

Thus it is gathered from Prof. Schaeberle's investigation that reflectors of large aperture must also be of correspondingly great focal length if the definition of the object to be observed is to be of the first order.

As refractors of large aperture are seldom made of such short focal lengths as are in question, it is unnecessary here to consider the effect of this source of bad definition.

Several interesting points with reference to the capabilities of large instruments have been brought prominently forward during the last few months, and may be appropriately referred to in this place. Thus Prof. Wadsworth (*Astronomical Journal*, vol. xviii. No. 414) has dealt with the efficiency of large refractors for visual observations of planetary details. He finds that from an optical point of view, it is a distinct advantage to increase the apertures of telescopes intended for visual use of planetary detail, such as fine linear markings, up to such a point where the atmospheric aberration will amount to about one-seventh or one-eighth period under the best conditions of observation. If this point be exceeded, then no advantage is obtained, the efficiency actually falling off; the tendency is for the faint lines under observation to be blotted out, instead of becoming more distinct. Indeed so sure is he of this, that he says the limit of efficient size is about reached between 30 and 35 inches, or the limit is very rapidly approached.

Another point of great importance *re* large apertures is that such telescopes cannot always be efficiently used unless the night be very fine and the air still. The well-known observer, Dawes, always used to judge the night by the aperture that could be employed. Thus he spoke of a one-inch night, two-inch night, up to an eight-inch night, this being the greatest aperture he possessed. As a matter of history, one may relate that a comparison of the drawings of Mars made by Sir Norman Lockyer with his six-inch refractor, and by Lord Rosse with his big reflector, showed that although both series were made at the same time, they displayed striking dissimilarities. Dawes, who had also made some valuable drawings at the same opposition, in discussing this question of dissimilarity, concluded that Lockyer's drawings were the more correct, since they were found to be exactly like those he (Dawes) had made, especially with regard to a certain marking which he had called the "double tooth."

Dawes, however, was no lover of large apertures, and on the occasion just referred to he was heard to repeat one of his favourite phrases, "What have the giants done?"

Apart, then, from the quality of the instrument employed, definition depends on the state of the atmosphere through which the light rays pass. On clear nights the question of the movements of the air is of the highest importance, and it is only on this movement that the aperture for any particular night can be gauged. In consequence of these air undulations, which vary in different currents from half an inch to several feet in length, the definition varies enormously.

In the case of a small aperture, and supposing the wave-length to be more than double the diameter of the object-glass, the image of the object under observation would only be bodily moved without confusion; for a large glass the image would be very considerably blurred.

Dr. T. J. J. See has recently (*Astr. Nach.* No. 3455) been making investigations on the sizes and movements of these aerial movements, and his paper on this subject indicates the importance of increasing our knowledge by more systematic study.

Thus it will be seen that in discussing the question of how large telescopes may be made to do useful work, a most important item to take into consideration is the locality in which they will be used. If such a spot be happily found, situated on a high plateau where the

movement of the air is practically nil, then theoretically there seems no reason why apertures should be limited in size; but as such a condition as this is rarely if ever to be obtained, a limit is necessarily imposed on the diameters of object-glasses. W. J. S. LOCKYER.

THE WOBURN ABBEY DEER.

FROM the difficulty of obtaining an adequate series of specimens, either living or dead, the deer are one of the groups of large mammals with regard to which our present state of knowledge is decidedly not up to date, comparatively little advance having been made since the appearance of the late Sir Victor Brooke's well-known synopsis in the *Proceedings* of the Zoological Society for 1878. Fortunately the noble owner of Woburn Abbey, who takes a great interest in animals of all kinds, is endeavouring to get together as complete a collection as possible of these beautiful and interesting ruminants, or rather of such kinds as experience shows to be best suited to withstand the vicissitudes of the English climate. With characteristic liberality the whole of the magnificent collection now assembled is accessible to zoologists interested in this group of animals, and by its means considerable additions have already been made to our knowledge thereof. From the extent of ground much larger numbers of specimens of the same species can be collected than is possible in the limited space available in the Zoological Society's Gardens in Regent's Park; and the conditions existing in a large country park are, of course, far more favourable to the well-being and display of the animals than is possible in London.

In the Regent's Park the larger kinds of deer, such as the American wapiti, are generally, from necessity, represented by only two or three individuals at a time, but at Woburn these and other species are assembled in herds of considerable size. And as deer are remarkable for their seasonal variations in coat and colour, it is in such manner only that a full grasp can be obtained of these periodical changes. A further advantage is the opportunity of seeing closely allied species or varieties either in the same paddock or in near juxtaposition; while the facilities for studying the habits of the animals are infinitely in advance of what is possible elsewhere.

For a long period of years the domain at Woburn has been a deer-park where large herds of red and fallow deer wander at their own sweet will; and the undulating wooded ground alternating with level expanses of excellent pasture, and the numerous lakes and ponds dotted over the latter area afford an ideal situation for all animals of this class. Such foreign species as adapt themselves easily to these conditions, and do not make themselves objectionable by developing habits of ferocity, are allowed to run at large in the open park. Among these are Père David's deer, of Northern China, the elk, the Virginian deer, and the Japanese and Manchurian sikas; while muntjacs and roe run wild among the coverts. Such an amount of liberty cannot, however, be permitted to many of the species on account of their dangerous propensities; while it is found convenient or necessary to afford more protection from the wind and weather to yet other kinds. But even in the case of species deprived of their full liberty, the amount of space accorded them is ample, and quite different from what is practicable in domains of smaller magnitude. The American wapiti, for instance, live in a "paddock" of about 150 acres, surrounded by an eight-feet iron fence; and in the same enclosure, as shown in our first illustration, run the various races of sambar, as well as some of the sikas, and various other small species. A small herd of American bison are also among the denizens of this enclosure. Hard by, in a paddock of but little inferior dimensions, is a magnificent herd of

the Altai wapiti, a species first made known in this country by antlers obtained by the second Yarkand expedition in Kashgar, and described by Mr. Blanford. The herd includes the first living examples of this splendid species ever brought to this country, although visitors to the Zoological Gardens have now an opportunity of seeing an immature specimen. And it is not a little remarkable that a stag so well known in the Altai, where it is kept in a semi-domestic condition by the farmers, should so long have remained a stranger to the menageries of Europe.

Perhaps, however, the most generally attractive of all the enclosures is the one which may be called the Chital paddock, on account of its containing a large herd of the beautiful chital or Indian spotted deer. A most successful photograph of a group of deer feeding in this paddock, for which we are also indebted to Her Grace the

case, and whereas these animals thrive and multiply at Woburn to an extraordinary degree, some northern species, like the elk and reindeer, which might have been expected to flourish best, die off in an unaccountable manner. Out of several head of American elk only a solitary survivor now remains, while all the adult reindeer are dead. Some young American calves of the latter species have, however, been recently received, and it may be hoped their fate will be happier. Possibly if Norwegian reindeer and elk were tried, they might do better than their American representatives. But it must be remembered that both these animals have disappeared at a comparatively recent date from Britain; and there may be something in our climate at the present time absolutely unfavourable to their existence.

The various Oriental races of sambar and rusa flourish at Woburn equally well with the chital, and the large



Wapiti.

Wapiti.

Sika.
Wapiti.

Bison.

Wapiti.

Sambar.

FIG. 1.—The American Wapiti Paddock at Woburn Abbey, showing Wapiti, Sambar, Sika, and Bison. (From a photograph by the Duchess of Bedford.)

Duchess of Bedford, forms the subject of the second illustration. In addition to numerous chital, easily recognised by their dappled coats, this photograph shows several examples of the true maral, or Caspian red deer, from the Caucasus, which are the largest animals in the photo. This deer, it may be observed, although often regarded as a distinct species, appears to be nothing more than a race, or sub-species, of the red deer of Western Europe. Of the other smaller animals in the group, a Virginian deer occupies the foreground on the left, while several mouflon, and at least one Indian antelope, or black-buck, are in the centre.

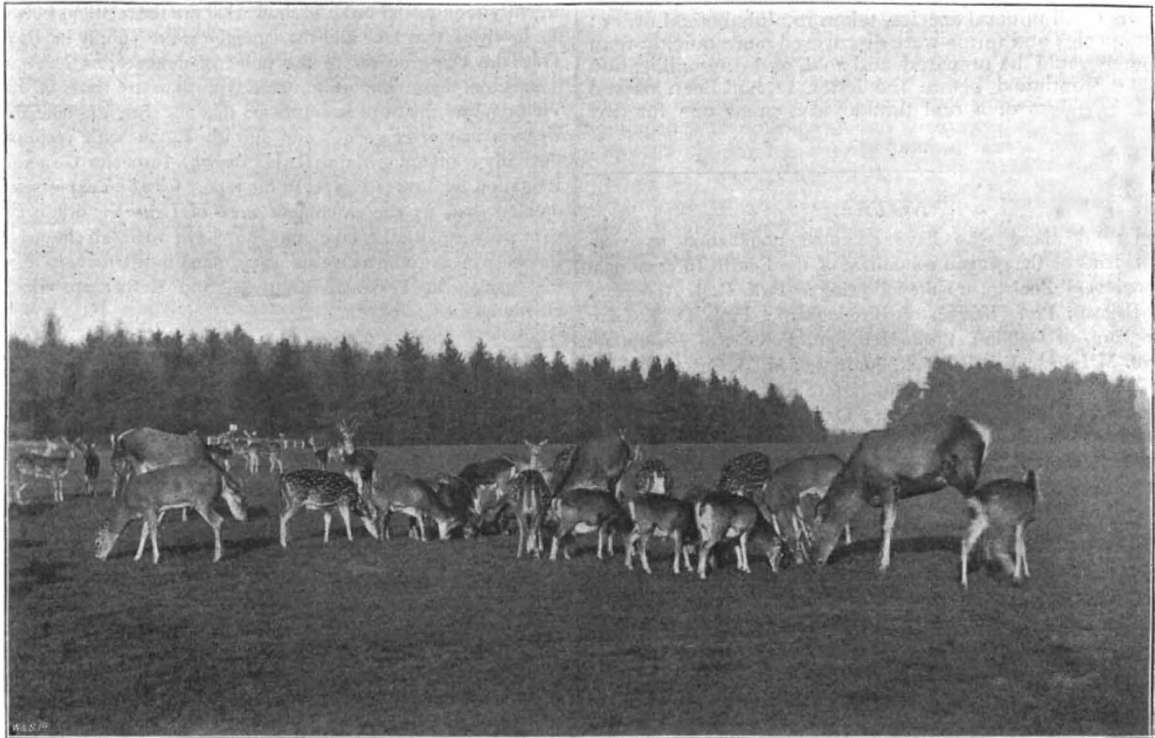
From the torrid nature of their environment, it might have been supposed that the Indian chital and black-buck would have been among the species least suitable to withstand our climate. Nevertheless, this is not the

series of these animals now collected there affords material for a fairly full study of an exceedingly difficult group. Hog-deer and muntjacs are also among those which are hardy and capable of acclimatisation. Other Oriental species represented in the collection are the swamp-deer of India, and the thameng of Burma and Siam; but these are kept in smaller and well-protected enclosures, with ample shelter. From the colder nature of their habitat, the various species and races of the sikas of Japan and Northern China might naturally be expected to do well, and as a matter of fact this has been found to be the case. In addition to the common Japanese and Manchurian sikas, the collection includes the large and handsome Pekin sika, previously known only by the type specimens sent home by the late Consul Swinhoe after the sack of the Imperial Summer Palace. Père David's deer has been already mentioned as among

those running at large in the park, and there is good prospect of the herd of this aberrant and interesting species increasing in number. A solitary male of the previously imperfectly known Bedford's deer (*Cervus xanthopygus*) has unfortunately succumbed to a lingering decline, although happily not till it exhibited the remarkable variation between the summer and winter pelage. Roe deer, of course, flourish; and recently there was the opportunity of seeing the European, Siberian, and Manchurian species, or races, living side by side. The rare Chinese water-deer (*Hydropotes*) is represented by a single doe, which exhibits to perfection the skulking habits peculiar to the species; but a specimen of Michie's tufted deer, which formerly was one of the attractions of the collection, now adorns the museum at the Abbey. Musk-deer do not belie their hardy nature, and it is one of the most interesting sights in the park to

marsh deer and pampas deer. Young examples of each of these two latter are, however, at the present time in the collection, and as they are very carefully tended, and the experience derived from their predecessors is available, it may be hoped they will survive. A tiny little deer, apparently referable to *Mazama gymnotis*, is also among the newest arrivals, and its career will naturally be watched with deep anxiety. Brockets have been tried with hopeless ill-success, and the attempt to acclimatise them has reluctantly been abandoned.

During the very short period the collection has been in existence it has included, counting red and fallow deer, close on forty distinct species and races—no mean record when it is remembered that the total number of valid forms which have been exhibited in the London Zoological Gardens since its foundation does not exceed forty-eight. As every effort is being made to increase



Virginian. Chital. Mouflon. Chital. Mouflon. Caspian Red Deer.
Black-Buck.

FIG. 2.—The Chital Paddock at Woburn Abbey, with Chital, Virginian Deer, Caspian Red Deer, Mouflon, and Black-Buck. (From a photograph by the Duchess of Bedford.)

watch these little deer bounding across their enclosure in the manner so well-known to all Himalayan sportsmen.

In marked contrast to the adaptability of the Oriental deer to their new surroundings is the ill-luck attending the introduction of most of the American deer, exclusive of the wapiti. The only exception to this is the Virginian deer, which flourishes and breeds, some mingling with the chital herd, others roaming at will in the open park, and a few taking up their abode in the immediate vicinity of the Abbey itself. These latter exhibit tameness and fearlessness to an extraordinary degree—only, indeed, exceeded by the members of a little herd of roe from the Caucasus, one of which permits itself to be fondled like a pet lamb. Black-tailed and, we believe, mule-deer have been tried without success; while the same ill-fate has attended several examples of the South American

the Woburn collection, it bids fair to beat the record in the number of species, as it already does in individuals.
R. L.

THE LATE PROFESSOR A. SCHRAUF.

THE comparatively small number of mineralogical workers and teachers has been once more diminished, and to the recent deaths of Mallard, Daubrée, DesCloizeaux, Sohncke, Retgers, Kenngott, Haughton and Heddle, must now be added that of Albrecht Schrauf, Professor of Physical Mineralogy in the University of Vienna, who has passed away, after long illness, near the end of the sixtieth year of his age. A. Schrauf was born on December 14, 1837; he became assistant in the Mineral Department of the Imperial Museum of Vienna in 1861, and Keeper in 1867; after