



RADIO TELESCOPE at Cambridge, where Sir Martin Ryle and his colleagues catalog radio sources.

and Margaret Burbidge present a systematically classified and beautifully compiled account of the observational properties of quasars; their book could well become a classic in its field. Although one of the authors is a strong proponent of a speculation known as the "local theory of quasars," admirably those chapters devoted to observational facts contain only traces of favoritism.

The discovery of quasars came in 1961 almost by accident. The radio astronomy group at Cambridge University, under the direction of Martin Ryle, had been engaged in the cataloging of radio sources since the middle 1950's. Their aim was to provide precise locations of radio sources with the hope that they might ultimately be identified with objects visible on photographic plates made with large optical telescopes. In the 3C catalog there were a number of isolated radio sources whose positions did not coincide with any of the known supernova remnants or galaxies.

In a fruitful collaboration, radio astronomers provided their optical coun-

terparts with the precise locations of several of those isolated radio sources that were then identified with starlike objects on plates made at the Mt Wilson and Palomar Observatories.

At first the images were thought to be stars, but, as data volleyed back and forth between England and southern California, further study showed that they were not stars, but objects of a kind hitherto unknown.

The spectra of these starlike images showed sets of emission lines that could be interpreted as highly red-shifted lines of common elements such as hydrogen, magnesium and oxygen. To date, the largest red shift found is 2.223 (PKS 0237-23) and the smallest, 0.16 (3C273).

Certain quasars also show absence of radio emission, but many quasars also show absorption as well as emission lines. Generally the red shift of the absorption lines is different from those of emission lines, and a large number of absorption-line red shifts are clustered at 1.95, for objects with emission-line red shifts ranging from 1.95 to 2.22. One quasar, PKS 0237, shows two sets of red-shift lines of 1.95 and 2.20 whereas the emission-line red shift is 2.223. Another quasar, PKS 0019-04, shows an absorption-line red shift of 1.965 although that of the emission line is only 1.955. This implies that the matter that produces these absorption lines is falling into the quasar. No explanation has been offered for this and other related peculiar phenomena.

The Burbidges present further analysis on the energy distribution from quasars, which cannot be explained in terms of any simple radiation mechanism such as black body or synchrotron. Their variability appears to be quite random and provides no insight, and their distribution in space is isotropic. These data, valuable as they are, offer little clue to the nature of quasars.

About one third of the book is devoted to theories. The authors are correct in dismissing present theories of quasars as inadequate or inapplicable. A valid question, however, still remains: Does the red shift of quasars indicate their distance or their state of motion? Those propounding cosmological distances for quasars are faced with the energy problem (and many others); those propounding local origin for quasars are faced with even more serious problems in addition to those already existing in the other

case. (Caution: As the evolutionary path of physics has shown, one theory does not merit acceptance over another simply because it has fewer fundamental difficulties.)

In conclusion, I feel that the Burbidges did an excellent job. As new data piles in, this book will not only survive but will also serve as a guide for further presentations. I would compare this book with *The Realm of Nebulae*, which was also written when new data on cosmological observations were arriving at an astonishing rate. 30 years after it was published, students are still profiting by it. The basic method of research in cosmological observation has not changed, although many telescopes up to twice the size used by Edwin Hubble, in making the initial discovery, have since been built. Another 30 years from now, we can expect a student still to be profiting by reading the Burbidges' presentation of observational data on quasars in the golden 1960's.

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Beams at work

NARROW ANGLE ELECTRON GUNS AND CATHODE RAY TUBES. By Hilary Moss. 224 pp. Academic Press, New York, 1968. \$11.00

by J. AROL SIMPSON

From time to time a determined worker succeeds in clearing a small patch in the thicket that grows rank on the border between science and technology. Once this area is cleared it presents no hazards for later settlers.

Hilary Moss has accomplished this task for his chosen subject by dint of almost 30 years of diligent and productive work.

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The book has no pretensions of

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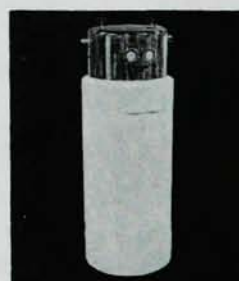
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great theoretical generality although the author's proof of Irving Langmuir's thermal limit, given in the appendix, clears up many points that have given a generation of students difficulty and should be much more widely known. Moreover the book presents the best and most complete description of a successful semiempirical approach to a difficult engineering problem for which the scientific foundation is incomplete and, as such, presents an interesting "case study" for a course in methods of applied physics.

The book should be in the collection of anyone working in applied electron optics and on the shelf of any reasonably complete electrical-engineering library.

* * *

J. Arol Simpson is chief of the Electron Physics Section, National Bureau of Standards. He says that he has "been trying to design electron guns with only mixed success for the last 20 years."

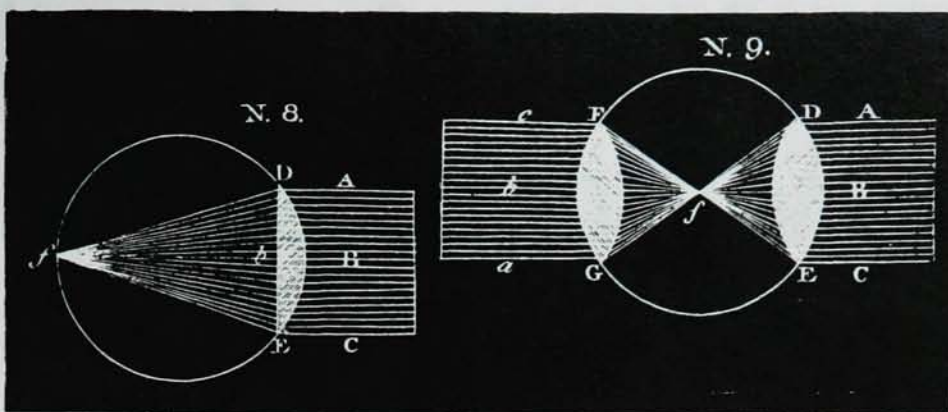
Image watching

IMAGES OPTIQUES. (4th Edition)
By Pierre Fleury, Jean-Paul Mathieu.
614 pp. Eyrolles, Paris, 1968.
110 F

by JACQUES ROMAIN

Pierre Fleury is the head of the Institut d'Optique, and Jean-Paul Mathieu is a professor at the Faculté des Sciences of Paris. Their *Physique Générale et Expérimentale*, an eight-volume textbook, is one of the leading general physics treatises, at the university level, in the French language. Of the eight volumes, two are devoted to optics. The second of these, titled "Lumière" (Light), deals in detail with a qualitative and quantitative study of light, with its propagation conditions in various media, with emission and absorption spectra and with the optical phenomena pertaining to geophysics and astrophysics. The present book, which is meant as the first of the two volumes on optics, has to do with all the aspects of image formation, understood in a broad sense.

It begins with fundamental notions on light beams, reflection, refraction, light waves and the nature of light and on the perception of images. The text is then divided into three parts: The first deals with the elemental optical



200 YEARS AGO *Encyclopedia Britannica* showed with figures how light passed through plano-convex and convex-convex "glasses" to converge and form optical images.

systems, plane refracting interfaces, prisms, thin lenses, thick optical systems, aberrations, birefringence and the polarization related to it. Light rays at a small angle with the optical axis and the contrasting large aperture are both studied.

The second part is devoted to interference and diffraction and their application to image-forming problems, for example, interferometry, phase contrast, gratings and holography (a noteworthy addition to this new edition). The last part deals with the various optical instruments, including photography, and ends with short notes on the construction of optical apparatus. Two more features of the new edition are an exposition of convolution relationships between object and image and the use of Fourier transforms in the theory of diffraction gratings.

The emphasis is on the interrelation rather than the differences between "geometrical" and "wave" optics, and the approach is decidedly experimen-

tal even though elaborate formulas are derived when needed. The exposition is profusely interspersed with descriptions of experiments, both for the classroom and simple ones for every reader without specialized instruments.

These experiments are either experimental demonstrations of properties mentioned, or illustrations of the descriptions in the text. Also mentioned, at every possible occasion, are examples of practical uses of the properties or systems considered. The exposition is quite clear, precise, and concise.

A generous supply of figures and plates makes the text self-explanatory, and a satisfactory subject index is provided. Each chapter concludes with a good many exercises, the answers to which are collected at the end of the book.

* * *

The reviewer taught general physics in highschool and theoretical physics at the University of Elisabethville in the Congo.

Cryostat design

EXPERIMENTAL TECHNIQUES IN LOW-TEMPERATURE PHYSICS, (2nd Edition) by Guy Kendall White. 397 pp. Oxford U. Press, London, 1968. \$12.00

by HARMON H. PLUMB

In the preface to the first edition, Guy White states that his purpose was "to meet the need for a book which gives details of designing cryostats, filling them with liquid helium, maintaining and measuring various temperatures." The author, in an exemplary fashion,

has conveyed most of the important experimental cryogenic techniques. With the reader in mind, White has clearly expressed the techniques and the basic ideas involved without delving into intricate details of specialized apparatus. Appropriately he has provided pertinent references for those who may desire to pursue experimental or apparatus details. The first edition was published in 1959, and this second edition is sufficiently up to date to cite literature of 1966 and