Dr. Thackeray. I am glad to see this question studied statistically. A casual investigation of the published figures for velocity-changes had convinced me that a statistical analysis of a large number of observations would be required before Pettit's second law could be regarded as established.

The President then asked Fellows to remain whilst Capt. W. C. Aubrey-Rees was admitted a Fellow of the Society. This having been done, *the President* thanked Dr. Hulme for his paper and adjourned the meeting until 1939 April 14.

NOTES ON ANCIENT EGYPTIAN ASTRONOMY.

By HERBERT CHATLEY, *D.Sc., A.Inst.P.*

ALTHOUGH popular legend accredits ancient Egypt with profound wisdom, the archæological discoveries so far made in the field of astronomy do not confirm this belief, but they do show the very great antiquity and persistence of certain astronomical ideas. Important additions to the data have been made in recent years.

The fundamental work on this subject was done by Henri Brugsch and is accessible in German in his "Astronomical and Astrological Inscriptions from the Ancient Egyptian Monuments" (Thesaurus Inscriptionum Aegyptiacarum, Part I, Hinrich, Leipzig, 1883). Some of his deductions are no longer acceptable, but the book is a mine of information which can never become obsolete. Valuable further information has been provided in sundry papers by Daressy, Borchardt, Schott and Pogo. A useful text is Gundel's 'Dekane und Dekansternbilder' (Augustin, Hamburg, 1936), although only the early part of this book deals with Egyptian matters. Zinner's 'Geschichte der Sternkunde' (Springer, Berlin, 1931) is very good on the subject. Antoniadi's 'L'Astronomie Egyptienne' (Gauthier-Villars, Paris, 1934) is interesting, but quite antiquated in its data. The periodicals 'Isis' and 'Osiris', dealing with the history of science, contain many interesting papers on the subject, especially those of Pogo.

The broad results of the study are as follow:—

(1) Numerous references to Sirius and Orion occur in

the Pyramid funereal texts of the Vth and VIth dynasties (say, 2800 B.C.) as well as sporadic references to the Great Bear and certain other star groups, possibly including some of the dekans.

(2) In the Xth dynasty (B.C. 2000) there are full lists of the dekans (10 day stars whose heliacal risings marked the ten-day week of the Egyptian year), associated with the twelve " hours " of the night. Quite a number of coffins from Assiout of this period bear tables purporting to show the dekanal risings at the various " hours " of the night for every " week " of the year. It is not clear whether these were based on clepsydra readings or if the " hours " were supposed to be determined by the risings. In actual fact such risings would only be correct about the time of the summer solstice if the " twelve hours " were taken from dusk to dawn (about 8 mean hours in latitude 27° N.) as the stated progression is one dekan per " hour ".

Incidentally the dekans differ markedly in some respects from the later lists.

Four celestial deified entities (The Vault of Heaven, The Great Bear or Ox-leg, Sirius and Orion) are specially shown on the coffins and the prayers refer to them, to the planets Jupiter, Saturn and Mercury (?), and to some of the dekans.

(3) Important additions have been made to the list of examples of the standard celestial diagram, in the ceiling of the tomb of Senmut (XVIIIth dynasty, time of Queen Hatshepsut)—See the ' Bulletin of the Metropolitan Museum of Art, New York ', Feb. 1928, Part II.— and the beautiful clepsydra of Amenophis III of which latter there is a replica in the Science Museum at South Kensington. Both date to about 1500 B.C.

The writer has, by the kindness of the Keeper of Egyptian and Assyrian Antiquities in the British Museum, received a photograph of the interior of the lid of the inner coffin (No. 6678) of Heru-netch-tef-ef (circa 350 B.C.), which also has a good specimen of the celestial diagram, although it contains some draughtsman's errors and has some omissions.

The most perfect reproductions of the celestial diagram are those of Seti I and Rameses II (Ramesseum) in Lepsius' monumental ' Denkmaeler ' (Vol. VI, plates 137, 170 and 171). There is a good photograph of the diagram

of Seti I (about 1300 B.C.) in the ' Bulletin of the Metropolitan Museum of Art, New York ', Dec. 1923, but unfortunately the ceiling was damaged since the time when Lepsius visited it, so that the planetary panels are defective. Another good example is that from the sarcophagus of Prince Nekhtanebo (about 600 B.C.) in the Berlin Museum, where a rubbing is well shown. The latest example in time is the sarcophagus of the priest Hetar (Roman period) which is described by Brugsch.

All these examples, a dozen or so in all, agree in principle and contain the following elements :—

(*a*) The 36 dekans by name, with a kind of chart below showing the Boat (Scorpio ?), the Sheep (Aquila or Capricornus ?), the Belly (Aries ?) and Orion, with the deities associated with the individual dekans. Senmut's diagram shows a trail of stars to the right of the Sheep which seems to represent the Milky Way in the region of Sagittarius.

(*b*) Sirius (Isis-Sothis), Jupiter, Saturn, Mars, the Tortoises, five so-called meta-dekans, Mercury and Venus.

Sirius, whose priority as a mark is very noticeable, appears separately as the last of the dekans and in the planisphere of Denderah (Roman period), which is the basis of all interpretation of the dekans, is actually inside and apart from the decanal circle. The constellation of the Tortoises and the five metadekans appear to be star groups lying between Orion and Virgo which were used as supplementary fixes for the beginning of the sidereal year. Some of them appear interchangeable with certain of the early dekans.

(*c*) The so-called northern or, perhaps, circumpolar stars, represented by the Ox-leg (Seven Stars of the Great Bear), attacked by Horus-An and held by a chain by the Hippopotamus goddess, one or two crocodiles, a lion, a scorpion goddess and one or two unnamed gods. In the Senmut ceiling, the Karnak clepsydra and some other examples a thin long wedge reaches up towards the Ox-leg and its tip *may* represent the pole (which was near to Alpha Draconis in 2800 B.C.). The relative positions of the figures vary so much that it is clear that much artistic licence was used and the absolute identification of any member of the group except the Ox-leg is impossible. A few examples show inversion, the Hippopotamus goddess being to the left of the Ox-leg instead

of the right. This unusual arrangement agrees with the planisphere of Denderah which is the only record which permits any real comparison of the groups with the actual stars. The hour tables from the tombs of Rameses VI and IX also refer to the Hippopotamus with an implied right ascension differing by about 12 hours from that of Orion, so that this group (a very large one) seems to include the constellations Lyra, Hercules and Bootes. Brugsch identified it with Draco, but this would be impossible to reconcile with its use in the hour tables. The Lion also appears in the hour tables with a right ascension not very different from that of the Graeco-Babylonian Leo. There is also a lion, not the same as Leo, in the planisphere of Denderah, south of Libra, but such a group could never go north of the prime vertical.

On each side of this collection of oddities there is a procession of divinities. On the one side there are seven stellar deities, whose names appear in connection with certain days of the month, but certainly have nothing to do with the sabbatical week. On the other side the goddess Isis leads the four " sons of Horus " (associated with the four cardinal points) and the four grandsons of Horus, who are also associated with certain days of the month. The deceased may also be represented at the tail of one or both of these trains, worshipping the powers of Heaven.

(*d*) The twelve months of the Egyptian year, in various forms but frequently so that the first month comes near the middle over or under the figure of Isis. A baboon, associated with the god Thoth and the recording of time, may also appear in the middle.

In Senmut's ceiling the months are represented by twelve circles, each divided into 24 sectors, bearing the names of the gods specially worshipped in each of the months, but in many cases actual figures of the month gods are given. In some examples the months are not shown.

(4) Further examples of the goddess Nut, the Vault of Heaven, with various groups of symbols, lists of dekans, etc., have been found but are not standardized like the celestial diagram.

(5) No progress has been made in the matter of the Sothic cycle of about 1500 years. The general conclusion

seems to be that until quite late times no such cycle was used in chronology.

It is too soon to draw any final conclusions as to the Egyptian knowledge of astronomy. The records we have are practically all magical or religious pictures whose purpose was to protect or help the dead and only throw an indirect light on the actual observations of their inventors. The errors of copyists are frequent and misleading. It is clear, however, that the dekanal lists were revised about the beginning of the New Kingdom (say, 1600 B.C.) and it seems probable that the celestial diagram was invented then as a talisman which concentrated into one form the whole power of the heavenly bodies. The differences of the individual diagrams are too unimportant for the diagrams to have been horoscopes.

SOME REMARKS ON THE VARIABLE STARS IN GLOBULAR CLUSTERS *.

By P. TH. OOSTERHOFF.

NEARLY half a century has passed since the first variable stars were discovered in globular clusters. The study of these variables has proved to be of the utmost importance, as they provided a powerful instrument for the determination of the distances of these clusters by means of the period-luminosity relation. The great majority of the variables have periods shorter than one day. These are the cluster-type variables. Further some δ Cephei-type and long period variables have been found.

It soon became evident that the number of variables differs greatly from cluster to cluster. In some clusters only a few or no variables at all have been discovered, although a special search for them was made by different astronomers. In ω Cen and M 3 on the other hand we know more than 130 variables. This difference has remained a puzzle up to the present day. A theory advanced by G. P. Kuiper (*H. B.* **903,** 5) may possibly prove helpful. According to his hypothesis the globular clusters and the group of Cepheids are each composed of stars having nearly the same hydrogen content. Thus

* A paper by O. Hachenberg (*Zs. f. Ap.* **18,** 49, 1939) on variables in globular clusters has appeared while this article was in the press.