

9. COMMISSION DES INSTRUMENTS ASTRONOMIQUES

Report of Meetings

PRESIDENT: G. E. Kron.

SECRETARY: Neville Woolf.

First meeting, 16 August 1961

This was a short business meeting, following a meeting of Sub-Commission 9a under the chairmanship of W. A. Baum. Discussion of the *Draft Report* was called for, but there was no discussion and the *Draft Report* was considered to be acceptable.

It was announced that G. Dimitroff had offered to make a list of the world's observatories, and that information about astronomers and instruments was also required. It was also announced that there would be a change in the constitution of the Commission, in that the two Sub-Commissions 9a and 9b would become Working Groups of the main Commission 9.

There was a proposal from Rösch concerning a change in the name of Commission 9 (see *Draft Report*). The proposal was brought up for discussion, but there was no discussion. There was also a proposal from Dunham that an informal symposium be held on the problems of coudé spectrographs. It was decided to hold this discussion at a second meeting of the Commission.

There was no further business. The meeting was brought to a close by a description of the St Andrews 37-in.—37-in. Schmidt Cassegrain telescope by Stibbs.

Second meeting, 21 August 1961

During a short business session, an organising committee consisting of Rösch, Kron, Hall, and McGee was selected. The remainder of this session was turned over to the discussion of the problems of coudé spectrographs. Speakers were Aller, Bowen, O. C. Wilson, Hiltner, Fehrenbach, Feast, Berg, and Woolf. There was sufficient discussion to make the content of the meeting of some interest, and it is planned to have the complete minutes mimeographed and distributed to members of Commissions 9 and 29.

9a. SOUS COMMISSION DES CONVERTISSEURS D'IMAGES

Report of Meetings, 16 and 19 August 1961

PRESIDENT: W. A. Baum.

SECRETARY: J. D. McGee.

Sub-Commission 9a met at 9^h00^m on 16 August 1961, under the Chairmanship of Dr W. A. Baum, President of the Sub-Commission.

In opening the session the Chairman referred to the change in status of the Sub-Commission in the future, when it would become a committee of Commission 9.

Before beginning formal business the Chairman proposed that a telegram of congratulations should be sent to Professor A. Lallemand on his recent election to the French Academy of Science. The proposal was carried unanimously.

The Chairman then called for corrections to the *Draft Report* to appear in Vol. A of the *Transactions*. These were collected for transmission to the General Secretary.

The remainder of the session was devoted to the following reports on work in progress by: M. F. Walker of Lick Observatory; J. A. Hynek of the Northwestern (Dearborn) Observatory; W. A. Hiltner of Yerkes Observatory; and G. Wlérick on behalf of several of his colleagues in France.

The Sub-Commission met again at 9 a.m. on 19 August 1961, when the following further progress reports were presented by: J. Rösch, Pic du Midi; J. Hall, Lowell Observatory; J. D. McGee, Imperial College; W. A. Baum, Mount Wilson & Palomar Observatories and Imperial College; G. Kron, Lick Observatory; J. H. DeWitt of Dyer Observatory, Nashville, Tennessee.

M. A. Tuve outlined a proposal, that he hoped to have adopted and financed in the U.S.A., for having a few types of image-intensifier tube manufactured on a reasonably large scale. In this way he hoped tubes might become available for astronomers, both in the U.S.A. and in other countries.

The following are summaries of the reports given as listed above.

TRAVAIL EFFECTUÉ À L'OBSERVATOIRE DE PARIS

M. Duchesne, L. Gallouet and B. Guinot

A l'Observatoire de Paris, en juin et juillet 1961, M. Duchesne, L. Gallouet et B. Guinot ont obtenu une série de spectres de Venus avec la caméra électronique de A. Lallemand. Ces spectres sont destinés à la détermination de la constante de l'aberration par la mesure interférométrique de la vitesse radiale. Ils ont été obtenus en 15 minutes de pose, avec un gain en temp de pose de l'ordre de 30, par rapport aux plaques 103aD. En outre la qualité des spectres est bien meilleure que par la photographie classique. Les auteurs projettent d'appliquer cette méthode à Mercure, dont la vitesse radiale atteint le triple de celle de Venus.

REPORT ON WORK WITH LALLEMAND ELECTRONIC CAMERA AT LICK OBSERVATORY

M. F. Walker

Instrumentation. During 1960-61 a number of improvements have been made in the technique of operating the electronic camera. These include semi-automatic refilling of the liquid air Dewars on the camera, the use of a titanium ion pump, vacuum storage of the nuclear plates prior to use, extreme precautions in the cleaning and preparation of the tube and in the elimination of corona discharges around the tube during operation. As a result of these improvements, it is now possible to preserve a single photo-cathode for two successive nights of observation and to expose each plate up to four or, under the best conditions, six hours, before parasitic blackening of the plate becomes excessive.

The speed of the tube was re-measured and found to be about 40-60 times that of Kodak 103a0 at 4000\AA and for exposures in the range of 10-100 minutes with the tube, the range usually employed at the telescope. The speed-gain over the photographic plate is of course a function of the exposure time owing to the reciprocity failure of the tube.

This increase in the signal-to-noise ratio has made it possible to obtain spectra of stars down to $m_{pg} = 16$ with the electronic camera attached to the focus of the 20-inch camera of the coudé spectrograph of the 120-inch reflector, using a grating giving $48\text{\AA}/\text{mm}$ on the photo-cathode and $65\text{\AA}/\text{mm}$ on the nuclear plates.

Observations. Among the observing programmes carried out, two of the most significant are the following:

(a) *AE Aqr.* High time-resolution spectra have been obtained to investigate the spectroscopic changes occurring during one of the explosions which are characteristic of this system. Simultaneous photo-electric observations with the Crossley reflector were used as a guide to determine when to expose the plates. With a cathode of only moderate sensitivity, exposures at minimum light ($m_{uv} \approx 12.5$) required 20-30 minutes and at maximum light ($m_{uv} \approx 11.0$) 12-15 minutes. The plates show that during an outburst, the emission lines of H and Ca II became stronger and broader, either symmetrically or asymmetrically to the red or to the violet, indicating that the explosion occurs in a localised spot on or near the surface of one of the stars and sometimes on the side toward the observer and sometimes on the side opposite. Also, a hot continuum appears which falls in the late-type absorption spectrum of the companion.

High time-resolution observations of this sort are only possible by means of an image tube.

(b) Five faint, gravitationally contracting stars in the Orion Nebula cluster and NGC 2264 which have ultra-violet excess have been observed. In order of decreasing UV excess they are: VY Ori, LT Ori, MO Mon, YY Ori and IP Mon. In all except IP Mon (which has a UV excess of only 0.3 mag and an essentially normal spectrum) there is either direct or indirect evidence of material falling into the stars. It appears that in these stars infall is more important than ejection, unlike the majority of T Tau stars. In at least three of the stars the underlying late-type absorption spectrum is partially or totally obscured by a blue continuum. The nature of the UV excess is not yet clear; it could be the effect of extreme wings of Balmer emission lines whose central intensities are cut down by self-absorption, but it cannot be caused by confluence of the lines themselves. In any case, it is tempting to suggest that both the excess and blue continuum might result from the infall of material.

Ch. Fehrenbach, M. Duflot, M. Chopinet

Reported on the results of observations, at the Observatory of Marseille, on spectra of galaxies and planetary nebulae using the Lallemand Electronic Camera.

PHOTOGRAPHIE DES ÉTOILES DOUBLES AU MOYEN
DE LA CAMERA ÉLECTRONIQUE

J. Rösch, G. Wlérick and Mlle. C. Boussuge

La caméra électronique de Lallemand a été utilisée à l'Observatoire du Pic du Midi pour la photographie des étoiles doubles serrées. Associée à un réfracteur de 60 cm de diamètre, elle a permis d'obtenir des images d'étoiles de 7^e magnitude en 1/8 de seconde, bien que le spectre secondaire de l'objectif convienne mal à la répartition spectrale de sensibilité de la photo-cathode.

L'intérêt de cette technique vient de ce que, pour un objectif de ce diamètre (et à plus forte raison pour un diamètre plus grand) et pour une séparation angulaire de l'ordre de 2" au moins, les faisceaux issus des deux étoiles traversent pratiquement les mêmes masses d'air. En conséquence, l'image de chaque composante, altérée par l'atmosphère, diffère beaucoup, en général, de la figure d'Airy théorique, mais la distribution de l'énergie est la même dans les deux images. On a donc deux images quelconques mais identiques (à la différence de magnitude près), qui se déduisent l'une de l'autre par un déplacement rigoureusement égal à la séparation angulaire des composantes. Le fait que l'émulsion nucléaire employée n'ait pas de seuil rapproche encore des conditions idéales.

Les clichés sont mesurés au moyen d'un micromètre à double image spécial, qui permet de *superposer* soit les deux images de la composante A et les deux images de la composante B, soit une image de A et une image de B, de façon à tirer parti de tous les détails de structure pour accroître la précision de la mesure.

PHOTOGRAPHIE ÉLECTRONIQUE DES PLANÈTES

G. Wlérick, J. Rösch, M. F. Dupré and C. Boussuge

Au Pic du Midi, en juillet 61, G. Wlérick, J. Rösch, M. F. Dupré et C. Boussuge ont photographié Jupiter et Saturne avec la caméra Lallemand. Avec le réfracteur de 60 cm, ouvert à $f/60$, les temps de pose sont respectivement $1/8$ sec et $1/2$ sec. Les clichés permettent la photométrie précise des anneaux de Saturne, y compris l'anneau de crêpe, et une bonne détermination de l'assombrissement centre-bord de Jupiter.

A MODIFIED LALLEMAND IMAGE TUBE

G. E. Kron

An electronographic type of image tube that operates on the Lallemand principle has been built and operated experimentally at the Lick Observatory. An attempt is being made to achieve prolonged photo-cathode performance by dividing the tube into two compartments with a straight-through ball valve. When the valve is closed, the photographic plate can be changed in the one part of the tube while the photo-cathode is protected by the valve in the other.

The valve is, in fact, the anode electrode, and it is also the backbone and chief structural part of the tube. The pierced ball is turned by a stem that protrudes from the valve, and is double-sealed to prevent leakage. The ball itself is suspended between two seals, and the volume trapped outside the ball and between the seals is continuously pumped by a small ion pump. All seals are of PTFE and all are double to prevent leakage.

Good photo-cathodes that have shelf half-lives of several months can be made in the tube. When the tube is used to make pictures, each cycle of plate loading and picture taking reduces the cathode sensitivity by 1% to 5%, depending upon the care with which the plate half of the tube has been evacuated prior to opening the valve. Contaminants introduced along with the photographic plate are immobilized, as in the Lallemand tube, by cooling the plate and plate holder with liquid air.

A new tube has been designed and constructed during 1960-61 at the Mount Stromlo Observatory, in Australia. The valve in this new tube is entirely made of metal, so that the whole tube can be baked to clean it. It is hoped that better cathodes can be made in this tube, and that these cathodes will have a very long shelf-life. Furthermore, it is hoped that the changes in design will eliminate some of the causes of cathode damage with use, and alleviate others.

A LOW-BACKGROUND IMAGE TUBE FOR ELECTRONOGRAPHY

W. A. Hiltner and W. F. Niklas

An electrostatically focused electronographic image tube of new design, incorporating a barrier membrane of aluminium oxide to separate the electron-sensitive emulsion from the photo-cathode section of the tube, is described.

A semi-conductive wall coating between the low-potential focus electrode and the high-potential anode equalizes local potential gradients in such a way that the probability of field emission between these electrodes is much reduced. The photo-emissive surface is restricted to the desired area by evaporating the antimony for the photo-cathode externally, thus reducing spurious electron emission from photo-sensitive surfaces deposited on tube elements other than the photo-cathode.

Field emission is responsible for only about 25% of the total background of the tube at room temperature. With the tube at the focus of the $f/20$, 40-inch refractor the sky background

is 160 times greater than the tube background. Further, when a cool tube is in total darkness, it may be exposed for eight hours before the background density is in excess of 0.1. The resolution thus far achieved is 40 lp/mm.

The principal difficulty with the operation of the tube is the need for two kinetic vacuum systems in order that emulsions may be inserted into, and retracted from, the tube. In the laboratory the vacua are provided by two small oil diffusion pumps, but to make the unit completely mobile and free from all utilities, the telescope model will use cryogenic pumping. It is anticipated that these cryogenic pumps will operate unattended for intervals of one week or more.

AN IMAGE TUBE WITH LENARD WINDOW

J. D. McGee and B. E. Wheeler

In this tube the electron image produced from a photo-emissive cathode is accelerated to sufficient energy to penetrate a mica window capable of withstanding atmospheric pressure, and be recorded on an electron-sensitive emulsion in contact with the end window. A sealed-off tube of this type has the advantage over other electronographic equipment of not requiring any auxiliary pumping equipment and of having a long shelf-life.

For such a tube to be feasible, an operating potential of approximately 50 kV and a mica window less than 8 microns thick are required. Under these operating conditions approximately 80% of the electrons penetrate the end window and about 70% have an energy greater than 10 keV and will therefore be recorded as small clumps of grains on a nuclear emulsion.

The development of a tube constructed entirely of lime-soda glass, employing uniform coaxial electric and magnetic fields to accelerate and focus the electron image, and which is capable of withstanding 50 kV with a very low background, was described.

A method of sealing very thin mica windows, less than 8 microns thick, on to the tube was also described. This was found extremely difficult to accomplish in a conventional circular window, but by sealing the mica on to a curved surface in which a slotted window had been cut, it was found possible to produce windows as thin as 6 microns, which would consistently withstand 3 atmospheres over an area of 1.0 cm by 3.0 cm.

An electron sensitive stripping emulsion (Ilford K2) is used to record the electron image, since a flexible emulsion to press against the curved end window is needed. This involves special techniques.

Finally the performance of the tube was described, special emphasis being given to the excellent resolution obtainable and the ability to detect images of poor contrast by the use of nuclear emulsions of small grain size.

FURTHER DEVELOPMENTS AND PERFORMANCE OF A THIN WINDOW IMAGE TUBE WITH PHOSPHOR OUTPUT

J. D. McGee, R. W. Airey, and B. E. Wheeler

The tube to be described is a single-stage image intensifier, focused by uniform, co-axial electric and magnetic fields, in which images on the phosphor screen are recorded by direct contact photography through a thin mica membrane.

The present image tube is a development of that previously described by Zacharov and Dowden (Zacharov, B. and Dowden, S. *Advances in Electronics*, **12**, 31, 1960. Academic Press, London and New York.) In order to eliminate contamination of the photo-cathode by gases evolved from the metal parts employed in the original design, an all lime-soda glass tube has now been developed, with special features to reduce background in the image to a very low level. Metallized annular glass baffles are inserted at intervals along the length of

the image tube to suppress secondary electron multiplication which appears to take place because of the migration of stray electrons and ions in the region of the tube walls, and also to shield the photo-cathode from wall fluorescence.

A REPORT ON THE IMAGE ORTHICON USING SLOW READ-OUT

John H. De Witt, Jr.

With the advent of the magnesium oxide target for the image orthicon it became apparent that this type of tube might have uses in the field of spectroscopy and other applications where the photographic plate is not now sky-limited. For the past three years development of a practical light amplifier utilizing this tube has been underway. It has been found that the use of target storage and slow read-out has certain advantages which will be reported upon. By the use of degenerative feedback beam control the signal-to-noise ratio in the output is improved by a factor of two to one.

Recent evaluation of the equipment at the 24-in. Morgan telescope of the Lowell Observatory indicates that gains of 100 or more are possible over fast photographic plates. The chief limitations of the system lie in the field of resolution and dynamic light range. In spite of these limitations it appears that the equipment could have numerous uses in spectroscopy and in the photography of faint objects at the output of long-focus telescopes. For spectroscopy the image is widened electronically in the image section of the tube, thereby eliminating the need to drift the star in the slit.

By utilizing electronic techniques and tubes which are common to the television industry a practically useful system becomes possible without encountering the expense and development effort necessary by other means.

IMAGE INTENSIFIERS WITH TRANSMITTED SECONDARY ELECTRON MULTIPLICATION

W. L. Wilcock, D. L. Emberson and B. Weekley

Image intensifiers with transmitted secondary electron multiplication, of design essentially the same as those first made at Imperial College and described by us in *Trans. I.R.E.* NS-7, 126, 1960, have been produced in significant numbers by 20th Century Electronics Ltd., New Addington, Surrey, and are now generally available. Current tubes have Sb-Cs photo-cathodes deposited on the entrance window, five 19 mm diameter edge-supported dynodes of KCl on aluminised Al_2O_3 , and a blue (ZnS:Ag) output phosphor. Between stages the electrons are accelerated and focused by uniform co-axial electric and magnetic fields. With 36 kV overall voltage the mean electron multiplication between cathode and phosphor is 3 000 or more, with the result that single electrons from the photo-cathode give rise to scintillations from the phosphor which are easily photographable. With cathode sensitivity $40 \mu\text{A}/\text{lumen}$ the photon gain for blue incident light is about 10^5 . Typical dark emission rates lie within the range $10-10^3$ scintillations $\text{cm}^{-2} \text{sec}^{-1}$.

For a typical tube the limiting visual resolution with test patterns of equally-spaced black and white lines is 23 line-pairs/mm at 36 kV overall voltage. At lower voltages the resolution falls, reaching a value of 19 line-pairs/mm at 20 kV overall voltage, when the photon gain is of the order of unity. This relative insensitivity of resolution to voltage variation indicates that in present tubes the deterioration of the image is not predominantly due to the inhomogeneity in energy of the secondary electrons, but that other factors make a significant contribution. This conclusion is strengthened by the performance of a recently-prepared 5-dynode tube

which is in all respects similar to the normal tubes, except that the photo-cathode, dynodes and phosphor are more closely spaced. From preliminary measurements with this tube, it appears that the limiting visual resolution does not much exceed that of the longer tubes, although, as expected, the variation of resolution with overall voltage is smaller.

Measurements have also been made of the distribution of intensity amongst output scintillations from the phosphor corresponding to single electrons from the photo-cathode. This distribution is found to be exponential, as for many types of photo-multiplier. It is found that when, by varying the voltage between the photo-cathode and first dynode, the mean electron multiplication of this dynode is reduced by a factor of 5, the mean intensity of the scintillations is reduced by a factor less than 2. This shows that the voltage dependence of the mean electron multiplication of a dynode is due principally to changes in the probability of an incident electron producing no transmitted electrons. The value of this probability is found to be about 0.15 at normal operating voltage.

The cathode sensitivity and electron multiplication of a 5-dynode tube have been monitored continuously during a period of operation sufficiently prolonged to cause permanent damage to the cathode and dynodes. It was found that after an area of 1 cm² of the last dynode had been bombarded by a total charge of $\sim 5.5 \times 10^{-3}$ coulomb, the mean electron multiplication of the tube had fallen to ~ 0.75 of its initial value, and the cathode sensitivity had fallen to ~ 0.67 of its initial value.

POTENTIALITIES AND LIMITATIONS OF IMAGE
SCANNING TECHNIQUES IN ASTRONOMY

J. A. Hynek

Two programs of the application of image scanning techniques to astronomical problems are currently in progress at the Northwestern University, under the sponsorship of the U.S. Air Force and of the National Aeronautics and Space Administration, respectively. The first program is being carried out at the Dearborn Observatory directly, where an image orthicon system has been attached to the 18-inch refractor, and the other at the Organ Pass Station of the Dearborn Observatory in New Mexico, where a 12-inch reflector and image orthicon system have been set up especially for these purposes. It is expected that the parameters of operation and effectiveness determined through the employment of these modest instruments can be extrapolated to use with larger instruments without the introduction of a serious scale error.

Enhancement of contrast discrimination, the detection of faint objects, and the study of slow-scan techniques are the specific problems under investigation at the Dearborn Observatory. It has been found that small areas showing a 5% contrast can be transformed into areas of about 90% contrast; this technique is being applied to the determination of albedo differences on the lunar surface at the full lunar phase.

At the Organ Pass Observatory the investigations comprise the determination of limiting stellar magnitudes by use of special techniques, the resolution of spectral class differences in objective prism spectroscopy, and the determination of positional resolution of asteroids and other slow moving astronomical objects.

A fine potential for scanning systems appears demonstrated, especially if the image orthicon tube is improved by the utilization of a "mono-kinetic" scanning beam. Their limitations arise largely from lack of resolution, a matter which can also be remedied by improved scanning systems.

LABORATORY EVALUATION OF IMAGE TUBES FOR ASTRONOMICAL PURPOSES

W. A. Baum

During the past few years various workers have devoted much effort to the testing of image tubes on telescopes and on astronomical spectrographs. It is not sufficient to know only the resolution and the cathode sensitivity. We have to know how different image tubes compare with one another and with unaided photography in detecting typical features in stellar spectra or in recording faint images against the sky background.

An instrument has been built at the Imperial College, London University, for making quantitative "astronomical" tests in the laboratory. A tiny test-image is projected with a controlled amount of light on to the photo-cathode of a tube being evaluated. In addition to a resolution pattern, the test-image includes three calibrated sequences of simulated spectrum lines, a calibrated sequence of simulated star images against a "sky" background, an intensity step-wedge, a sequence of double stars, a contrast-dilution test, and a scheme for measuring magnification and distortion. Except for the last item, the performance of the tube can be quantitatively specified by simple inspection of the image recorded by the tube.

The instrument was designed for convenience of operation so that tubes can be tested at the time of production. Duplicates of the instrument are planned.

9b. SOUS-COMMISSION DE LA QUALITE DES IMAGES

Compte rendu de la Séance, 17 août 1961

PRÉSIDENT: J. S. Hall.

SÉCRÉTAIRE: J. Rösch.

L'ordre du jour appelle en premier lieu la discussion du *Draft-Report*. Ce rapport figure dans le volume distribué aux membres de l'Union avant l'Assemblée Générale. Le Président propose d'apporter à ce texte quelques adjonctions pour tenir compte des travaux publiés depuis sa rédaction. Cette proposition est acceptée, et l'ensemble du Rapport est adopté.

Le Président expose ensuite que la principale tâche de la Sous-Commission est de discuter les conclusions du rapport sur *le Choix des Sites* établi par le Groupe de Travail créé par le Comité Exécutif de l'Union en 1959 sous la présidence de J. Rösch. Ce rapport a été distribué en mai 1960 à plus d'une centaine de membres de l'Union intéressés à ce problème, et des exemplaires sont disponibles en séance.

Ces conclusions sont essentiellement les suivantes:

(a) que le Groupe de Travail soit maintenu en activité au delà de la XI^e Assemblée Générale de l'Union;

(b) que soit organisé le Symposium dont le principe a été adopté lors de la X^e Assemblée Générale;

(c) que les observatoires existants s'attachent, au moins à l'occasion de leurs observations courantes, à noter les corrélations entre les conditions atmosphériques locales et la qualité des images;

(d) que les observatoires qui consacrent des moyens très élaborés à l'étude de la qualité des images utilisent, conjointement, les instruments des types plus simples employés dans les prospections, de façon à asseoir sur une base plus large les résultats fournis par ces derniers.