(18) The orbital planes of the major planets by Mr. R. J. Pocock, B.A., B.Sc., F.R.A.S.

(19) The revolution of the components of Zeta Ursa Major by Mr. P. C. Bose.

(20) The effects of Tidal friction upon the evolution of the Earth-Moon system by the Rev. A. C. Ridsdale, M.A., F.R.A.S., etc.

(21) A mathematical calculation showing that the duration of the Sun's radiating energy is sufficient to meet the demands of Geology by the Rev. A. C. Ridsdale M.A., F.R.A.S., etc.

Presidential Address.

I HAVE now to inflict on you my presidential address, and I will first of all briefly refer to the progress of the Society during the past year, and our proposals for next year; and will then touch on the subject of some of my own researches in connection with the Moon.

The Astronomical Society of India is now six years old, and as you will no doubt have noticed from the report of the Council, its position is satisfactory in some ways distinctly so. We have to regret a diminution of our members by 19; some I regret to say were due to death. We had seven new members during the year, and of these most are prospective workers for the Society. It will, of course, be remembered by those who are original members, that when the Society was founded a very large number of people joined it mainly for the novelty of the institution. In one of my early addresses I referred to these members, and anticipated that they would probably fall off when their interest flagged. This has been the case, and I think now that we have probably parted with most of them.

We have at present a membership of 90, and I hope that this will soon be made up to three figures again with real working members.

As regards our finances—always an anxious problem—I am sure you will all join me in thanks to the Bengal Government for their assistance of Rs. 600 which has been referred to in the report. This has not only helped us to secure the Society against unpleasant monetary surprises a year earlier than we hoped, but has enabled the Council now to adopt a programme of work for the next year, which we could not otherwise have hoped to undertake. We are, therefore, under a very deep debt of gratitude to Government.

As regards our financial policy, I should like to say a few words. In its early years the Society literally lived from hand to mouth, that is to say, we required all our money as it came in to meet the demands of the Society ; and I do not think I am publishing any secret, when I say that our Treasurer who has been faithful to us from the beginning, has on some occasions been very hard put to it to make ends meet, and tide us over the rocks. We decided that our first duty was to try and secure ourselves against financial disaster after allowing for operations on a reasonable scale. These last few years have, therefore, been a time of great economy, and we had even to cut down our activities in some directions, though much against our will. As you will see from the report we have now succeeded fairly well in doing what we aimed at. The Rs. 1,200 which we have reserved is not, of course, a very large sum, and we should always be glad to add to it ; but it will prevent our being cut off in the midst of our operations, and we can now go forward with some certainty of continuing even if the progress we make has to be modest to begin with. The move we are making this session will be in the direction of definite active observations, and we have two schemes in hand to this end. The spade work of one of them is finished, and the instructions and necessary papers for the systematic watching of the sky are issuing at once. We have had one or two grumbles about the delay, but I may explain that not only has the weather during the last few months been against sky observation, but it has also interfered drastically with the reproduction of the charts which we required for the work, and as a matter of fact it has only been possible during the last two or three weeks to make the prints. The start will probably be all the more effective now that the observing conditions are better. The other scheme is one to associate some of the educational institutions in India with the Society. It has met with some response, but there has not yet been time to judge of it.

These are two practical schemes which we have in hand at present, but I should like to remind members that what we aim at is the development of the observational side of the Society, and that the results of members' work will be welcomed. There have been some signs of a beginning. Mr. Pincombe has sent in three interesting drawings of the lunar feature known as the Mare Serenitatis, and Mr. P. C. Bose has been investigating a star in Ursa Major. Both are examples of practical work, which are to be encouraged, and the latter, which is still in progress, seems likely to be of very considerable interest.

I come now to that part of my address which it has been customary to allow the President to devote to some subject

of his own choosing, and as I do not think the matter has yet been before the Society, or at any rate only very briefly so, I propose to speak for a few minutes on my own work on those peculiar markings on the Moon's surface known as the white rays.

The most casual glance through even a small instrument reveals these markings,—indeed when the Moon is full they are so conspicuous that it is impossible to miss them, and if one knows where to look and has keen eyes, the two largest systems can be glimpsed with the naked eye at the time of Full Moon.

Generally speaking, these white rays lie round some central crater, and radiate from it in all directions in white streamers over the lunar surface. They are not of great width, and they vary in length from very short projections to as much as 1,000 miles. It should be said, however, that these very long rays are usually jointed (as one might say), that is, they seem to proceed a certain direction and then a craterlet occurs, and they go on again and so on. The rays proceed over hill and dale regardless of obstruction : they will reach across a plain, climb up the outside wall of a crater, down the inside wall, go across the floor and over the opposite wall, and on. They are not always straight, but may take all kinds of shapes subject to their general direction, and they frequently have in their course small craters which are evidently intimately connected with them in some way. Some of the rays are slightly elevated above the lunar surface, but this is not certain about them all. They appear to the eye about two days after sunrise and disappear about two days before sunset. I must here make a slight digression regarding this peculiarity in the appearance of the rays. The late visibility and early disappearance was at one time attributed to the constitution of the rays themselves, and as a cause it was suggested that the rays underwent some physical change under the action of the Sun's rays : that is to say, they were features on the lunar surface, which became visible as the Sun rose on them and affected them, and they became less and disappeared again as the Sun set.

The first objection urged against this explanation was that Professor Barnard. and I think also one or two others suspected that they had seen the rays on the Earth lit portion of the Moon —that is to say, in the portion of the Moon where it was still night, but which was illuminated by the Earth in the same way as our Moonlight. I was able to confirm their suspicions definitely, and also to photograph some of the rays completely to the edge of the terminator. As, therefore, the rays are to be seen on the Moon in the absence of the Sun, it is

obvious that the explanation of the action of the Sun's rays falls to the ground. My attention was about this time directed to certain saline tracts in the Punjab, to which I shall again refer in a minute. I noticed that when watching these tracts under a low Sun, the whiteness of the salt was not so apparent as under a high one—in other words the albedo varied with the strength of the light. I, therefore, made some experiments with a model and a strongly projected illumination, and I found that at a certain angle of illumination the rays disappeared; in other words I reproduced on the model the appearances seen on the Moon, and was also able to photograph them. This, therefore, disposes of the question, and it is evident that the peculiar appearance and disappearance of the rays is not due to any physical cause or change in the rays themselves, but is simply due to increasing or fading light as the Sun rises or sets. It has been necessary to make this explanation in order to clear away this apparent peculiarity from our path.

We now have to consider what is the nature of the white rays, and why they lie in these peculiar radial formations. Various explanations had been put forward, none of which were very convincing. Some thought them to be the result of currents of wind which blew the exudations of the central craters (assuming them volcanic) in all directions; others thought them to be the results of bolides striking the lunar surface from outside; others again held them to be cracks in the lunar surface through which matter had welled up from below. Professor W. H. Pickering thought them to be due to snow lying in crevices on the lunar slopes. It has always seemed to me that something more akin to nature as we know it on the Earth ought to be looked for, and in the first place it occurred to me to consider the problem in two distinct parts, firstly, the configuration of the rays, and secondly, their albedo. That is to say, given the configuration, could any explanation be found for covering it with some white substance? This greatly simplified the problem. First as to the configuration. Assuming the existence at some time of the Moon's history of volcanic forces, we should expect upheavals to occur not unlike many of the formations we see there. I am not referring now to the ring shape of the craters, but merely to the upheaval. Anyone who has carefully observed the Moon cannot fail, I think, to have observed many such indications. When the upheaving force waned, a partial subsidence would occur; and I, therefore, made a series of experiments with plastic material to see what would be the result of these actions. On a small scale I reproduced radial formations of all sorts, and the results were sufficient to confirm me in the belief that

upheavals from below at given centres would probably produce a central mound (or crater perhaps) with low ridges radiating from it, and that these ridges might easily extend to great distances. Variations in the composition of the surface would also, of course, result in variations in the course of the rays to almost any extent. If we assume some such action as this to have been the cause of these radial configurations, it then only becomes necessary to clothe them with a white substance in order to have a ray system. I may mention again perhaps that actual observation has shown many of the rays to be slightly elevated ridges, and some of those round Copernicus and Tycho are clear cases in point.

Let us now consider the albedo of the rays. I will not trouble you with the many enquiries that were made into the constitution and behaviour of various white substances which occurred to me as being possible to explain this, but will say at once that on being transferred to the Punjab, I found there what I had been seeking, I refer to the large saline efflorescences which cover great tracts of the country in that Province looking exactly like plains of glistening snow I have put some photographs on the table for you to see. An exhaustive examination of these tracts was made. They are composed generally of a variety of sodium—either chloride, sulphite or carbonate. The chloride is nothing more or less, of course, than common salt, and it abounds round the salt range. The white covering on the ground is an efflorescence, not a deposit. The sub-soil contains large quantities of the salts, and these enter into solution in the water in the soil. The Sun then causes upward currents in the moisture, which it evaporates leaving the white salt behind on the ground as an efflorescence. Rain, of course, dissolves the stuff, but when the Sun comes out again and dries the ground, the efflorescence reappears, for the same reason as before. Thus the efflorescence depends largely on the evaporation which takes place. For instance, on the outer banks of a canal it lies thick owing to the saline water evaporating out through the banks. Similarly in the case of a low ridge, the salt appears along the top. This is very suggestive when we think of the elevated white rays on the Moon. With the kind help of district officers and others, I was able to obtain a large number of details regarding the particular sites covered by the salts in the Punjab, and some also in the United Provinces. Piecing them together I found, that considered as a whole, they approached in shape what we see in the Moon. Taking as the centre the salt range, three streamers radiate from it (and perhaps more). One of them reaches nearly to Benares, another proceeds towards Karachi, and a third

runs into the Frontier Province, and on, as far as I have been able to see, pretty well to Lake Van in Western Asia. For this last ray, I had to explore the records of the British Museum and the Royal Geographical Society, from both of which institutions I received the greatest assistance. I also examined the records of saline countries in Europe, and found a small, but, as far as I could see, the essentials of a typical ray system in Germany. These results would go to show that we may have ray systems or at any rate the makings of ray systems on the Earth, but of course we should not expect to find the fully developed article on the Earth owing to the differences in physical condition of the Earth from the Moon. The question now is, could the white substance of the rays on the Moon be saline efflorescence such as we have on the Earth? Firstly, you ask how do you know there is salt on the Moon? Well, there are good reasons for thinking there may be. Firstly, the substance we are considering, namely sodium, is more widespread in the universe than perhaps any other. Spectroscopic observation shows large quantities in the Sun: it also shows it to exist in the stars. We know that in the case of the Earth it is almost universally present. With such definite information before us, therefore, it would be rather astonishing, if it did not exist also in the Moon and planets. A further piece of evidence also is to be found in the researches of Sir George Darwin into the origin and movement of the Moon. Sir George Darwin has practically proved mathematically that the Moon was once probably part of the Earth, and was thrown off as a satellite and its orbit gradually enlarged to its present size and condition by the agency of tidal forces. If this was the case, we should naturally expect to find the elements on the Earth present also on the Moon, and sodium among them. It may be regarded, therefore, as highly probable that sodium salts exist in the constitution of the Moon in the same way as they do on the Earth. The next question is whether water or other form of moisture has ever been present on the Moon or in its constitution. Opinions differ greatly. Some hold that it never has been so, but others and notably Professor W. H. Pickering of America, not only think that water has existed on the Moon, but the latter holds that snow at present exists there, and is evaporated and redeposited at each lunation. I do not wish to press the matter so far as this, but merely to suggest that there may have been, and (as the Moon was part of the Earth) there probably was, a time when moisture existed at any rate in its constitution. This is not generally denied. Now given these two things the white ray problem is capable of explanation. With moisture in the soil, evaporation on the Moon during the lunar day would be very great. The

lack of atmosphere would accentuate the evaporation. No rain would fall, nor dew, as there is neither cloud nor air to hold the vapour. Consequently the process would be all in the one direction, and would all the time make for more and yet more effloresence. If you think the matter over you will see that there would be nothing to hinder the appearance of the salts on the surface as is the case of the Earth where rain and damp immediately send it down into the soil again in solution, but that it would go on coming up all the time, and in the end would be permanent on the surface of the soil. It is interesting to consider what would happen on the Earth, were all moisture gradually to disappear, clouds cease to form and rain and dew to fall. We have partial cases of the kind in the terrestrial deserts ; and what does happen there ? The very name desert is almost synonymous with salt, and I think it is more than probable, if such a condition as that of the Moon overtook the Earth, that prominent among the changes would be the appearance on the Earth's crust of huge tracts of saline efflorescence wherever salt was present to any extent in the soil. We do not see it now, because it is solution in the soil ; but if the moisture evaporated, the salt would appear on the surface as indeed it does now to a limited extent when conditions are favourable. I, therefore, think that what would happen to the Earth if lunar conditions prevailed here, has actually come to pass on the Moon, and the white tracts we see are the saline tracts to which I refer.

Why then on the Moon do these tracts frequently assume a radial shape ? I think the explanation is that they follow the configuration of the ground in which the salts exist. You will remember that I referred to these configurations in the early part of this address, and showed how they might be accounted for. The saline efflorescences favour the tops of elevations, and I have already explained that many of the rays are low ridges radiating from the central formation. It seems likely, therefore, that a preference would be given to the radiating ridges at the expense of the ground between them, and we should thus have the systems we see on the Moon. Careful examination reveals the fact, however, that the white substance is not by means invariably on the ridges. It often is, and so much so, as to make the peculiarity marked, but there are many places where it lies on the plains and my view at present is that it is probably contrast in a great measure that leads one to a first conclusion that the substance and the rays are so intimately connected.

I have given you a very brief outline of the matter. The enquiry has engaged my attention for many years now, and I thought the subject appropriate for my address this year, as I hope this winter to be able to carry the research a little further.