

Photo-Electronic Image Devices

PROCEEDINGS OF THE SECOND SYMPOSIUM HELD AT
IMPERIAL COLLEGE, LONDON, SEPTEMBER 5-8, 1961

EDITED BY

J. D. McGEE, W. L. WILCOCK and L. MANDEL

*Department of Physics
Imperial College, University of London*

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FOREWORD

When about five years ago I learned first of Professor McGee's intention to organize a symposium on Photo-Electronic Image Devices, I was curious to know how publication of the proceedings of such a symposium, as a special volume for *Advances*, would be received by its readers. The reception was so good that I had not the slightest hesitation to propose to Professor McGee again publication of the *Proceedings*, as soon as I learned from him that he was to organize a second symposium. Negotiations were very smooth, and the results are presented here to the scientific public. I hope that it will be received as well as or even better than its predecessor.

It has been by custom lately to list the items which we hope to treat in the coming volumes of *Advances*. Listing without authors, however, led to confusion: a number of people interpreted my listing as a request for authors, whereas I listed subjects only after preliminary agreements with prospective authors. I will, therefore, give below both the subject and author for the expected contributions in the next few volumes of *Advances in Electronics and Electron Physics*:

P. A. REDHEAD, J. P. HOBSON AND E. V. KORNELSON	Ultrahigh Vacuum Techniques
K. L. BOWLES	Scattering in the Upper Atmosphere
F. E. ROACH	Airglow
J. M. HOUSTON and H. F. WEBSTER	Thermionic Energy Conversion
H. F. IVEY	Electroluminescence
E. KAY	Impact Evaporation and Thin Film Growth in a Glow Discharge
W. G. DOW	The General Perturbational Theory of Space-harmonic Traveling-wave Electron Interaction
F. E. JAUMOT, JR.	Thermoelectricity
M. A. BIONDI	Atomic Collisions
J. F. DENISSE	Radioastronomy
A. H. SCHOOLEY	Electronics in Oceanography
G. BIRNBAUM	Light Optical Masers
K. G. EMELEUS	Plasma Oscillations
D. P. KENNEDY	Semiconductor Component Evaluation
F. K. BUELOW	Semiconducting Circuitry
G. MOLLENSTEDT AND F. LENZ	Electron Emission Microscopy
J. L. JACKSON AND R. A. PICCIRELLI	Cooperative Phenomena
L. A. RUSSELL	High Speed Magnetic Core Memory Technology

G. K. WEHNER
J. KISTEMAKER AND C. SNOEK

M. SEATON

Cathode Sputtering
Atoms and Metastable Ions Produced
in Sputtering Experiments
Electron Atom Collisions (Low Energy)

It remains for me to thank Professor J. D. McGee for his excellent organization, also his two co-editors, W. L. Wilcock and L. Mandel, and to thank all the authors for their cordial cooperation.

L. MARTON

Washington, D.C.

July 1962

PREFACE

In September 1958 a Symposium on Photo-Electronic Image Devices as Aids to Scientific Observation, which we believe was the first devoted exclusively to this form of instrumentation, was held in London at the Imperial College of Science and Technology, and the *Proceedings* were subsequently published as Volume XII of *Advances in Electronics and Electron Physics*. The success of that meeting, and our awareness of increasing interest in the subject, encouraged us to hold a second symposium with the same title at the Imperial College in September 1961, and the papers presented are collected in the present book. It is nearly twice the length of the *Proceedings* of the 1958 meeting, and includes a greater variety of devices and applications, which reflect the growth of activity in the field and confirm our judgement that the interval of three years between the meetings was not too short to show significant developments.

We are sorry that we did not succeed in attempts to arrange for Soviet scientists, who have made such notable contributions in the field, to take part in the Symposium; but otherwise we believe it was broadly representative of research workers throughout the world, and we are grateful to all those who came to London to make it so. We are also particularly grateful to the authors of papers for the co-operation they have given us.

It is a pleasure to record our thanks to our secretary, Miss N. C. Little, for her help, both in the organization of the Symposium itself, and subsequently while we have been preparing these *Proceedings* for publication.

J. D. MCGEE

W. L. WILCOCK

L. MANDEL

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Quelques Réflexions sur la Caméra Électronique

A. LALLEMAND

Observatoire de Paris, Paris, France

Depuis quelques années la caméra électronique est utilisée dans les Observatoires de Paris, de Meudon, de Haute Provence, du Pic du Midi et de Lick Observatory. Les résultats qui ont été obtenus dans ces observatoires permettent aujourd'hui de porter un jugement objectif sur ce moyen d'observation et d'orienter les développements qui sont nécessaires.

Du point de vue des performances obtenues, la caméra électronique réalise les trois conditions qui permettent d'enregistrer les informations de la façon la plus satisfaisante: premièrement, la possibilité d'une haute définition; deuxièmement, la possibilité d'enregistrer un seul photon en conservant dans un grand intervalle d'énergie reçue une réponse linéaire; troisièmement, une sensibilité qui peut être beaucoup plus grande que celle de la plaque photographique classique.

La définition obtenue est bien meilleure qu'avec la plaque photographique classique et cette définition pourrait encore être grandement améliorée si cela était nécessaire. A l'heure actuelle nous sommes limités surtout par l'optique classique qui ne fournit pas toujours des images assez bonnes pour exploiter complètement les possibilités de la caméra électronique et aussi par l'ajustement des potentiels des électrodes qui devraient être définis dans les caméras actuelles à 50 V près pour une tension totale de 25 kV. Les électromètres les meilleurs que l'on puisse trouver permettent difficilement cette précision.

Les mesures micrométriques pour déterminer la position des raies spectrales se font avec une grande précision et la caméra électronique n'apporte pas d'erreurs propres. Duflot-Augarde¹ a montré que sur la nébuleuse NGC 1068 on peut mesurer une vitesse radiale de 1085 km/sec avec une dispersion ne dépassant pas 7 à 9 km/sec. 1 micron sur la plaque représente une vitesse radiale de 25 km/sec.

Walker² a montré que l'on pouvait faire des poses de 6 heures en conservant un noircissement de fond acceptable, ce qui permet de dépasser largement toutes les possibilités connues pour enregistrer des images peu lumineuses. Aux faibles éclaircissements il a été possible de compter les traces des photoélectrons et d'arriver ainsi à une sensibilité incomparablement plus grande que la plaque photographique classique.³ Les mesures photométriques précises peuvent se faire en mesurant la densité des plaques nucléaires exposées aux photoélectrons.^{4†}

† G. Wlérick, J. Rösch, M. F. Dupré, et M. Bellier, *La Photographie Électronique des Planètes et ses Applications Photométriques*. Voir p. 371.

L'utilisation de la caméra électronique présente cependant encore aujourd'hui certaines difficultés : la mise en service est longue, 6 heures environ avec la technique qui a été utilisée jusqu'ici. C'est un instrument en verre, il est fragile et les commandes magnétiques ne fonctionnent pas avec assez de sécurité. Nous avons essayé de pallier ces inconvénients. Dans la préparation du tube l'opération la plus délicate est le nettoyage du tube et des pièces de l'optique électronique. Ce nettoyage est rendu nécessaire par le dépôt de baryum qui s'oxyde lorsqu'on ouvre le tube, d'autre part l'évaporation de baryum est une opération assez délicate. On peut aujourd'hui éviter ces difficultés en supprimant les getters au baryum. Duchesne† vous présente une solution qu'il a mise au point. Il montre combien la préparation est devenue simple et plus rapide. La fragilité du tube a été diminuée. Cette fragilité était causée par l'encombrement du tube avec des bras dans 2 ou 3 directions. Nous avons étudié un tube qui est presque plat et qui ne possède des bras que dans une direction. D'autre part il est réuni par une canalisation souple à la pompe sur le bâti de préparation et la jonction se fait très simplement et rapidement sans être obligé d'ajuster la caméra dans une position précise. Les entrées de tensions ne se font plus par des passages fragiles mais par des soudures verre-métal qui assurent le refroidissement des plaques et de la photocathode. Le tube en place derrière le télescope peut toujours être tenu sous vide élevé soit par une petite pompe ionique, soit par du charbon activé refroidi.

Toutes ces améliorations rendent l'usage du tube beaucoup plus facile. Naturellement c'est encore un tube en verre mais nous pensons qu'il pourra encore subir beaucoup de perfectionnements, en particulier on peut envisager de le laisser à demeure dans son blindage ce qui le protégerait contre les chocs. D'autre part l'usage de la céramique pourrait être étudié.

La fabrication des photocathodes à l'antimoine-césium est facile, certainement plus facile que celle des plaques photographiques ; c'est une question d'organisation et il serait bien désirable que l'industrie s'en charge. Nous avons la certitude de pouvoir employer des photocathodes à l'oxyde d'argent césium sensibles à l'infra rouge. Mais nous n'avons pas encore réussi à fabriquer de bonnes couches dans les petites ampoules utilisées dans la caméra, mais ce n'est qu'une technique à trouver en particulier à mettre au point les meilleurs cycles thermiques pendant l'activation ; il n'y a pas de difficultés de principe.

† M. Duchesne, Sur une Nouvelle Technique d'Utilisation de la Caméra Électronique. Voir p. 19.

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DISCUSSION

A. BOUWERS: La difficulté du champ courbé comme les exigent les tubes ne pouvait-elle pas être réalisée par les systèmes à miroirs ?

A. LALLEMAND: Les systèmes à miroirs procurent une courbure intéressante et dans le bon sens mais elle est encore insuffisante pour s'adapter à la courbure de la photocathode qui est grande.

A. M. GUREWITSCH: What kind of titanium pump is used: that is, is it a "getter" pump or a so-called "ionic" pump ?

A. LALLEMAND: Nous utilisons une pompe à titane du type ionique.

J. D. MCGEE: What is the spread in the size of individual electron records ?

A. LALLEMAND: La grandeur des traces des électrons dépend de la tension appliquée sur le tube, et de la plaque nucléaire utilisée; pour une tension de 25 kV, généralement utilisée, elle peut varier de 1 à 5 microns.

