photography, and can record more detail through seeing disturbances(5). Tubes with wide target-mesh spacings are best for planetary work. A good match between optical resolving power and the resolution of the tube is often attained with imaging at $f/40$ to $f/90$. A focal ratio of about $f/150$ is theoretically necessary to record all the detail that the optical image can contain.

The general conclusion from the work is that photo-electric image devices have great potentialities as primary receivers of radiation in astronomy. Nevertheless, photography, properly understood and used, can probably yield equivalent quantum efficiencies of over 1% and, consequently, the gains from photo-electric devices are likely to be useful rather than spectacular. Larger gains may be possible by improved design of observations.

References

(1) A. Rose, *Advances in Electronics*, ed. Morton. Academic Press, N.Y. (1948), pp. 131ff.

(2) P. B. Fellgett, Proc. Columbus Symposium on Spectroscopy (Columbus, Ohio, 1952). Paper I, 1.

(3) P. B. Fellgett, *Optica Acta*, **2**, 9, 1955.

(4) A. N. Argue, *Observatory*, **74**, 213, 1954.

(5) P. B. Fellgett, *Vistas in Astronomy*, ed. A. Beer. Pergamon Press, London (1955).

(6) P. B. Fellgett, Proc. Manchester Symposium on Astronomical Optics. North-Holland Publishing Co., Amsterdam, 1956.

OTHER PAPERS AND DISCUSSION

Among the informal reports of research presented during the afternoon session, five are summarized on the preceding pages in papers **6**, **7**, **8**, **9** and **10**. The others, for which no manuscripts were prepared, included discussions by Morton, Lallemand, and Hiltner.

Dr Morton described in more detail some of the technical problems encountered in image tubes of the electron-storage type (see review paper no. 2) at the Princeton R.C.A. Laboratories. Among other things, he referred to a special orthicon-like tube in which a uniform background could be continuously removed at the same time as the signal was being accumulated. The electron-storage target of this tube consisted of an inner mesh conductor which was covered with an insulator of suitable leakage resistance and then with a conducting material in the interstices of the mesh. Under the action of an applied potential, a constant leakage current could be made to cancel background charges at the same rate as they were produced. Fellgett, however, questioned whether the weight given to a photo-event is truly independent of its time of occurrence.

There was a discussion (Morton, Redman, Hiltner, Fellgett, Ring) as to the practical importance of secondary multiplication of internal pre-target intensification of the signal in orthicon-like systems. Morton described the phosphor-photocathode intensifying pellicules used in the intensifier orthicon. P16, P11, and a special Ag-activated ZnS are used in conjunction with a cesium-antimony photocathode.

In response to questions raised by Hiltner regarding field emission, ion currents, and the possible advantages of excluding cesium, Morton described the means of reducing field emission, the use of a cooled charcoal trap to improve the vacuum, and the exclusion of cesium from unwanted areas.

In conclusion, Morton told about some new photocathodes recently developed at R.C.A. by A. H. Sommer (*Rev. Sci. Inst.* **26**, 725, 1955). These 'multi-alkali' cathodes, Sb-K-Na-Cs, are not only more sensitive than cesium-antimony cathodes, which have heretofore been the best available, but they maintain high sensitivity all the way from 3000 Å to 8000 Å. This is a development of far-reaching astronomical importance.

Prof. Lallemand showed again some of the slides used in his review paper in the morning session and described in more detail some of his experiments at the Observatoire de Paris. In particular, he referred to a converter system employing Ag–Mg grids of 0·03 mm. mesh for secondary electron multiplication. The accelerating potential was 500 v. per stage, and the electrons were channelled by a strong longitudinal magnetic field. Owing to their relatively broad velocity distribution, the secondary electrons could not be strictly focused, and the resulting resolution was insufficient for astronomical use. There was a discussion (Lallemand, Hiltner, Baum, McGee) regarding the problems of cesium contamination and the interaction of cesium with ZnS in the phosphor screen.

In connexion with his usual system of putting photographic plates into the same chamber with the photocathode, Lallemand mentioned the relative merits of Kodak MR emulsions, Ilford nuclear emulsions, and the possible use of F-centres in alkali-halide crystals. He emphasized the importance of matching both the cathode and the electron-receiver to the problem. In this connexion, Baum pointed out that ideally an emulsion should spend only one or two grains to record each electron, whereas actual emulsions spend many grains per electron if the electrons are given enough energy to penetrate the full thickness of the emulsion. Lallemand expressed the view that very fine-grain emulsions afford high storage capacity in spite of this, and Ring mentioned some current research on extremely fine-grain emulsions at Ilford.

Hiltner summarized briefly the status of his work in collaboration with Burns at the University of Chicago (see *Ap. J.* **121**, 772, 1955). He described tests made in the laboratory with an image converter consisting of an antimony-cesium photocathode, electrostatic optics, a thin film, and a vacuum plate exchanger. In this style of converter (also discussed in paper no. 9) the thin film, which is of the order of 500–1000 Å thick, forms an electron-transparent barrier between the portion of the vacuum surrounding the photocathode and the portion of the vacuum contaminated by gases exuded from the photographic emulsion. Hiltner and Burns have experimented with commercially available nickel foils, with silicon-monoxide films, and with aluminium-zapon-aluminium sandwich films. These sandwich films proved to be the most successful with regard to freedom from flaws and the facility of mounting them in the converter; they have been found to withstand a 300° C. vacuum bake-out during the processing of the photocathode. In tests of one such film over a four-day period, the photocathode showed no perceptible decrease in its sensitivity; during that time, photographic plates were changed frequently to simulate actual operating conditions.

More recently Hiltner has contracted with the Farnsworth Electronics Company to obtain some commercially fabricated thin-film converters similar to those being made for Hall and Baum. As already mentioned, these commercial converters use an evacuated glass cap to protect the thin film until the converter is installed into the vacuum-plate exchanger.