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The History of the Gradual Development of the Groundwork of Geographical Science:
Discussion

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to remind him of anything he may have overlooked, or to suggest to him anything that had not occurred to him. I know that this arrangement of Mr. Galton's proved to be useful to several explorers who were about to set out on their enterprises.

When I first joined the Royal Geographical Society in 1854 there was no instruction of any kind for our Fellows or others, and the intending explorers could only learn the rudiments of their business by going to an old lady in the Minories. Their observations consisted in taking down chimney-pots into a back yard with a quadrant. The duty of this Society seemed to me to be clear from the first, but it was a good many years before I could get that duty recognized by the Council, and several more years before the present excellent system of instruction was established. I now submit that the time has arrived for crowning the edifice by the formation of the museum I propose.

The PRESIDENT (before the paper): It is a great pleasure to us all to see Sir Clements Markham back again here in good health and prepared to talk to us on a subject of which he has such an intimate knowledge, early geographers and their instruments. It is now fifty-three years since Sir Clements first came on the Council. It is thirty-six, I think, since I became his colleague as one of the Honorary Secretaries, and I look back with very great pleasure to the years when I was able to work with him, when between us we planted seeds which have since borne fruit. One of these innovations was the foundation of a monthly journal; another was the carrying of geographical education into the universities. The journal has had the greatest help from its two editors, Mr. Bates and Dr. Keltie, and in the universities also we have had able lieutenants in Mr. Mackinder, Prof. Herbertson, and Mr. Yule Oldham. I think we may both feel happy in what we did in those days.

Captain WILSON-BARKER (after the paper): Sir Clements Markham has given us a most interesting paper on the gradual development of the instrumental side of geographical science. He mentions having given a lecture at the United Services Institution some years ago, dealing with this matter, and the reading of that lecture interested me so much that I took up the study in such time as I could spare from the practice of my own profession. I am firmly convinced that the suggestions he makes would be of great value to the Society, and I am very glad that I am able to attend here to-day, and to bring some old instruments from my small collection, which may be of interest to those present. Sir Clements Markham's wide knowledge and power of research have enabled him to give us an account of the early use of these instruments, and he has so sifted the information that the Portuguese have been vindicated with regard to the great part they took in the development of navigation. It is extremely difficult at the present day to understand the troubles with which these old navigators had to contend, and it was only by taking a great number of observations, and correcting these observations with the very greatest care, that they were able to obtain any positions at all. It appears to me that the earliest instrument used on board ship must have been a sundial of some sort, but navigators quickly discovered that the motion of the ship would interfere too much with its action, and therefore modified it, so as to make it useful on board ship for the purpose of taking altitudes. Having once established the principle of measuring the angle to the horizon they were soon able to improve on the class of instrument in use, but it was not until

Hadley's quadrant was brought forward that it was possible to obtain any scientific observations of latitudes.

(Illustrations of the methods adopted for using the instruments were then given.)

Sir Clements Markham has given us an interesting account of the number of observers who were taking the sun on board the *Grifo*. I am afraid that I fell into the error, in my little paper "The Development of Instrumental Nautical Astronomy," of supposing that Martin Behaim took a much more prominent part in the development of navigation than he appears to have done, but I am particularly interested to see that Sir Clements Markham is able to clear that difficulty up for us.

He also calls attention to the great work done by practical seamen in advancing the science of navigation, and of extending our geographical knowledge, and I entirely agree with him that if it was possible to form a complete collection here of the early books and instruments of navigation and geography, it would be a very interesting one. When it would be impracticable to obtain the actual instruments, models could no doubt be substituted, so that there should be no break in the continuity of the display. I think it very likely that careful research in China may reveal some interesting nautical information, and attention should be paid in these investigations to the system followed by natives in the Pacific Ocean.

I should like again to say how extremely interested I have been to hear the account that Sir Clements has given us of these old instruments, and of the methods pursued by the early navigators. The amount of research required in preparing such a paper is very great.

Mr. REEVES : The subject of Sir Clements Markham's paper is specially interesting, and to many of us these old instruments have a great fascination, not only on account of the ingenuity of their construction, but from the remarkable manner in which they exhibit the general evolution and development of the present instruments and apparatus from the early primitive forms. In this respect they possess an important educational value, and the instruction to be gained from them is considerable. For this reason I feel sure that a collection, made as complete as possible, would form a valuable addition to this Society's museum, and I sincerely hope that it may be found possible to put Sir Clements' proposal into practical form. There are various old surveying and navigation instruments on view in different places, but I do not know of anything like a complete set properly arranged in order of the dates of their invention and use, nor do I believe that such exists in this country. In the Society's house at Savile Row we had, as Sir Clements mentioned, a case which was intended to show the necessary instruments for a traveller to take abroad with him ; but this, in course of time, proved much too small for what was required, specially when theodolites and other somewhat bulky instruments came into general use. There was no idea of forming a collection to show the progress of instrument construction, and only those actually in use were exhibited.

The question of the degree of accuracy attainable by these old instruments has frequently been raised, and considerable surprise has at times been expressed that it was found possible to take observations that could be of any value whatever with them ; but with practice and care it is wonderful what can be done even with such things as these. The results accepted were doubtless in most cases the means of repeated observations, and so the errors would tend to balance one another. Then it should be remembered that the charts were, as a rule, drawn on comparatively small scales, so that an error that would appear considerable if the plotting had been done on a large scale would not amount to much on a small one. Out of curiosity I have occasionally taken observations with home-made instruments much like some of these, and on one occasion remember getting a latitude with

a form of quadrant and plumb-line from four or five altitudes taken in rapid succession, when the sun was about on the meridian to within 8' or 9' of the truth, although the instrument only read to degrees. It is doubtful if the instruments these old navigators used could be relied on to give nearer results than this, even when repeated observations were taken on land; when at sea their results must have been rougher still. Sir Clements mentioned that Vasco da Gama found the latitude of St. Helena Bay to be 33° S. by the use of a large astrolabe fitted up on shore on a triangle of poles; now I see, on referring to the Admiralty chart, that the true latitude of the head of this bay is 32° 47' S., from which it appears that this result was about 13' error.

Mr. ALBERT GRAY: I would just add one word of thanks to Sir Clements on behalf of those who are not experts in navigation, and I am glad to assure him that it has given us very great pleasure to hear his lecture, although we have not that expert knowledge which would enable us to understand all the details. One part of his paper I think was of general interest to us all, viz. that which dealt with the claims of the Germans in regard to these inventions; and it is interesting to hear from Sir Clements that those claims, made by Humboldt and others, are now abandoned. I do not think that the German professors who have abandoned the claims can belong to the Pan-Germanic League, because in that case I hardly think they would have been allowed to do so. It is the fixed conviction of that League that every invention and discovery made in the world was made by a German, if there was a German near at hand at the time. If there was no German at hand, then the inventor or discoverer was really a German, though he did not know it. It is satisfactory to find that this particular claim has been abandoned.

The PRESIDENT: It only remains for me to bring this discussion to a close, and in doing so I must associate myself with Mr. Albert Gray's remarks. To a layman like myself, who is no expert in these old-world instruments, this paper has been very instructive. I may turn to the practical point which has been raised, and that is that we should have a museum, or rather extend our museum here, so as to include a number of these instruments, and also, as I understand, a collection of instruments such as are used by a modern traveller. Well, that is a matter in which we should all be glad to assist, but I would remind the meeting that there is one preliminary which is necessary before we can found this museum on the scale it ought to be to be thoroughly effective. It is that we should either sell our surplus land, or that some Fellow of the Society should advance without interest the money necessary to build our Hall with its appurtenances. As soon as this is done, we shall be able to organize a museum on a suitable scale. But until it is done, we may start it, but I am afraid we shall not be able to do it full justice. In the preliminary plans which we have prepared for our proposed Hall, we have considered how, in the substructure of the place where we hold our meetings, we can provide rooms which would be suitable both for a permanent museum and temporary exhibitions. I am sure such accommodation would be a most useful adjunct to the work of the Society. I can only conclude with an expression of admiration of the enormous knowledge Sir Clements Markham has accumulated of ancient geography and ancient geographers, a knowledge which he has shown not only in his labours here as Secretary and President for so many years, but also in his long continued connection with the Hakluyt Society. I am sure we all desire to thank him for the lecture he has given us this afternoon, and to express a hope he may come again for many years and give us another lecture—another fragment out of his vast store.