data that RR Centauri and V Puppis approximate very closely to the form which Poincaré and Darwin demanded from theory. He demonstrated that the components of these binaries are spheriodical in figure ; that in the case of V Puppis they are almost in contact as they revolve round one another, and that in the case of RR Centauri they are in actual contact, forming a monstrous rotating dumbbell.

An important preliminary paper, read at the inaugural meeting of the S.A. Association for the Advancement of Science in 1903, gave particulars of five close binary systems. Two years later when the British Association visited South Africa under the presidency of Sir George Darwin himself, Roberts expanded and amplified what he had written earlier, discussed six very close systems, and read a classic paper upon apioidal binary stars. For the two stars under examination he added important new matter.

Of V Puppis he wrote :—

> The component stars, which are apparently equal in size, but slightly unequal in brightness, do not quite touch one another. A gap equal to the tenth part of either of their diameters divides them.

When fission in this interesting system took place it is impossible to say; but reasoning from the analogy of β Lyrae* the birthday of V Puppis is but in the yesterdays of astronomical time. Probably 400,000 years is the outside limit for its age as two separate stars.

Both stars are considerably flattened; and there is evidence in the light-curve of great tidal pulsations due to the slightly eccentric orbit of the system.

Each component of V Puppis measures 16,000,000 miles along its greatest diameter; the total mass of the system is equal to 310 suns; the density, however, is only 0.02, that is, the stars are two vast gaseous masses.

His investigation of RR Centauri involved over 10,000 observations! He wrote:—

This variable is in some respects the most remarkable of the apioidal binary type. The two stars forming the system are not merely in contact, they coalesce, thus forming one dumbbell body. As might be expected, the prolateness of the figure of both components is much greater than we find in any other star of the same class.

The light-curve, which is very regular, indicates a slightly elliptical orbit.

The density of the system is 0.25 and there is evidence of tidal contraction and expansion.

The gist of Roberts' two papers was later incorporated by Sir George Darwin in his book—the standard work on the subject —"The Tides and Kindred Phenomena in the Solar System." To that book the reader interested is referred.†

The work incorporated in his book by Sir George did not end Roberts' investigations into the nature of eclipsing binaries. Nearly ten years later he made substantial contribution to the theory of Algol variation when, from a consideration of the elements of southern binaries, he showed that the density of the Algol class is from one-tenth to one-hundredth that of water; that is, he showed that the great majority of these variables are gaseous.

It must not be thought, however, that Roberts' observations were confined to eclipsing binaries. He took all variables to his province. When the British Association visited South Africa in 1905, Sir David Gill called public attention to his work. Gill wrote:—

Roberts has made in all about 250,000 independent estimations of stellar magnitude, and all this work outside heavy duties in connection with the Lovedale Institute, of which he has, in Dr. Stewart's absence, been the responsible director. I know of few instances of more successful devotion of small means and limited opportunity to the attainment of great scientific ends than the work of Dr. Roberts.

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* Roberts showed that in the case of β Lyrae there is evidence of a recession between the two component stars.

† A full account of Roberts' work on close Algol variables may also be found in W. W. Campbell's "Stellar Motions"—another standard work.

With W. H. Finlay (then Chief Assistant at the Royal Observatory of the Cape of Good Hope) and R. T. A. Innes*, Roberts co-operated in a long series of observations of that temperamental variable η Argus. Their observation showed that the star was wavering between 7.0 and 7.7 magnitude, and that there seemed to be no promise of a return to its flaming maximum of the year 1843.

Roberts also inquired into the proper motion of η Argus and found the star practically devoid of this attribute. From this it was concluded that η Argus is at a prodigious distance from the earth.

Of another puzzling southern variable, R Trianguli, Roberts made an exquisite series of observations. More exquisite still is his long series of observations of the Cepheid variable S Arae. A sequence of papers by him on the variation of this star ranges over a period of about fifteen years. His work on it made it one of the best-known short-period Cepheid variables, and he gave particulars of it in his presidential address to the Astronomical Society of South Africa in 1928: " S Arae completes its light changes in less than 11 hours. Its rise to maximum is very rapid, occupying about 40 minutes only; indeed, so rapid is it at certain stages of its ascent that the star is seen to increase in brightness during the two or three minutes that the observer takes to make his observation. S. Arae is the typical star of the group called cluster variables because they are found in globular clusters." S Arae itself is not in a cluster. It is an isolated southern star whose variation was detected by the late Dr. R. T. A. Innes.

When the significance of Cepheid variation was realised, Roberts' delight knew no bounds: " I think it is a matter of great gladness to workers in the region of stellar variation," he said, " that the portion of astronomy which fifty years ago ranked low in the science should to-day be the most powerful engine in arriving at a conception of the dimensions of the Universe."

He had a long list of Cepheid variables which were under observation at Lovedale. Particularly he was watching for secular decrease, in such stars, of the amplitude of variation. The evidence, it seemed, was there; but unfortunately his researches were incomplete and unpublished when he died.

That is the tragedy of Roberts' career. He fought a lone hand. He lived at an isolated outpost. His days were full of grinding routine and exacting labour. Inevitably his health suffered; more than once he was on the verge of breakdown. The gigantic task in astronomy he had set himself was too much for one man.

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* Then Secretary to the Royal Observatory; later first Union Astronomer and second President of the Astronomical Society of South Africa.

As long ago as 1897 he was forced to return to Scotland to recuperate and rest. While he was there his old friend, Sir David Gill, wrote to him from the Cape :—

> . . . No, my good friend, you have been getting a lot of human sympathy which you have long been without—and now kind nature has said to your soul—I bring you peace and rest, just live with me awhile. You are wise and have done as she bade you—and you will live to be thankful that you have left your reductions alone till the nerve-healing process is complete.

The nightmare of those reductions was to haunt him for forty years. He was always behind his schedule ; yet he seemed unable to delegate a portion of the task to willing volunteers. Not only his work on the Cepheid variables remains incomplete. There remain, too, observations of nearly a hundred long-period variable stars extending over thirty years. " Now that the time is mine in which to reduce and compare these observations," he said in 1928, " I find that in the case of over seventy of these stars there is the clearest evidence of a period-variation usually from twenty to thirty times the length of the mean period." But in 1928 Roberts had still far to go in the reduction of his long-period observations. In the last years when questioned he would shrug his shoulders despairingly. Despite the bitterness of unfulfilment, the sweetness of his nature endured ; he remained the wise, kind partriach with the heart of a boy.

That Roberts' interest in binaries should extend from the spectroscopic to the visual was predestined. As a theoretical research worker he was without peer among South African amateur astronomers. His earliest investigation in the field of visual binaries was an inquiry into the orbit of the well-known double star Sirius. When his paper on this star was presented to the Philosophical (now the Royal) Society of South Africa, Sir David Gill hailed it enthusiastically as the first contribution of a mathematical nature submitted by a non-professional scientist. There have been several determinations of the orbit of Sirius since then. But the student would do well to search out Roberts' paper, which for sheer lucidity of presentation is probably unsurpassed.

After this preliminary essay, Roberts achieved an important piece of work in his determination of the orbit of the famous southern double, α Centauri. He also re-examined Henderson's pioneer determination of the parallax of this star and showed how fine was the work accomplished by Henderson.*

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* Thomas Henderson was His Majesty's Astronomer at the Cape in 1832 and 1833.

Roberts obtained a new determination of the parallax of α Centauri from an examination of meridian observations; a method similar to Henderson's. His new value for the parallax was splendidly in accord with Gill's and Elkin's, from heliometer measurements, and with Wright's from spectroscopic measurements of the radial velocities of the components of the system.

Another laborious task which Roberts set himself was an investigation of future solar eclipses (including annular and partial) visible in South Africa. For over a quarter of a century his work remained the most authoritative pronouncement on the very important total solar eclipse of 1940 and was constantly consulted by astronomers.

That an observer of Roberts' calibre, with his flair for theoretical research, should investigate the circumstances surrounding photometric measurements of star-light was inevitable. A notable paper, contributed forty years ago to the Royal Astronomical Society, is cited by Mr. W. M. H. Greaves, Astronomer Royal for Scotland, in the article on Photometry in the latest edition of the *Encyclopedia Britannica.* Roberts, he writes, investigated the effect which the position angle of two star images had on an estimate of their brightness. He "found that his eye-estimations of the brightness of variable stars required a correction depending on the position angle of the comparison star and ranging over nearly two magnitudes."

Dr. Roberts was a prince among astronomical correspondents. Nothing was too much trouble. Ask him about the suspected variation of a star and he would reply, in his clear handwriting, with quotations of magnitudes from Herschel and Gould down to the present day, illustrated with beautifully drawn star charts. He was, too, a gifted speaker, poetic and lucid when talking on astronomy, and rising to real heights of eloquence when pleading the cause of the native. His last public appearances as an astronomer were as lecturer during the Herschel Centenary Celebrations in 1934.

Dr. Roberts was a splendid raconteur. One tale may be permitted, for it has an astronomical twang. Among his duties at Lovedale was the instruction of a class of native pupil teachers. Each pupil in the class was required to give a lesson to the remaining pupils. On one occasion Dr. Roberts instructed a favourite pupil to give the class the lesson on "the proofs that the earth is round." The lesson progressed perfectly; questions, answers, comments could not have been bettered. Then, at the end, the "teacher" glanced nervously at the doctor, and "Now do you believe that the earth is round?" he asked. "No!" vociferated the class.

" Well," remarked the teacher, " neither do I ! " Dr. Roberts often told this story to illustrate the inherent honesty of the native.

During his long life he had many scientific honours conferred upon him. Among others, was a Doctorate of Science conferred by the University of the Cape of Good Hope, and he was a Fellow of the Royal Society of Edinburgh and of the Royal Astronomical Society. In 1921 he was a member of the commission to inquire into land surveying in the Union ; in 1925 he was the South African representative at the meeting of the International Astronomical Union. But what pleased him most in his later years was not that his work had been honoured in the past, but that some of it at least would be continued by others in the future. For that purpose the Variable Star Section of the old Cape Astronomical Association (later the Astronomical Society of S.A.) was formed, after consultation with the doctor himself. In his presidential address to the Society some years later he was proud to say :—

> In our own southern land this Society, over which I have the honour to be president, has put variable star work in the forefront of its endeavours, and as an Association we may point with no mean gratification to the achievements of Watson, Long, Cousins, Houghton, Skjellerup, Smith, Ensor, and others, who in this wonderful, sun-drenched, star-lit land of ours have found success and happiness in their scientific pursuits.

The work goes on.

DONALD G. McINTYRE.

ASTRONOMICAL SOCIETY OF SOUTH AFRICA.

Session 1936-1937.

Annual Report of the Council.

The roll of the Society now includes 111 members and associates, 5 honorary members and 2 members emeriti.

The Council has met three times during the year, those members who are eligible under Article VI. (iii.) of the Constitution being represented by alternates.

During the year Vol. IV. No. 2 of the Society's Journal has been published.

The work of the observing sections has been steadily continued during the year. Members residing near Cape Town are reminded that should they wish to make astronomical observations, the telescope of the Cape Centre, housed at "Carnalea," Malleson Road, Mowbray, is available for this purpose.

The Council expresses its appreciation of the painstaking labour that directors and members of observing sections are devoting to the fulfilment of one of the objects of the Society, and would urge all who can to become members of observing sections.

The Council is very pleased to report that the Coronation Medal was presented to Mr. H. E. Houghton, in his capacity as President of the Astronomical Society of South Africa.

During the year Mr. G. E. Ensor, Pretoria, has secured 28 observations of occultations, which have been forwarded to the Union Observatory for reduction.

STATEMENT OF INCOME AND EXPENDITURE FOR YEAR ENDED 30th JUNE, 1937.

Income.	£	s.	d.	*Expenditure.*	£	s.	d.
To Balance 30/6/36 ...	3	12	7	By Printing Journal,			
„ Contributions:				Vol. 4, No. 2 ...	38	6	7
Cape Centre ...	30	9	6	„ Postages	0	17	0
Durban Centre ...	4	4	0	„ Commission on			
„ Sale of Journals ...	0	10	3	Cheques	0	0	10
„ Sale of Sundial ...	0	14	8	„ Balance carried fwd.	0	6	7
	£39	11	0		£39	11	0

Examined and found correct.

E. J. STEER,
Hon. Auditor.

W. H. SMITH,
Hon. Treasurer.

27th July, 1937.

REPORTS OF SECTIONS.

For the Year ended 30th June, 1937.

COMET SECTION.

With the exception of May and June which was rather cloudy at the Cape, the sky has been well scanned month by month for comet apparitions but without result.

We wish to thank the professional Astronomers for much help and encouragement. The Royal Observatory favours us with copies of cables announcing new comet discoveries. From the Union Observatory we get photographic star maps which are a great help to observers in solving knotty points about nebulous objects that so often arise.

But we need more observers to definitely join the Section, especially those who are situated on the higher veldt where the skies may be clear when it is cloudy at the Cape.

We heartily congratulate Mr. C. Jackson of the Union Observatory for the discovery of Comet 1936*c*. Comets south of the Equator are scarce now-a-days.

Since our last report, the following cometary discoveries have been made :—

Comet 1936*c* (Jackson). A new comet was discovered at the Union Observatory, Johannesburg, by Mr. C. Jackson on September 20th. Its position at discovery was R.A. 22*h* 59.8*m*. Dec.—12° 47′ The following elements are by the discoverer from early positions :

T. 1936, October 3.236155 U. T.

$$\left.\begin{array}{l}\omega\ 197^\circ .23456\\ \Omega\ 164^\circ .26784\\ \iota\ \ 13^\circ .13262\end{array}\right\}1936.0$$

e 0.6379229
q 1.4559783
p 8.0636334 years

At discovery it was Magnitude 12. but was too faint at any time for the telescopes of our amateur members.

Subsequently this comet was called Jackson-Neujim from a prediscovery image on September 9th.

A further orbit by Cunningham gives it a period of 8.5315 years but the orbit is being still further investigated.

Comet 1937*a* (Daniel). This comet was discovered in Japan by Mr. Simizu. It proved to be Daniel's comet 1909 IV. that had been given up for lost.

Comet 1936*b* (Whipple). A new comet was discovered by Dr. F. L. Whipple at Harvard. It was magnitude 12 and had a tail less than 1° in length.

Comet 1937*c* (Wilk-Peltier). This comet was discovered independently by Dr. Wilk of Cracow and by Mr. L. Peltier at Delphos, Ohio. It has a circular coma 2′ in diameter and a narrow, well defined tail more than a degree long.

Comet 1937*d* (Greig-Skjellerup, Periodical). This, now well known, comet due to return this year was detected at Harvard on April 30 by Mr. L. M. Cunningham. It will be recalled that this comet was discovered at Rosebank, Cape, in 1922, by Mr. J. F. Skjellerup and was subsequently identified with Comet Greig 1902 II. It returns every five years and is amongst our shortest periodicals.

We have to acknowledge our indebtedness to the Comet Notes by Dr. Crommelin in the B.A.A. Journal in compiling these notes.

A. F. I. Forbes,

Director.

VARIABLE STAR SECTION.

The total number of observations received during the year was 5,882, contributed as follows :—

A. W. Cousins ...	308	observations of	16	stars.
R. P. de Kock ...	1,692	„	65	„
G. E. Ensor ...	1,572	„	128	„
H. E. Houghton	2,257	„	90	„
Rev. S. Solberg ...	53	„	14	„

We are glad to welcome to the Section Mr. Cousins who has been studying variable stars for a good many years. Thanks are due to him and Mr. de Kock for many valuable early morning observations.

Notes.

Nova Pictoris is fading slowly and averaged mag. 9.4 during the year.

RS Ophiuchi brightened from mag. 11.1 to 10.4, but has since faded to 11.6.

S Apodis remained at normal maximum, about mag. 10.1 throughout the year.

RY Sagittarii was followed closely from July to December and varied from mag. 7.0 to 6.2 : when picked up in February after conjunction with the Sun its magnitude was 8.9 and it reached a short minimum of about 11th magnitude on 7th March, 1937, since when it has been brightening slowly.

S Chamæleontis and *XZ Velorum.*—Dr. Jackson has kindly drawn attention to these irregular variables. The first, which is included in the Royal Observatory parallax programme, is described in Prager's Catalogue as variable 7.0 to 8.0 (photographic), period unknown, spectral type F5. An observing chart was prepared from the Union Observatory map, and Dr. Jackson furnished the magnitudes of some comparison stars. It has been carefully observed since 1936 August and shews an irregular variation from 6.5 to 6.7. XZ Velorum was noted by Dr. Jackson as a very red star. It is described by Prager as varying from 12.0 to less than 14.0 (photographic), period unknown ; its visual magnitude is given variously as $7\frac{3}{4}$ to 8.6. An observing chart was constructed from the U.O. map and a catalogue, and observations by the Director from 1936 December to 1937 April record its magnitude as lying between 9.9 and 8.6. It is a difficult star to focus and estimate owing to its intense crimson colour ; it will be kept under further observation.

H. E. HOUGHTON,
Director.

ZODIACAL LIGHT SECTION.

Only two stations sent in reports this year, they are :—

Station No. 2. Eshowe, Rev. S. Solberg.

Station No. 6. Hermanus, A. F. I. Forbes.

These reports include, between them, observations for every month except September, November, December and February. The outstanding feature of both reports is that this Session the light has been faint and difficult to define. It has therefore not been possible to make much use of the charts because it has been so difficult to recognise the boundaries.

Mr. Solberg reports the Light, in eleven out of twenty-five observations as being South of the Ecliptic. He has traced the Band as far as 146° from the Sun and also reports having seen the band as wide as 18°.

Reports from Station No. 6 give an average distance of the Apex from the Sun as 56°, and the Band is reported to have been seen to 112° from the Sun.

From the few observations received this Session it is difficult to make comparisons or deductions and we will need to let our observations accumulate for a longer time before we can come to any definite conclusions.

So we can only go on and not only get as many observations as possible but train ourselves in the "finesse" necessary to observe this most subtile and delicately constituted object.

In considering the faintness of the Light reported this year we would like to call attention of observers to a passage in the Presidential Address to our Society by the late William Reid in 1927 (Vol. II. No. 2 of our Journal). In it he said: "My observations lead me to the conclusion that the Zodiacal Light fluctuates in brightness, and that it is always brightest at the sunspot minima. I noticed this particularly at the last minimum: sometimes it was so bright, it interfered with my comet searching and I was forced to give up long before dawn." We would like members when observing the Light to take particular notice of these coincidences. In Australia observers are devoting much attention to this.

The following is an abstract from the latest B.A.A. Memoir reporting the work of the Rev. R. B. Bousfield in Australia:

> "It seems probable that a certain period, either before, or after Solar Maximum, atmospheric opacity decreases to a minimum causing the Galaxy, the stars and the Zodiacal Band to increase their intensity for penetration of the atmosphere; and similarly, at a period in the vicinity of the Solar Minimum a decline of light sets in, dimming the Galaxy and Zodiacal Band in nearly equal ratio, at an equal altitude; and dimming the Zodiacal Cones in a ratio which is so exact that an equalizing photometer cannot distinguish any difference. As this problem is closely associated with the question as to the actual or apparent changes in intensity of Zodiacal Light, it has been definitely included in photometric study of the Light. . . . .

While on this subject we would like to quote the following notes made in 1936 July 31 at Station No. 6:

> "This morning the Light was so faint that one had to look carefully to see it at all. It was brightest at 5 o'clock; the whole sky seemed light and that I think is a possible explanation of why the Light appeared so faint. In the telescope, sweeping for comets, the sky seemed quite clear but I noticed that the small nebula near *r*3 Eridanus could scarcely be seen.

I will, after this, on any night that the Zodiacal Light can scarcely be seen, compare it with these known nebulae that I know are about my limit of seeing. I have an idea that the Zodiacal Light does not vary so very much. It may be the atmosphere, or some other cause, and I will try and see if these faint nebulae are also in unison with the seeing of the Zodiacal Light."

We have quoted the above three extracts to show that there is ample field for research in this branch of Astronomy.

We would like to get more observers. Africa possesses as good skies as any part of the world and we would like to see a chain of stations along the back bone of Africa up to Egypt.

We quote again from the same B.A.A. Memoirs on the Australian work :

" Investigation into changes in the light could be assisted by a chain of African observers along similar longitudes. This plan is being tried out by a longtitudinal chain of B.A.A. and Japanese workers, taking simultaneous observations in Australia and Japan, to determine the nature and causes of fluctuations in the Zodiacal Light and possible shifts in the boundaries of the Cones, seen at the same moment from both sides of the equator."

Members of our Society living in modern towns cannot hope to assist directly but they can be of great assistance if they can interest any one living in the country in any part of Africa to take part in the work. Sometime we may be fortunate and obtain a photometer for the Section. Instruments are not, however, necessary ; much can be done with the naked eye and we can assure members that the work is a most fascinating study, and much is yet virgin ground, full of beauty and interest.

A. F. I. FORBES,
Director.

JUPITER SECTION:

It is regretted that owing to the illness of the Director, Mr. Chas. E. Peers, it is not possible to publish the report of this Section.

Observers are urged to continue to forward drawings and reports of surface markings on the planet and to observe for variation in the magnitudes of the sattelites.

For some years Jupiter will be so badly placed for observers in the Northern Hemisphere that only by co-operation from Southern observers can a continuous record of surface phenomena be made possible.

CAPE CENTRE.

Twenty-Third Annual Report, 1936-1937.

MEMBERSHIP.

Five new members and two associates have been elected during the year. One associate has been lost through death, while six members have resigned. The total membership is now 99, consisting of 87 members, 2 members emeriti, and 10 associates.

MEETINGS.

There have been eight ordinary meetings during the year, held in the Mountain Club Room at 38 Strand Street.

ADDRESSES AND PAPERS.

The following addresses and papers were presented at the meetings :—

"Kepler's Laws," Mr. R. Watson.
"The Spectrum and its Application to Astronomy," Mr. D. C. Alletson.
"The Moon," Mr. H. W. Schonegevel.
"The Geological History of the Earth's Surface," Dr. J. K. E. Halm.
"Navigational Astronomy," Mr. J. G. Gwayde.
"An Early Pocket Star Atlas," Mr. H. E. Houghton, M.B.E.
"The Lick Observatory," Dr. R. H. Stoy.
"Transits of Mercury and Venus," Mr. A. W. Long, F.R.A.S.
"Accurate Time-keeping," Mr. L. T. Davis.

ARTICLES IN THE PRESS.

Articles detailing astronomical phenomena, together with charts and diagrams of the sky, have been published monthly in the "Cape Times." Astronomical notes have also appeared in Afrikaans in "De Suiderstem" and "Die Burger." Talks on Astronomy have been broadcast from the Cape Town Radio Station. All these were contributed by members of the Centre and were greatly appreciated by members and the public.

TELESCOPE FUND (see Treasurer's Report).

Donations received :—

Already acknowledged	£81	17	3
Mr. H. Russell	0	10	6
Total ...	£82	7	9

Mr. H. E. Houghton, as President of the Astronomical Society of South Africa, has been presented with the Coronation Medal during the year under review, and the Committee of the Cape Centre takes this opportunity of congratulating Mr. Houghton on the honour shown to him.

FINANCIAL STATEMENT FOR THE YEAR ENDED 30th JUNE, 1937.

Receipts.		£	s.	d.	*Payments.*	£	s.	d.
Balance at 30/6/36 ...		2	5	5	Stationery and Type-writing	5	1	6
Subscriptions:					Contributions under Article XIII. of Constitution	30	9	6
Arrears	£12 12 0				Subscription to Astronomical Society of Pacific	1	2	3
Current Year	43 15 9				"Cape Times" and Postage to Country Members	4	2	9
Advance	4 15 6				Rent of P.O. Box ...	1	5	0
		61	3	3	Rent of Meeting Room	7	10	0
					Donation to Telescope Fund	3	0	0
					Secretary's Expenses	1	12	0
					Treasurer's Expenses	0	18	6
					Bank Charges	1	10	6
					Balance	6	16	8
		£63	8	8		£63	8	8

TELESCOPE FUND

Receipts.	£	s.	d.	*Payments.*	£	s.	d.
Balance at 30/6/36 ...	3	3	6	Cartage of Dome ...	1	10	0
Loan	20	0	0	Erection of Dome ...	25	0	0
Donations	13	13	6	Painting and Fitting Dome...	1	5	0
Sale of Keys	0	3	6	Equipment	0	19	0
				Keys	0	5	0
				Dome Fittings ...	3	13	0
				Fitting for Sun Diagonal	0	10	0
				In hand...	3	18	6
	£37	0	6		£37	0	6

Examined and found correct.

E. J. STEER,
Hon. Auditor.

J. B. G. TURNER,
Hon. Treasurer.

14th July, 1937.

COMMITTEE OF CAPE CENTRE.

Chairman:	Dr. R. H. Stoy.
Vice-Chairman:	Capt. D. Cameron-Swan.
Hon. Secretary:	Mr. A. Menzies.
Hon. Treasurer:	Mr. J. B. G. Turner.
Librarian:	Mr. W. Andrews.
Auditor:	Mr. E. J. Steer.

Members of Committee: Messrs. A. W. Long, H. W. Schonegevel, J. Linton, and C. E. Peers.

ASTRONOMICAL SOCIETY OF SOUTH AFRICA.

OFFICERS AND COUNCIL, 1937-38.

President: Dr. J. S. Paraskevopoulos.

Vice-Presidents: Mr. H. E. Houghton, M.B.E., F.R.A.S.; J. Jackson, M.A., D.Sc., F.R.S., F.R.A.S.; Mr. A. W. Long, F.R.A.S.

Hon. Secretary: Mr. A. Menzies, F.R.A.S.

Hon. Treasurer: Miss. J. R. Robinson, Timour Hall Road, Plumstead.

Members of Council: Messrs. J. B. Mumford, A. F. I. Forbes, M.I.A.; G. E. Ensor, A. W. Robinson, R. H. Stoy, M.A., Ph.D., F.R.A.S., and Capt. Cameron-Swan, F.R.A.S., F.R.P.S., F.S.A. Scot.

Auditor: Mr. E. J. Steer.

Hon. Librarian: Mr. W. Andrews, "Tircreevan," Clifton Road, Mowbray.

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: H. E. Houghton, M.B.E., F.R.A.S., High Commissioner's Office, Cape Town.

Jupiter: C. E. Peers, "Cheshunt," Annerley Road, Rosebank, C.P.

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

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; Radcliffe Observatory; Astronomical Society of Tasmania; Royal Observatory, Cape of Good Hope.

ASTRONOMICAL SOCIETY OF SOUTH AFRICA.

List of Members and Associates, 1938.

Honorary Members.

Comrie, L. J., M.A., Ph.D., F.R.A.S., 131 Maze Hill, Blackheath, London S.E.3.

Dyson, Sir Frank W., K.B.E., M.A., Sc.D., D.Sc., LL.D., F.R.S., F.R.A.S., 27 Westcombe Park Road, Blackheath, London, S.E.3.

Eddington, Professor Sir A. S., M.A., D.Sc., LL.D., F.R.S., F.R.A.S., University Observatory, Cambridge.

Jones, H. Spencer, M.A., Sc.D., F.R.S., F.R.A.S., Astronomer Royal, Royal Observatory, Greenwich.

Schlesinger, Professor F., Ph.D., Sc.D., Yale University Observatory, New Haven, Connecticut, U.S.A.

Members Emeriti.

Halm, J. K. E., Ph.D., F.R.A.S., "Walcot," Hillside Road, St. James.

Mackenzie, T., F.R.A.S., Kingston House, Grahamstown.

Schonegevel, H. W., 10 Lingen Street, Cape Town.

Steer, E. J., 61 Kloof Road, Sea Point.

Members and Associates:

Andrews, W., "Tircreevan," Clifton Road, Mowbray.
Attwood, J. H., Box 23, Paulpietersburg, Natal.
Bell, H. J. S., P.O. Box 281, Durban.
Bentley, W. W., Campsie Glen, Umhlali, Natal.
Blackmore, N. L., c/o A. B. Jenner, Esq., Goedekoop, Karino, Transvaal.
Borcherds, R. B., B.A., M.Sc., 185 Balmoral Avenue, Pretoria.
Borlase, E. A., 390 Musgrave Road, Durban.
Botes, Mrs. K., P.O. Delpoorts Hope, District Barkly West.
Burrell, D. C., Lamberts Bay.
Butler, J., "Galatea," Blaauwberg Strand.
Byrde, Rev. L. S., Nqamakwe, Transkei.
Cameron-Swan. Captain D., F.R.A.S., F.R.P.S., F.S.A.Scot, Strathmore, Kalk Bay.
Christie-Taylor, C., P.O. Box 25, Germiston, Transvaal.
Cohen, E. C., M.B.E., High Commissioner's Office, Cape Town.
Collins, G. Churton, Acutt's Arcade, Durban.
Cousins, A. W. J., 6 Evans Road, Durban.
Cowen, G., P.O. Box 30, Idutywa, Transkei.
Crawford, Prof. L., M.A., D.Sc., F.R.S.E., 12 Pillans Road, Rosebank.
Davies, H. C., Oakville Private Hotel, Ladysmith, Natal.
Deas, M., Beaufort West (Associate).
De Klerk, J., 30 Victoria Court Flats, Queen Victoria Street, Cape Town.
De Kock, R. P., P.O. Box 239, Paarl.
Druker, M., 64 Buxton Street, Doornfontein, Johannesburg.
Eaton, W., Post Office, Amalinda, East London.
Ensor, G. E., 43 Maple Avenue, Pretoria.
Flett, J. G., "Anadale," Main Road, Plumstead.
Fodish, E., Serowe, Bechuanaland Protectorate.
Forbes, A. F. I., M.I.A., "Blairythan," Main Road, Hermanus.
Forbes, Mrs. L. E., "Blairythan," Main Road, Hermanus.
Ford, Rev. Canon Edward B., M.A., F.R.A.S., The Rectory, Wepener, O.F.S.
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