One hundred and seventy presents were announced as having been received since the last Ordinary meeting, including, amongst others:—


Note on a Method of Balancing Dome Shutters.
By W. H. Maw, LL.D.

For many years past the form of shutter-opening adopted for observatory domes of moderate, or large size has generally been a segmental one, this opening being covered by a shutter (or pair of shutters) moving laterally. This arrangement is a convenient one in many respects, and if the shutters are properly designed and mounted, they can be operated easily.

In the case of smaller domes—of, say, 20 feet diameter and under—the rectangular form of opening, fitted with a rising shutter, has certain advantages, and the reason why its use has been chiefly confined to quite small domes appears to consist in the difficulty in controlling the movement of the shutter, so that it may be readily used with any amount of opening desired. The ordinary unbalanced lifting shutter has of course only three positions in which it will remain without being secured, these being: completely closed, half open, and completely open; and of these three positions, the central one is the only one in which the shutter is in balance and can be moved readily. During the first part of the operation of opening the shutter—namely, from the closed position to half open—the shutter has to be lifted; while during the last period of the movement—from half open to completely open—it has to be prevented from overrunning, and in the case of a shutter of any but very small size these conditions involve considerable inconvenience.

Seventeen years ago—in 1896—I erected an observatory with an 18-foot dome at Outwood, Surrey, and decided to adopt the rectangular form of shutter-opening fitted with a rising shutter, this shutter, however, being so constructed as to be in complete
balance at all points of its path. The arrangement devised to secure this end has proved entirely satisfactory, and hence it has been thought that a brief note on it might be of some interest.

The principle on which the balancing is arranged may be explained by reference to diagram fig 1. In this diagram, A denotes approximately the position of the centre of gravity of a rising shutter in its closed position, and as the shutter is opened the centre of gravity will move successively to the positions B and C. Now it is evident that if it were possible to carry a lever across the dome, this lever being pivoted at its centre and having its upper end connected with the shutter and its lower end provided with a suitable balance weight, the shutter could be completely balanced and would remain indifferently in any position. But such an arrangement is of course impracticable, and the problem to be solved was to find a mechanical equivalent for this arrangement.

And here, I may say, that some years after my dome had been erected, I learned that there existed at Harvard College Observatory a small dome having a rising shutter balanced on the principle just explained. In this case the shutter travelled outside the dome casing, and the balancing lever had an arched form—like the handle of a pail,—the crown of the arch being connected to the shutter and the ends of the arch being pivoted on the base of the dome one on each side, and being extended downwards to carry balance weights. This arrangement was no doubt effective, but it would be somewhat cumbrous in any but a very small dome and would have other disadvantages. Whether or not this dome is now in use at Harvard, I do not know.

To return to fig. 1. In the arrangement there shown the balance weight would move in the arc D, E, F, and it is quite evident that if the lever across the dome was done away with and the shutter connected by some other means to a balance weight moving in a curved path D, E, F, so that the movements of the shutter and balance weight were coincident, the desired end would be attained. This would mean that as the shutter was opened the balance weight would first be lowered from D to E, and subsequently raised from
E to F. Now it is quite easy to couple the shutter and balance weights by a flexible connection which will transmit tension, but much more difficult to devise a connection which will resist compression and at the same time satisfy the other requirements existing in this particular case. It occurred to me, however, that as the two halves of the arc D, E, F were symmetrical, the proper thing to do instead of lowering the weight from D to E, and pushing it up from E to F, was to lower it to E and then pull it back again to D, the connection between the shutter and weight being thus always in tension.

Acting on this idea, I devised the arrangement which is shown diagrammatically in figs. 2, 3 and 4, which respectively show the shutter closed, half open, and fully open. In this arrangement the balance weight G rolls on a pair of curved angle iron guides, H, mounted on the dome on the side opposite the shutter-opening. The balance weight is connected by a pair of light chains to the shutter at the centre of its length, each chain passing over a pair of guide pulleys I and J, placed as shown.

Fig. 2 shows the positions of the parts when the shutter is closed, the balance weight G being then at the top of its guides. In fig. 3 the shutter is half open, the balance weight being then at the bottom of the guides and exerting no pull on the connecting chains. The further opening motion of the shutter beyond the position shown in fig. 3 causes the connecting chains to pass under
the pulleys I, thus hauling the balance weight up the guides until the shutter is fully open, the parts then having the positions shown in fig. 4.

The shutter is opened and closed by cords running over guide rollers which keep the cords close to the inner side of the dome casing. The shutter being completely balanced will of course stay in any position, and the whole arrangement has been found to work well and to be very convenient.

Photographs showing exterior and interior views of the dome are appended.


The force which at any moment acts on a star may be regarded as made up of two parts, viz. the central attraction of the whole stellar system, and the force due to the chance arrangement of the stars in the immediate neighbourhood. The appropriate dynamical theory depends on the relative importance of these two components. By an argument from the existence of moving clusters of stars which, though widely separated in space, have preserved closely equal and parallel motions for a vast period of time, I have been led to the conclusion that the effect of the stars in the immediate neighbourhood is of negligible amount. This appears to be confirmed by direct numerical estimates of its probable value. The discussions in this paper relate therefore to stars moving under the general attraction of the system; there will be no chance deflections or encounters, and consequently the theory differs fundamentally from the dynamical theory of gases, to which some resemblance might at first sight have been expected.

The actual discontinuous field of gravitational force, due to a number of point-centres (stars), is thus replaced by a continuous field due to a smoothed distribution of density. It is necessary to form a rough idea of this density. We know of about 20 stars contained in a sphere whose limit corresponds to a parallax of 0'02. Doubtless there are some others yet to be found; and there may be almost any number of dark stars. Although many of the 20 stars are much fainter than the sun, their masses are probably not greatly less. We shall probably be considerably underestimating the density if we take the matter in this sphere as ten times the sun’s mass. If the universe were a globular system of this density, each star would describe an elliptic orbit about the centre of the system in 300,000,000 years—a period less than current estimates of the age of the earth. The period is independent of the size of the orbit or of the system. It seems probable then that a mature star will have made at least one, and probably many journeys round its orbit since it came into existence. We are therefore