9. COMMISSION DES INSTRUMENTS ASTRONOMIQUES

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INTRODUCTION

The years under report 1964–67 are noted by a rapid development of the theory of optics in general and astrometrical instruments in particular. This period was characterized by the application of a new method to the study of the quality of optical systems on the basis of frequency-contrast characteristics, etc. The method of control and adjustment of optical instruments improved considerably (**1, 2**).

The design and construction of instruments also improved. Optical systems of new large instruments with diameters of 1 to 1·5, 2·5 to 3·0, 3·3 to 3·5, 5 to 6 m are being developed and there is a tendency to design 7·5 to 15 m telescopes (**3**) for the Kitt Peak Observatory!

Some of the above instruments are under construction and will be mounted in the near future. Much attention is being devoted to the selection of suitable sites as regards seeing, meteorological data and the astroclimate in general. Much progress was attained in the development of the theory of star visibility in telescopes, and especially in the problem of limiting exposure and magnitude.

It was found that the focal length is of primary importance in this respect (**4**).

This was the reason for changing the primary focus *f*/3·7 (with a correction lens) of 200-inch (508 cm) Mt Palomar telescope to the Cassegrainian focus *f*/9 (with a correction lens) for the field of 15′. Experimental and observational tests showed that this gave a gain of about one magnitude (**4**).

There was also progress in the development of detectors of radiation (for wide range of the spectrum), in particular photographic plates. The new sort of Kodak plates IIIa-J (087), specially baked, which have a sensitivity less by a factor of two than Kodak 103a-O (at identical detecting quantum efficiency), permit longer exposures and a gain in limiting magnitude from $23^{m}.8$ to $24^{m}.5$ or even $25^{m}.0$ (200-inch telescope, *f*/3·7) (**5, 6, 7**).

Special attention is given to automatic control of temperature during the development of plates, which is of great importance (**8**).

A new method for the reception of information, the holographic (**9**) imaging method, has found application. The possibilities of auxiliary apparatus have increased greatly: photoelectric (new photomultipliers with multilayer cathodes and new infrared detectors for 8–14μ), spectroscopic (Fourier transformation, SISAM, diffraction grating with a surface of 320 × 280 mm, échelle, etc.), interferometric (wide and narrow band filters), and other techniques. Significant progress has been made in automatic driving and guiding of large telescopes (10), possible compensation of the instability of star images, etc. Automatic telescopes and spectral apparatus on balloons, rockets and artificial satellites for outside the atmosphere observations also attained a high technical level.

At present, it is possible to devote serious attention to the development of astronomical instruments and auxiliary apparatus for observations on the Moon. In connection with this it seems desirable to discuss with members of Commission 9 the possibility of organizing a working group, which might be named 'Astronomical Instruments for Observations on the Moon'.

REPORTS FROM OBSERVATORIES OUTSIDE U.S.S.R.

Yerkes Observatory

Professor W. A. Hiltner reported:

1. A 24-inch (61 cm) Cassegrain reflecting telescope has been installed in the northeast dome of the Observatory. This telescope is unique in that it is rotatable on its optical axis for the elimination of systemic errors in polarization measurements. This instrument has been entirely successful for any residual systematic error is less than 0·0001 magnitude.

2. A small laboratory-observatory has recently been completed at Yerkes Observatory. The building consists of two domes with a laboratory in between. An equatorial mounting is available in either dome. At the present time a seven-inch *f*/4 Schmidt telescope is in one dome and large-aperture (6-inch/15 cm) spectrometer with a 10-inch (25 cm) telescope in the other. The Schmidt is used for the identification of faint OB stars with an ultra low-dispersion objective prism, and the spectrometer is used for spectrophotometric observations of comets and nebulae.

3. A 40-inch (102 cm) Cassegrain-coudé reflector is now under construction for the Observatory. It will be installed in the southeast dome, originally occupied by the Ritchey 24-inch (61 cm) reflector. (The Ritchey instrument has been donated to the Smithsonian Institute, Washington, D.C.)

Stockholm's Observatory

Professor Dr Y. Öhman reported:

1. Zeiss in Oberkochen is considering manufacturing our flare photometers if this would prove of value to solar research.

2. S. E. Nilson has tried a double image line shifter (see also (**11**)) for the purpose of determining Doppler velocities of dark and bright surges, etc. (**12**).

3. Kerstin Fredga who has been research associate at Goddard Space Flight Center in 1964, 1965 and 1966 has made in 1965 several recordings of the solar disk in the Mg II line at 2802·7 using a Solc-type birefringent filter of about 4Å (**13**).

4. Y. Öhman has designed a spectrograph for recording from an unstabilized rocket the spectrum of various parts of the solar surface. The instrument uses a great number of small lenses placed on a spherical surface. The focus of all these lenses is situated in the centre of curvature. Here a very small (0·5 mm or so) reflecting sphere is used, functioning as slit for a spectrograph. By using a continuously moving film tracings are obtained when the various lenses project, by chance, the solar image on the small sphere. The instrument is mainly intended for the study of the Mg II lines at 2800 in flares.

5. J. O. Stenflo has started the design of a spectrograph which he would like to use in space research for studying solar magnetic fields in small structure elements of the solar surface.

6. The coronograph of the Stockholm station in Anacapri has been used recently by B. Rydgren (**14**) for photometric measurement of the Earth shine on the Moon. Rydgren has found

a very good agreement with Danjon's previous measurements and has been able to extend the curve between intensity and phase angle.

7. Y. Öhman and B. Rydgren published a brief paper in 1963 on the method of measuring radiation by means of the thermomagnetic effect (**15**).

8. U. Kusoffsky is following up a suggestion made by Y. Öhman in (**16**) for reducing scattered light in sunspot photometry by using two diaphragms, one with a size equal to the Airy disk of the telescope and placed in its focal plane, the second one of greater size and placed in front of the phototube. Observations show that the influence of diffracted light from the circumference of the objective is reduced to a minimum with these simple devices.

9. Finally work has been done by Y. Öhman on shearing interferometry of the diffraction image (**17**) in collaboration with U. Kusoffsky (**18**). This work aims at increasing resolution (and may have particular applications in spectroscopy and in space research) but seems to open up some new ways for studying atmospheric seeing also.

Stockholm's Observatory

L. O. Lodén reported:

A new type of combined starlight photometer and polarimeter is under construction by myself at the Stockholm Observatory. The instrument will secure automatic sky background compensation like the previous one used by the author (see (**19**)), but it has only one multiplier. A special mechanism will switch rapidly between star and sky and the subtraction of the sky deflection from the star deflection is made automatically in the amplifier.

The Lick-Stromlo-U.S. Naval Observatory Electronic Camera

(U.S. Naval Observatory, Flagstaff, Arizona)

Gerald E. Kron and I. I. Papiashvili (personal report)

(*a*) *General.* This electronic camera is identical to the Lallemand camera in principle, but quite different in operation, as the photocathode can be protected by closing a special valve during plate change, thus making possible the use of the same photocathode for many plates. The equipment was moved from the Lick Observatory to the U.S. Naval Observatory at Flagstaff in October 1965, where development and use of the camera is continuing.

(*b*) *Photocathodes and tube background.* Formerly we were able to prepare tubes with low electronic background only by starving the photocathode of caesium during its preparation, thus limiting our photocathode efficiencies to a maximum of 6% at 4200 Å. During the last 18 months the camera has been modified by rebuilding the electronic lenses with larger radial clearances and with larger radii on the ends of the electrode terminal surfaces both for the purpose of reducing the electrostatic field strength in the lens gaps. In addition to this, we have modified our cathode preparation technique so as to give us some control over unwanted caesium deposition on tube walls and electrodes. As a result of these changes, we can now prepare tubes with fully caesiated Cs-Sb photocathode whose electronic background, at an operating potential of 30 kV, is determined by the thermal emission of the photocathode. Photocathodes can now be made with efficiencies of from 6 to 12% at 4200 Å, and they maintain 90% of their initial sensitivity for from 2 to 12 months. There is a tendency for the more efficient cathodes to have the longer lives.

(*c*) *Photometric possibilities.* Further laboratory studies of the growth of density with exposure for Ilford K.5, and L.4 nuclear track emulsions strengthen the belief held by us and others that there is a very nearly linear relationship between density and exposure up to densities of between 3 and 4. The electronic camera therefore offers the possibility of accurate photoelectric photometry on star and nebula fields, and the equivalent of photoelectric scanning of spectra. The electronic camera has the obvious advantage over the photomultiplier of recording a whole star field or an entire spectrum with one exposure. However, experimental application of our electronic camera to surface photometry of E type galaxies has brought to our attention a new difficulty. The light from the field is, of course, focused on the semi-transparent photocathode, where its work is done. Unfortunately, the light then continues into the interior of the electronic section of the camera, where it suffers a number of reflections from very highly polished steel electrodes; some of the light then returns to the inside surface of the photocathode, where it reacts a second time to produce a vague, faint but troublesome pattern. The intensity and shape of this optical background pattern depend upon the characteristics of the original subject; it can be said that this spurious pattern can reach a density of as high as 0·1 on L.4 emulsion after a two-hour exposure with the 61-inch (155 cm) astrometric telescope of the U.S. Naval Observatory. The presence of this background pattern interferes with accurate photometry, and we are now experimenting with methods for reducing or eliminating the effect. We have built an experimental camera with a cathode support surface that has been ground with 500 mesh carborundom, instead of being polished as usual. The definition of this tube is only slightly inferior to that of a tube with a polished cathode surface, but the incoming light is widely scattered before encountering the reflective electrode surfaces. We also plan to experiment with elimination of the polish on certain critical areas of the inside of the electrodes, with the hope that return of light to the photocathode can be decreased without an increase in electronic background resulting from the lack of polish.

(*d*) *Some performance results*. We have obtained a number of one hour exposures of E type galaxies on L.4 and K.5 emulsion employing the 61-inch (155 cm) *f*/10 astrometric reflector. The camera, which had an 11% cathode, was operated at 30 kV. The plates were developed for six minutes in D-19 developer at 68°F. Equal exposures were made by photography with Eastman 103a–O plates for comparison. Photographs and electrographs were both scanned with a microdensitometer for determining both signal and noise levels. We found that the L.4 electrographs were somewhat more dense than the photographs, whereas the photographs had a noise level about 3·6 times larger than the electrographs. At the sky level of brightness (density 0·1 on the photographs) the information gain of the electronic camera over the 103a–O emulsion was about 40/1. At the brightness level at the centre of the E galaxy (density 2·3 on the photograph, 3·7 on the electrograph) the gain on the light from the galaxy in favour of the electronic camera was about 16/1. We were able to follow the light in the outer portion of the E galaxy down to a level of about magnitude 28 per square second of arc with the electronic camera, as compared to about magnitude 26·5 per square second of arc generally reported for photography. When K.5 emulsion is employed in the electronic camera the noise level and density growth rate both increase, so that the information gain is the same as for L.4 emulsion, but the K.5 quite naturally saturates with less exposure, owing to its fewer, coarser grains.

When one makes a visual comparison between a photograph and a fine-grained electrograph, one notes less contrast in the electrograph, and the almost complete absence of granularity; otherwise the two pictures look much alike. The superiority of the electrograph as a repository of scientific data can be fully appreciated only by comparing scans made with a microdensitometer.

(*e*) *The future*. We plan to finish our experiments on the reduction of optical background, and then build a background-free functional tube, which we plan to use on various difficult photometric problems, employing the 61-inch (155 cm) astrographic reflector. We also plan to continue development of the tube by trying to produce more sensitive cathodes especially of the multi-alkali types. In addition, we hope to improve the definition at the edge of the 34 mm diameter photocathode, now only about 35 l.p./mm as compared with about 80 l.p./mm for the central region of the cathode.

Uppsala Observatory

Professor Dr A. Wallenquist reported:

1. The 100/135/300 cm Schmidt telescope at the Uppsala Observatory Kvistaberg station is in operation since 1963 and several hundred plates of good quality have been secured for various investigations. The spherical mirror is of a low expansion borosilicate glass from Pilkington Brothers Ltd, England. The final polishing was carried out by Professor Y. Väisälä, Turku, Finland. He also figured the 100 cm correcting plate of borosilicate crownglass of type BK 7 from Schott and Gen. Jena.

The telescope is also furnished with an objective prism with a diameter of 80 cm and a refracting angle of 7°, figured by Carl Zeiss Jena from UBK 7-glass. The dispersion on the plate at Hγ is 262 Å/mm.

2. A detailed description of the instrument will be published in the beginning of 1967, a preliminary description is given in (**20**).

Mt Wilson and Palomar Observatories

Professor I. S. Bowen, Dr H. W. Babcock, J. Boke, E. W. Dennison, B. H. Rule reported:

1. The construction of a 60-inch (152 cm) photometric telescope to be located on Palomar Mountain has been started by the Mt Wilson and Palomar Observatories. The mirrors of fused quartz will be figured as a Ritchey-Chrétien system with a Cassegrain focal ratio of 8·75 and a coudé focal ratio of 30. A fork mounting and a conical steel telescope tube will be used. A small primary focal length of 3·8 meters permits the use of a very short tube and allows the Cassegrain focus to be located only 92 centimeters from the intersection of the declination and polar axes. These design features will permit very rapid shifts from one object to another. The telescope will be equipped for wide-field photography at the Cassegrain focus and with the latest multichannel photoelectric system for pulse counting. A coudé spectrograph will also be provided.

2. During the last three years efforts have been made to provide much more versatile and powerful data-acquisition system for use with various photoelectric and photo-conductive detectors. These systems have been designed and built under the direction of Dennison and are now installed on the 200-inch (508 cm), 100-inch (254 cm), and 60-inch (152 cm) telescopes. From λ 3200 to λ 11 000, the impressive success of pulse-counting technique indicates that almost all future photoelectric measurements are likely to be made in this way. All systems are being built with either reversible counters or dual counters. By using two apertures, one for sky, the other for star plus sky, and by switching rapidly between them, it is possible by commuting the counters to obtain the difference signal only. The continuous compensation for the sky leads to much higher stability and accuracy than was previously possible.

Although pulse-counting techniques have proven very successful, one limitation has persisted for work on brighter standard stars: the pulse amplifiers and discriminators have been limited to count rate of at most 10^5 counts per second. Recent experiments with commercial and other amplifiers have shown that count rates of 4×10^6 counts per second can now be readily achieved. This gain in counting speed now makes existing standard stars much easier to measure with large telescopes.

3. A large Cassegrain observing facility has been mounted below the 200-inch (508 cm) mirror cell. The system includes a universal chair for the observer, precision off-set guiders and direct-viewing optics. A rigid mounting base has been incorporated which will readily accept large and heavy new instruments.

4. An *f*/9 conversion lens system has been built and is in use at the new Cassegrain station.

A new Cassegrain nebular image-tube spectrograph employing a short focal length concentric mirror system has been designed by Bowen. Both the input camera optics for the image-tube and the re-imaging camera optics are provided with thermal-expansion compensation. A wide variety of image-tubes can be used. The instrument will be completed by the end of 1966.

5. A 33-channel photoelectric spectrometer has been designed by Oke, Rule, and Dennison; construction is well under way. The instrument will cover the spectral range from λ 3200 to λ 11 500 with band passes of 2 Å or larger. The instrument will employ only pulse-counting and will feed into a versatile and automatic data system. Spectrophotometry will be possible down to 22nd magnitude.

6. The 100-inch (254 cm) coudé scanner has been completely modernized to use pulse-counting techniques and complete digital controls. It can be used either in the conventional fashion or with Fabry-Pérot interferometers. A two-channel scanner is being built for the 200-inch coudé spectrograph. When used with a Fabry-Pérot étalon a resolving power of 150 000 should be achieved.

7. A new equatorial solar telescope designed primarily by Rule is under construction. When finished the telescope will include a 15-inch (38 cm) off-axis reflection system for spectroscopy, a 9-inch (23 cm) reflecting coronagraph, and two 10-inch (25 cm) refracting systems for cinematography.

Sacramento Peak Observatory

Dr J. W. Evans reported:

1. Construction has been started on a solar tower telescope designed by R. B. Dunn with an all reflecting or quartz optical system of 75 cm aperture and 64 m focal length. All reflecting surfaces are enclosed in an evacuated tube with quartz windows to keep the surfaces clean for minimizing scattered light, and to avoid image degradation due to convection inside the instrument. The contract completion date is September 1968.

2. A punched card digital recorder has been added to our microphotometer, the recording Doppler comparator, and the photoelectric scanning spectrograph. These recorders have been very useful, but are now being replaced by digital magnetic tape recorders because of their greater convenience.

3. J. Beckers has prepared a computer programme by means of which the state of polarization of light as a function of wavelength can be traced through any system of partial (or complete) polarizers and birefringent elements. This programme has been useful in the design of special birefringent filters, and is available to anyone wishing to use it.

4. J. Beckers has built a 22 cm aperture photoelectric coronameter for scanning the emission lines in polar coordinates. The instrument has a threshold considerably less than 10^{-6} Å equivalent width through a sky of brightness 10^{-4} that of the Sun.

5. R. B. Dunn designed an eclipse unit consisting of a 25 cm reflecting telescope and $f/5$ grating spectrograph with an average dispersion of 35 Å/mm. Its purpose is to obtain coronal spectrograms showing the continuum as well as emission lines. Two samples were built and successfully used at the 1965 eclipse. One of these was operated by Dunn from the NASA aircraft. It was guided to about 10″ accuracy by a gyro actuated servo system designed by Dunn. Both instruments are to be used again at the November eclipse in South America.

6. H. Mauter built a spectroheliographic attachment for our 13 m spectrograph to photograph a small area of the solar surface in Fraunhofer lines of small width. Mauter has successfully used bandwidths down to 0·03 Å.

Washburn Observatory at the University of Wisconsin

Dr. A. D. Code reported:

1. *Scanning Spectrometer*. A new scanning spectrometer has been placed into operation at the Pine Bluff Observatory. This instrument is of the type described by Schröder (1965), having only two reflections, one from a concave mirror, the other from a plane grating. This particular instrument operates at $f/12$ with a reciprocal dispersion at the exit slit of approximately 70 Å/mm in the first order. The spectrum is scanned rapidly by rotating the plane grating by means of a stepping motor, in four angströms steps. The output from a photomultiplier mounted behind the exit slit is amplified and stored in a core memory multichannel digital analyser. Each four-angström interval is stored in a separate location in the core memory and the output of successive scans are added to the accumulative spectrum. A single scan of 4000 angströms is executed in about 0·5 seconds.

In operation, three distinct advantages have been found over the method of single slow scans. It was found that it was possible to obtain spectra of fainter objects for a given accuracy in the same total exposure time. More impressive, however, was the ability to record high quality data through moderate cloud cover, and essentially doubling the number of useful observing nights. Finally, it was noted that the rapid comparison of different spectral regions decreased the scintillation noise on bright objects, resulting in higher precision than that obtained with single scans. The technique is also applicable to high resolution line profile measurements without requiring seeing compensation. In short, the system has the integrating properties of the photographic plate and the inherent accuracy of the photoelectric technique. Any night on which photographic spectroscopy can be done is suitable for photoelectric spectrophotometry by this technique.

2. *Automatic telescope*. An automatic telescope has been installed at the Pine Bluff Observatory. This instrument automatically sets on programmed stars and makes multicolour photoelectric measurements. The instrument is used to continually observe a number of standard stars throughout the night, to provide data on atmospheric extinction, and therefore reduce the amount of time required for this purpose by the larger instruments. The automatic telescope is an 8-inch (20 cm) reflector under the control of a PDP–8 general purpose computer. The stars to be observed are read in on punched paper tape. The telescope sets on the coordinates, and then centres the star. If approximate colours and magnitudes are inputed to the computor, the telescope is capable of identifying and centring on the particular star in the neighbourhood of brighter objects. When the object is acquired, a set of measurements is obtained with three filters, a Čerenkov standard source, and a dark measurement. This output is recorded both digitally and in analogue fashion; and the data is processed by the control computer.

3. *Wide field high resolution spectrometer*. A crossed échelle spectrometer has been constructed and tested in the laboratory by Schröder. This instrument was designed to give a very high ratio angular field to spectral purity. By operating in very high orders, correspondingly large areas of the sky may be observed for a given spectral resolution. The instrument may be used as a photoelectric scanner or operated photographically. It is ideally suited for use with image tubes, since the crossed dispersion puts a large spectral region within the physical dimensions of the photocathode.

4. *Standard radiation sources*. We have recently completed an extensive calibration of tungsten ribbon filament lamps for use as stellar radiation sources. The absolute spectral distribution of these lamps was directly compared with a fundamental platinum black body. The internal accuracy of these measurements is less than the fundamental uncertainties that exist in the determination of the radiation constant in Planck's law. The agreement between our calibrations and those of the National Bureau of Standards are excellent. The reason for this note, however, is to point out that we found the pyrometric technique for determining the

spectral distribution of tungsten ribbon lamps to be unreliable. Apparently the emissivity of tungsten varies among filaments of different manufacture. A description of this work by R. C. Bless, A. D. Code and D. J. Schröder is now in press.

Observatoire de Paris-Meudon—Instruments solaires

1. G. Wlérick signale que le laboratoire solaire horizontal de l'Observatoire de Meudon, décrit dans le rapport précédent, est entré en service en Février 1965. Il est composé de quatre parties: coelostat, télescope, monochromateur, spectrographe. Un soin particulier a été apporté pour supprimer l'astigmatisme. Les barillets des miroirs du coelostat comportent les dispositifs antiflexion. Dans chacune des autres parties, l'astigmatisme est corrigé, grâce à la déformation d'une pièce optique, suivant le dispositif imaginé par A. Couder. L'ensemble télescope-monochromateur-spectrographe est isotherme pour minimiser les turbulences instrumentales. La qualité optique de l'instrument est révélée par le fait qu'il a permis d'obtenir en plusieurs occasions de très bons spectres montrant la structure fine des raies photosphériques.

2. G. Wlérick signale aussi que le bâtiment de la Tour Solaire est achevé. Sa hauteur est de 34 mètres et il est constitué par deux chemises entièrement séparées. Le télescope vertical, qui doit entrer en service en 1967, a une pupille de 60 cm de diamètre et une longueur focale de 45 mètres. L'objectif est un miroir sphérique qui travaille en-dehors de l'axe; le faisceau est replié grâce à un miroir plan, légèrement déformé pour corriger l'astigmatisme de l'objectif. Le télescope est fermé à ses deux extrémités par des glaces pour réduire la turbulence. Le spectrographe associé doit entrer en service en 1968.

3. P. Charvin a construit une nouvelle version du coronomètre Lyot-Charvin décrit dans le rapport précédent. L'instrument est muni d'un objectif de qualité coronographique; il travaille 'dans l'axe' et mesure l'intensité et la polarisation de la raie coronale $\lambda\,5303\,\text{Å}$. Sa mise en service, à l'Observatoire de Nice, est prévue en 1967.

4. R. Michard fournit les renseignements suivants:

(*a*) Nouveaux héliographes monochromatiques. L'héliographe $\text{H}\alpha$ de Lyot, utilisé à Meudon depuis 1954 à la surveillance cinématographique des éruptions solaires, a été remplacé en 1964 par un instrument plus moderne, permettant d'obtenir simultanément une image correctement posée du disque solaire et des protubérances.

D'autre part, un 'héliographe à longueur d'onde variable' a été mis en service en 1965; il permet d'enregistrer en succession rapide trois images de la chromosphère en $\text{H}\alpha$, $\text{H}\alpha + 0{\cdot}7\,\text{Å}$, et $\text{H}\alpha - 0{\cdot}7\,\text{Å}$ à l'échelle de 42 mm pour le Soleil entier et avec une bande passante de $0{\cdot}7\,\text{Å}$. Cet appareil s'est révélé très utile pour l'étude des phénomènes à grande vitesse radiale normalement invisibles au centre de la raie $\text{H}\alpha$.

(*b*) Les laboratoires de spectroscopie solaire de Meudon (spectrohéliographe de 7 mètres) et du Pic du Midi ont été améliorés; remplacement de tous les anciens miroirs en verre par des miroirs de silice, guidages photoélectriques, automatisation des observations, nouveau coelostat pour le Pic du Midi.

(*c*) Pour mesurer les petits déplacements locaux des raies sur un spectrogramme (effet Doppler ou effet Zeeman en lumière polarisée), on a construit deux 'lambdamètres' photoélectroniques qui ont trouvé de nombreuses applications en physique solaire. Ils permettent aussi de mesurer les champs magnétiques stellaires pour des étoiles à raies larges.

Observatoire Royal de Belgique

Professor E. Vandekerkhove reported on the following items:

1. Un déviateur (to be published in the November-December issue of the Revue *Ciel et Terre*).
2. Etude du grand prisme de l'Observatoire d'Uccle (just finished for publication).
3. Le grand télescope de l'Observatoire d'Uccle (in preparation).

U.S. Naval Observatory

Professor K.Aa. Strand reported:

1. An extensive programme in the development of new transit circle instrumentation is in progress at the U.S. Naval Observatory under the supervision of A. N. Adams and B. L. Klock. An electronic circle and automatic star and planet tracking micrometer are under construction. This instrumentation should have a repeatability of 0·05 seconds of arc. The photoelectric micrometer will be able to observe, in both coordinates, night and day objects, including the Sun. The new system will be connected to an electronic control and data acquisition for initial pointing of the telescope and for storage of the observational data. The equipment is to be initially installed and tested on the 6-inch (15 cm) Transit Circle.

2. Designs for an automatic transit circle are in progress. The new instrument will incorporate the electronic circle and photoelectric tracker mentioned above. Special attention is being given to reducing the thermal and flexural errors known to exist in the present transit circles. The new transit circle will be installed at the U.S. Naval Observatory, Flagstaff Station, in Arizona.

3. A two-coordinate measuring machine, capable of high speed precise measurements on photographic plates over a 10 × 10-inch area, has been acquired by the U.S. Naval Observatory. Based upon design specifications by K. Aa. Strand, the machine incorporates the following new features: granite structural members, granite-air bearing stages, granite guideways, automatic acquisitioning and centring, and moiré fringe position recorders. Output data are obtained on punched cards, and repeatability of centring is within one micron. So far, this machine has been used principally in the parallax and photographic double star programmes.

Royal Greenwich Observatory, Herstmonceux

Professor R. Woolley reported:

Construction of the Isaac Newton telescope is complete. The fully-assembled instrument has passed its works tests satisfactorily, and erection on the site at Herstmonceux should be completed in 1967, April. The building housing should be finished later in the summer. The optical train employed is standard: the 98-inch (250 cm) mirror is an $f/3{\cdot}0$ paraboloid and observing will be possible at the prime focus (from a removable cage carrying the observer), at a Cassegrain focus ($f/14{\cdot}2$) and at a coudé focus ($f/32$). The main innovations are in the mechanical design. The polar axis consists of a squat cylinder fabricated from mild steel plate (the 'polar disk') 6·7 m in diameter and 0·9 m deep, rotating on pressurized oil pads. The telescope tube is hung between stout tines springing from this disk. The mirror is supported axially in its cell by an air-bag, 6 mm thick, inflated to a pressure varying automatically with the elevation of the telescope tube. In use, the control system ensures that the axial component of the weight of the mirror (4000 kg) is supported to ± 0·5 kg by the air-bag.

Cassegrain and coudé spectrographs are being designed and built in the Engineering Department of the Observatory. Work on the first is well advanced and it should be ready when the telescope itself is commissioned. Its optical axis will be at 90° to that of the telescope and two Newtonian collimators, both working at $f/14{\cdot}2$, are being provided. One of 11 cm aperture will work with either of two field-flattened Schmidt cameras of equivalent focal length 14 and 33 cm; the other of 6·5 cm aperture will work with a semi-solid Schmidt camera of e.f.l. 4·4 cm. Several gratings will be available, giving a range of linear dispersions from 12 Å/mm to 36 Å/mm in the blue and 25 to 60 Å/mm in the red.

2. The 30-inch (76 cm) Thompson reflector has been modified to illuminate a vertical coudé spectrograph by the addition of two flat mirrors, one moving on the declination axis and one fixed on a tripod support to the north of the polar axis. The focal ratio of the telescope, with this arrangement, is $f/47$. The collimator of the spectrograph is off axis with aperture of 12 cm and focal length 570 cm. The grating of 600 lines/mm carries the twice-through corrector plate

of the off-axis Schmidt camera of 81 cm focal length. The 18 cm × 2·5 cm plates are bent to the required radius, and 1500 Å of spectrum at 10 Å/mm in the 2nd order (blue) are recorded. Observations of IAU standard velocity stars show an s.e. per plate of ± 0·3 km s^{-1} for this instrument.

3. Experimental work in co-operation with Professor McGee's department at Imperial College, London, has been carried out on this telescope with a Lenard-window image intensifier. Stellar spectra were obtained on Ilford XM emulsion with a resolution of 40 l.p. per mm and exposure gain of x18, compared with baked IIa-O photographic emulsion exposed at the same focus. G5 emulsion with an improved resolution of 80 l.p. per mm gave a gain of x6. The image quality was reduced for long exposures by the changing component of the ambient magnetic field due to the movement of dome and telescope.

4. A 5 cm lens grating spectrograph of low dispersion, for use with a magnetically shielded 'Spectracon' image tube, is being installed on the 30-inch reflector. An alternative lens camera using the full collimator aperture of 13 cm will provide further focus experiments with image intensifier tubes at higher dispersions of up to 3·5 Å/mm in the blue.

5. A linear measuring engine fitted with digitization and printed read-out of position has been modified to give oscillograph display of the line profiles on stellar spectrograms. Two separate photocells are used for star and comparison display.

Kitt Peak National Observatory

Dr L. Crawford reported:

1. Now in operation at the Kitt Peak National Observatory are two 16-inch (41 cm) reflectors. One, called No. 3, is a Cassegrain *f*/7·6 equipped with a standard, single channel photoelectric photometer. The telescope is housed in the 16-foot (488 cm) diameter rotating dome, adjacent to the 84-inch (213 cm) telescope building. The other 16-inch (41 cm) telescope, called No. 4, is an *f*/18 Cassegrain, equipped with a standard, single channel photoelectric photometer. This instrument is equipped with a digital read-out system, which gives not only the intensity data on a Brown strip recorder chart, but also gives the star number, sidereal time, hour angle and declination, comments, and the output of the integrators with their gain, on punch paper tape suitable for reduction on the digital computer in Tucson. This 16-inch telescope is located in a 16-foot (488 cm) diameter rotating dome midway between the two 36-inch (91 cm) telescopes.

2. The No. 1 and 2 16-inch telescopes are both *f*/13·5 and were used during the site survey and first years at Kitt Peak. They are now located at the Cerro Tololo Inter-American Observatory in Chile. They are equipped with single channel photometers identical to those on the No. 4 16-inch telescope at Kitt Peak. They do not have provision for punch paper tape output, but the electronics consists of a precision timer and programmer for single channel or double channel work, to control one or two integrators in parallel. The circuits are digital and solid state Integrators or DC amplifiers are used.

3. The No. 1 36-inch (91 cm) telescope has been in operation since 1960 and is equipped with a single channel photoelectric photometer and with a digital read-out system identical to that on the No. 4 16-inch (41 cm) telescope. The telescope tube is equipped with a flip top that gives the choice of a *f*/16·6 Cassegrain or an *f*/7·6 Cassegrain. A Cassegrain spectrograph is available for the *f*/13·6. A direct camera with guider is now under design and construction and will be available for the *f*/7·6 focus. Instruments used on the 84-inch (213 cm) can be used at this *f*/7·6 focus. The No. 2 36-inch telescope is about ready to go into limited operation. It is also equipped with a flip top, and gives the choice of a *f*/13·6 Cassegrain or *f*/36 coudé focus. No instruments are presently planned for the coudé. A single and double channel photometer

will be available for the Cassegrain focus, and the telescope will be equipped with digital read-out similar to that of the No. 4 16-inch telescope.

4. The 84-inch telescope is now in full operation and was described in the previous Commission report. Additional instruments now available, not described in that report, are a single channel Cassegrain photometer, a two-channel (star-sky) photometer, and a Cassegrain spectrograph.

5. Reduction programmes are available for computer reduction of the photometry done at Kitt Peak. Programmes are available for Hα, Strömgren four-colour, and *UBV* type photometry. Input can be from punched paper tape produced at the telescope, punched cards, or punched paper tape produced in Tucson after the Brown recorder tracings have been read. Output is in any of several formats, depending on the wishes of the observer.

6. The design work for the 150-inch (381 cm) telescope is now well under way. Preliminary design was described in (**22**). The telescope will incorporate a 150-inch diameter fused quartz mirror, which will give *f*/2·8 at the prime focus through any of several corrector systems for wide photography. A *f*/14 Cassegrain focus will be available, with the observer riding in the telescope in an observing cage, and an *f*/30 coudé will be available. It uses a permanent five-mirror system with the beam in a horizontal plane. A coudé optical laboratory will be available, in addition to the spectrograph. It should be possible to change any of the foci to another in about ten minutes. The *f*/9 Cassegrain will be a Ritchey-Chrétien type system for wide field limit photography. Most photoelectric photometry and spectroscopy will be done at this focus. The telescope will be located in a dome approximately 100 feet (30 m) in diameter, and with the declination axis approximately 125 feet (38 m) above the ground. The detailed design of the telescope mounting is now under way by Westinghouse Electric Corp., Sunnyvale, California, and should be finished about March 1967. Detailed design of the rotating dome and building are under way by Skidmore, Owings and Merrill, Chicago, Illinois, and should also be finished about March 1967. The construction of both the mounting and the dome and building should therefore start by the summer or fall of 1967. The fused quartz mirror is being fabricated by General Electric Corp. in Cleveland and delivery is expected in March 1967. The optical work on the large primary mirror will be done in the Tucson headquarters. The optical shop facility is now finished and awaiting delivery of the mirror. The grinding machine for the large mirror will be fabricated by L. and F. Machine Co., Huntington Park, California.

Steward Observatory, the University of Arizona, Tucson

Dr D. J. Taylor reported:

1. A 90-inch (229 cm) telescope is being constructed for the Steward Observatory by Boller and Chivens Company. It will have an *f*/9 Ritchey-Chrétien focus and an *f*/30 coudé focus. The fork mounting will be 65 feet (20 m) above ground in a simplified dome consisting of cylindrical sections. The drive is a digitally controlled torque motor. The telescope is scheduled to be in operation at the Kitt Peak Station in 1968.

2. Development of auxiliary instrumentation for the 90-inch telescope is already under way. A $3\frac{1}{2}$-inch (8·9 cm) beam Cassegrain spectrograph with folded Schmidt and image tube cameras is currently being constructed. A horizontal 8-inch (20 cm) beam coudé spectrograph with 12, 30, 75, and 188-inch (30, 76, 191, 240 cm) focal length cameras has been designed. The three shortest cameras are arranged in a vertical stack and are changed by means of an elevator. Image tubes are being tested and evaluated, and an automatic-tracking offset guider utilizing an image dissector tube being developed.

3. Two photoelectric spectrum scanners have recently been completed for use with Steward Observatory's existing 36-inch (91 cm) telescope. One is located at the coudé focus and is designed for high resolution line profile spectrophotometry. The other may be used either at

the Cassegrain or Newtonian focus and is intended for low resolution energy distribution measurements.

Lunar and Planetary Laboratory

Dr Tom Gehrels reported:

The new 154-cm reflector of the Lunar and Planetary Laboratory is being used at *f*/13 and *f*/45 for polarimetry when it is not in use for the primary programme of planetary photography. The mirrors are nearly free from instrumental polarization thanks to careful aluminization. The internal probable error of the polarization measurements is ± 0·0006 magnitude for objects brighter than 7th magnitude and observations lasting about half an hour per filter. The filters are at 0·33, 0·36, 0·43, 0·52, 0·64, 0·83 and 0·95μ. A 71-cm reflector is being used with high-altitude balloons for polarimetry at 0·22 and 0·28μ.

Royal Observatory, Edinburgh

Professor H. A. Brück reported:

1. The twin 16-inch (41 cm) programmatic telescope of the Royal Observatory, Edinburgh, has now been commissioned and the effectiveness of the system has been demonstrated by a series of measurements in Cygnus by Dr V. C. Reddish, who obtained measures on different nights under poor atmospheric conditions.

2. Improvements are being made in the light of operational experience such as an improvement of the accuracy of the digital position measurements and of the form of pulse counting photometer.

3. A second Becker iris photometer, modified for digital punch-out, and a servo-controlled iris is being commissioned and will be the first machine in Edinburgh to be 'on-line' to the 4100 Elliott computer now being installed. The photometer will then be fully automatic after initial measurements have been taken.

4. The prime purpose of the 4100 computer installation is for the full 'on-line' automation of measuring machines and telescopes. It includes a 16 384 word magnetic core store, three magnetic tape units, paper tape input/output equipment, and a control typewriter.

5. Priority is being given to the control of measuring machines by computer as the number of Schmidt plates to be measured is likely to increase when the new Outstation of the Royal Observatory at Monte Porzio, Italy, becomes operational in 1967. This station will contain a 16/24-inch (41/61 cm) Schmidt telescope with a focal length of 60-inches (152 cm) made by Messrs. Grubb Parsons.

6. The first phase of automation of the Edinburgh 16/24-inch Schmidt telescope is complete. This provides for analogue control of right ascension, declination and shutter operation, while design studies have been initiated for autoguiding and the automatic loading of plates. These are essential first steps to fully automatic 'on-line' control.

7. There has been some delay in the construction of the automatic luminosity and *XY* co-ordinates measuring machine 'Galaxy' as previously reported. The major mechanical assembly, weighing some 3·6 tons is complete and the electronics are in an advanced state of construction. Delivery of the machine to the Observatory is now scheduled for May, 1967, when it will be installed in an environmentally controlled room which is now being built.

La Plata Astronomical Observatory, Argentina

Dr J. Sahade reported:

In regard to the La Plata Observatory 85-inch (216 cm) reflecting telescope project, the construction of the mounting and the control consoles has been constructed by Boller and Chivens, a division of the Perkin-Elmer Corporation, in the United States. It is planned that the project become sponsored by all the Argentine National Universities.

Torun Astronomical Observatory of N. Copernicus University

Professor W. Iwanowska reported:

A photoelectric photometer of standard type has been built for the use with the 90 cm telescope as well as with some smaller instruments.

Astronomical Institute of the Czechoslovak Academy of Sciences

Dr. B. Sternberk reported:

A two-meter reflector made by VEB Carl Zeiss Jena, equipped with the primary, Cassegrain and coudé foci is under construction at the Ondřejov Observatory, Czechoslovakia. It will be formally inaugurated at the XIIIth General Assembly of the IAU.

Tokyo Astronomical Observatory

Dr H. Hirose reported:

In 1964, a Schmidt camera of the ordinary type was completed and erected at the Dodaira Station of the Tokyo Astronomical Observatory. Principal features of the camera are as follows:

Aperture of the correcting plate	50 cm
Diameter of the main mirror	65 cm
Focal length	100 cm
Diameter of the field	10·5 cm (+ 5·3)

Flat plate can be used.

Manufacturer: Nippon Kögaki K.K. (Japan Optical Co.), Tokyo, Japan.

The International Latitude Observatory of Mizusawa, Japan

Dr H. Hirose reported:

The Observatory has completed an automatic measuring machine for the photographic plates obtained with the floating zenith telescope in order to make measurements free from personal errors. The aimed precision is ± 1 μ and this precision is realized by combination of two photomultipliers with a decatron counter (**23**).

Besides, following improvements have been applied to our instruments, respectively:

(1) The Talcott level of the visual zenith telescope (V.Z.T.) has been replaced by the level of electromagnetic type in order to set the whole telescope in fine equilibrium position with the use of servo-mechanism. The micrometer reading of the V.Z.T. is counted electrically with the use of a digitizer.

(2) Another new unit produced is for Danjon's astrolabe. This unit counts interval of the time-contacts electrically and is connected with the input-unit of an electronic computer (**24**).

The Hydrographic Office of Marine Safety Agency, Japan

Dr H. Hirose reported:

A new timing device for the observation of artificial satellites has been developed by Mr F. Ono (**25**) as given below:

A satellite trail is chopped by a narrow slit travelling in front of the photographic plate of the satellite tracking camera, while the serial position marks of the very slit are photographed on the same photographic plate by the aid of a multiple discharging flash lamp. With this device, we can obtain a dot-like image of a satellite corresponding to the time when the position of satellite's image on the photographic plate coincides with that of the moving slit. The actual apparatus has three slits and observations are made with an equatorially mounted camera having this device. The time of the flash of the discharge lamp are recorded with an oscillograph with the standard time signal. Accuracy of timing is expected to be 0·1 ms.

Mr F. Ono (**26**) developed a measuring device for personal equation by applying a principle that terminal voltage of a condenser of C–R integrated circuit is proportional to duration of charged time. By marking a time-scale on a meter of moving-coil-type, small time interval can be directly measured. This device has been employed regularly to determine personal equation for visual observation of occultations at the Hydrographic Office of Japan.

The Geographical Survey Institute, Japan

Dr H. Hirose reported:

A new satellite tracking camera has been completed in the Geodetic Observatory at Kanozan since 1963. This camera is equipped with a photoelectric timing device designed by Professor Tsubokawa and mounted equatorially.

It takes the photograph of the trail of a satellite and background stars simultaneously. Several knives are placed parallel with each other in front of the photographic plate with their axes oriented almost perpendicular to the direction of the satellite motion, and thus make sharp breaks of the trail of the satellite.

The photoelectric timing device is consisted of the knives and two photomultiplier tubes. A knife, 0·2 mm in width, has two optically flat surfaces, the intersection of which makes the knife-edge. The image of the satellite projected on the surface of one side is reflected and the total light comes in one photo-tube. Then, according to the movement of the satellite, the image moves to the other side, and the light comes in the other phototube. The effective sensitivity of the two tubes is made equal, and the difference of the outputs of them is amplified. Then the instant of the change of the current direction corresponds to the transit time of the satellite over the knife-edge. An oscillograph (visigraph) is used for recording the output current (**27**).

Thus, the time and the corresponding position of the satellite referred to the background stars are obtained.

Milano-Merate Observatory, Italy

Dr J. H. Focas, Secretary of Commission 16, reported:

Etude et Construction d'un nouveau type de miroir métallique pour l'Observatoire de Merate (Milan, Italie) d'un diamètre de 75 centimètres, ouvert à 1 : 3. Travail de construction d'un autre miroir du même type, d'un diamètre de 137 centimètres, ouvert à 1 : 4·5 pour le même observatoire. Construction d'une monture équatoriale d'un type nouveau pour ce miroir.

Astrophysical Institute of the Liège University, Belgium

Dr M. Migeotte reported:

A 76 cm telescope has been installed in 1966 at the Sphinx Observatory, a close dependance of the Jungfraujoch International Scientific Station, situated at an altitude of 3580 m in the Swiss Alps.

This instrument has been built by Grubb-Parsons, Newcastle-upon-Tyne (England), to be used at the Cassegrain and coudé focus, the relative apertures being respectively $f/15$ and $f/40$.

Acquired through Belgian and Swiss funds, the installation of this new instrument is the result of a fruitful collaboration between the Institut d'Astrophysique of the University of Liège (Belgium) and the Observatory of Geneva (Switzerland).

Boyden Observatory (internationally sponsored), Bloemfontein in South Africa

Dr J. Dommanget (Observatoire Royal de Belgique) reported:

The 32/36-inch (81/91 cm), *f*/3·75 telescope (system Baker-Schmidt) jointly established by the Armagh, Dunsink and Harvard Observatories (ADH telescope). The telescope has been installed with an objective prism and tested (**28, 29**) for a wide angle and flat field.

Recent programmes include surveys of star clusters and Hα emission lines objects in the Magellanic Clouds, searches for faint variables in the wing of the Small Magellanic Cloud, photographic photometry of galactic clusters, studies for the spectral classification of stars, etc. The limiting magnitude, for Kodak 103a–O (blue) plates, is 20 m for an exposure of 30 minutes. Magnitude correction for distance from the centre of the field of 2·3 degrees is only + 0·34 (the edge of a circular plate of 10·5-inch diameter). With the special aperture shopper the vignetting is reducing these errors to zero. The plates 16 × 16 cm are used (field 2·9 × 2·9 degrees); the field error at full aperture is only 0·1 magnitude (at the edge of a plate). A. D. Andrews (Armagh Obs.) and J. Dommanget give (**29**) critical and practical remarks on the possible and existing methods of optical alignment and adjustment of the telescope in general and the interesting ADH telescope in particular.

Dominion Astrophysical Observatory, Victoria

Professor Dr K. O. Wright reported:

1. At the 72-inch (183 cm) telescope a new all-mirror Cassegrain spectrograph is being tested which will replace the two prism arrangement.

2. At the 48-inch (122 cm) coudé spectrograph a large mosaic four-grating composite is being prepared which will have a 17-inch (43 cm) collimator which will greatly increase the efficiency of that spectrograph.

3. The most interesting development may be a 'Superpositioning Image Slicer' which is being prepared by Dr E. H. Richardson, who describes it as follows:

'Rather than stacking slices of the stellar image along the length of the slit, this device produces elongated slices and superimposes them on the slit. This eliminates between-slice interruptions in the illumination of the slit, making it practical to use the device without the necessity of placing a cylindrical lens near the focus of the spectrograph camera.

4. 'A multiple-reflection mirror system, fabricated from four identical mirrors, is used to perform the slicing operation. Thus, it is not necessary to aid one or more optical elements to produce each additional slide.

5. 'The device is being tested at the coudé spectrograph of the 48-inch telescope with the *f*/5 spectrograph camera. For stellar spectrograms 0·4 mm in width (i.e. spectral line length) the gain in speed is equivalent to that which would be achieved by replacing the grating with one having from four to nine times the ruled area: that is, exposure times are reduced by a factor of two or three.'

6. Additionally, Dr G. I. Odgers reported: 'In September 1964 Dr R. M. Petrie and I began design studies for a 150-inch new Queen Elizabeth II reflecting telescope. Last April 1966 this has become G. I. Odgers responsibility (the well known astronomer Dr R. M. Petrie, the famous specialist in different sections of astrophysics and astronomical instruments, passed away on 8 April 1966) in consultation with Professor I. S. Bowen and Mr. Rule who have provided very useful advice. The design study is given in form of a report by Dr G. I. Odgers (the report covers the design studies for the period up to 30 January 1966). The primary quartz fused silica mirror *f*/2.8 (due to arrive from Corning Glass Co.) has been built into a stubby stiff structure which will permit good observing at both the prime focus and Cassegrain. The optical system of the telescope for the prime focus is a Ritchey-Chrétien. The parameters

of the optical path are the following: prime focus $f/2{\cdot}8$, Cassegrain $f/8$ and $f/15$, coudé $f/30$. An horizontal coudé room of 60 ft between slit and collimation will contain a five mirror system. The automation and safety systems have been incorporated; all the preliminary engineering studies for this telescope has been finished. However the final design will be only in April 1967.

A design team composed of three men from Dilworth, Second, Meager and Associates Ltd., Toronto, one from A. B. Sanderson and Company Ltd., B.C., and the astronomers of the Dominion Astrophysical Observatory, was established in Victoria, British Columbia, at the end of January 1966. The telescope will be located at Mt Kobou (latitude 49°51, altitude 1905 m).'

National Aeronautics and Space Administration, Washington, U.S.A.

N. G. Roman reported:

1. The Manned Spacecraft Center is setting up solar and fixed frequency radio telescopes at the Apollo tracking and communication sites to provide 24-hour monitoring of solar activity. The data will be transmitted to the Apollo control centre to provide warning of solar proton events.

2. Goddard Space Flight Center. GSFC has ordered a standard 36-inch (91 cm) telescope from Boller and Chivens. Modification for radio astronomy of the 85-ft (26 m) antenna at the Rosman Data Acquisition facility has been completed. A programme of lunar occultation observations has been initiated.

3. Jet Propulsion Laboratory. JPL has ordered a 24-inch (61 cm) reflector with both Cassegrain and coudé foci for Table Mountain Observatory. Improvements in the dome and optics of the 16-inch (41 cm) telescope are underway. A millimeter radio astronomy antenna, 18 ft (5·4 m) in diameter and capable of operating at 4 mm is also being added; one of the radiometers to be used with the facility is an 8 mm, 300°K parametric amplifier. Observations of the Moon and nearer planets are planned.

4. Other work supported by NASA:

P. Baumeister (University of Rochester) has produced, essentially at will, narrow-band multilayer ultraviolet filters suitable for flight experiments to meet particular design specifications.

E. Eberhardt (ITT, Ft Wayne) is investigating the pulse counting capabilities of their tubes to answer such questions as: 'What is the source of dark pulses?' 'What role does ageing play?' 'Is a based tube superior to an unbased tube?'

5. Ames Research Center. G. Augason has constructed a Michelson-type infrared interferometer operated in liquid helium for wavelength between 10 and 40μ. Performance tests are being conducted. G. Augason and F. West have designed and are now having constructed a filter photometer for the near infrared. A. Margossi and F. West have conducted a series of tests on the performance of an infrared interferometer (Michelson-type) spectrometer capable of 5 cm resolution in the region out about 3μ.

Development of Astronomical Optics and Instruments in France

1. Dr F. Roddier (he is working mostly on solar physics) has quite recently developed (30) a new kind of spectrograph using atomic beam techniques. The profiles of the Fraunhofer solar line can be obtained by measuring the intensity of the fluorescence of an atomic beam excited by the light to be analysed. The source frequency is shifted by the Zeeman effect. The experiment uses calcium (4226·7 Å), strontium (4607·3 Å) and barium (5535·5 Å) atomic beams, in order to observe the solar spectrum in the neighbourhood of these wavelengths. The resolving

power is about 10^7. Using the resonance in zero field as a reference point, the absolute value of the shift of the solar line can be obtained; this method was used in 1953 by J. E. Blamont (**31**) for the measurement of the atmospheric Na lines. For the solar lines the method was used (Sr I 4607·3 Å) by J. E. Blamont and F. Roddier (**32, 33**). The result is: there is real limb-effect (in general accordance with M. G. Adam's interferometric and other results), there is a clear increase of the microturbulent velocities with height in the solar atmosphere, etc.

2. The same authors have made also some experimental studies on photomultipliers (**34**) for example the statistical study of the impulse in photomultipliers (experimental and mathematical distribution of the impulse).

3. Report by G. Courtès, C. Fehrenbach, E. Hughes and J. Romand (the total report is published in (**35**)). The authors give list of literature and non-exhaustive review of development and progress in certain fields of optics, concerning itself mainly with the conception and realization of instruments. The previous review (and also literature) of optical work in France was also published.

(*a*) *Réalisations optiques.*

(*i*) La Société Angénieux vient d'ajouter à la gamme des nombreuses focales variables qu'elle produit, deux objectifs de caractéristiques remarquables par l'extension importante du rapport des focales extrêmes ('range') qui atteint maintenant la valeur 20 (pour l'Orticon, dont la focale varie de 35 à 350 mm, le champ est exceptionnel avec 64° d'ouverture, $f/3{\cdot}8$, etc.). Les photographies de la Lune par Ranger ont été prises avec des objectifs Angénieux 25 mm/0·95. Les satellites Tiros et Nimbus sont équipés d'objectifs Kinoptik (TGA) $f = 5{\cdot}7/1{\cdot}8$ et l'une des caméras utilisées pour filmer la rencontre spatiale des capsules Gemini était équipée d'un objectif Kinoptik $f = 18/1{\cdot}8$.

(*ii*) La Société Kinoptik, spécialisée dans la réalisation d'objectifs pour le cinéma et la télévision, vient d'ajouter à sa gamme les objectifs suivants: Apochromat 9 mm, $f/1{\cdot}5$, champ total 80°; Tegea 9·8 mm, $f/1{\cdot}8$; Lynxar 60 mm, $f/0{\cdot}7$, etc.

(*iii*) Parmi les récentes réalisations de la Société Sopelem, nous citerons des objectifs à focale variable pour le cinéma et la télévision.

(*b*) *Instruments optiques.*

(*i*) L'Observatoire de Haute-Provence du CNRS a mis en service en 1958 un télescope de 1·93 m ($f/5$) de diamètre (Cassegrain $f/15$; coudé $f/20$) dont les miroirs ont été taillés au Laboratoire d'Optique de l'Observatoire de Paris (**37**). Un grand spectrographe coudé est disposé dans un grand laboratoire annexe (**38**). Le spectrographe est équipé de deux réseaux de Bausch and Lomb, comprenant l'un 774, l'autre 1200 traits au millimètre. La hauteur des traits est de 150 mm. Le changement de réseau et le passage de l'une à l'autre des diverses chambres se font automatiquement et ne demandent que quelques secondes. Les dispersions de 83 Å/mm à 3 Å/mm peuvent être réalisées. Tout le domaine spectral de 3100 Å à 17 000 Å est couvert par les diverses combinations. Ce télescope comporte de nombreux appareils auxiliaires (caméra électronique de Lallemand, etc.). Un instrument analogue est en voie de réalisation pour l'Observatoire Européen Austral (ESO). Il sera installé au Chili au cours de l'année 1967.

(*ii*) Parmi les autres instruments installés à l'Observatoire de Haute-Provence et en d'autres observatoires, signalons un prisme-objectif à champ normal de Fehrenbach de 40 cm de diamètre pour la mesure des vitesses radiales stellaires (**39**). Un instrument identique a été installé en Afrique du Sud, dans le cadre de l'Observatoire Européen Austral. Un télescope de Schmidt de 60 cm de lame (optique de l'Observatoire de Paris) est installé à l'Observatoire de Haute-Provence par l'Institut d'Astrophysique de Liège. Un autre télescope de Schmidt de même diamètre a été installé à Paris-Meudon. Un télescope de 1·07 m a été installé à l'Observatoire du Pic du Midi. Il est surtout destiné à des études du système solaire. Les deux grandes lunettes des Observatoires de Paris-Meudon et de Nice ont été remises en état et la première est de nouveau en service régulier; la seconde le sera bientôt.

Une grande tour solaire, comprenant un coelostat à deux miroirs de 80 cm et 70 cm de diamètre, est installée à Paris-Meudon. Elle comprend un télescope bouché de 69 cm de diamètre et de 45 m de distance focale qui permettra la photographie et l'étude directe des images solaires. Un grand spectrographe avec un collimateur de 14 m de distance focale comprenant des réseaux de 15 cm × 30 cm, permettra la spectrographie solaire.

(*iii*) Les opticiens et les astronomes francais ont été engagés avec leurs collègues européens dans la réalisation de grands systèmes optiques.

Dans une étude faite à Marseille par A. Baranne du système Ritchey-Chrétien (**40, 41**), cet auteur a pu montrer que cette combinaison n'est pas plus sensible aux flexions qu'un système parabolique classique de même rapport d'ouverture. On a calculé l'optique du télescope Ritchey-Chrétien ouvert à *f*/3, de 3·50 m de diamètre (*f*/3 primaire, *f*/8 Cassegrain), destiné à l'Observatoire Européen du Chili. M. Baranne a calculé pour le foyer direct un système de correction à trois verres dont un seul légèrement asphérisé. Il donne un champ de 1° de diamètre, avec des images de 0″5. Ce système correcteur a 25 cm de diamètre, et n'est situé qu'à 33 cm du foyer primaire.

(*iv*) D'un autre côté, A. Baranne, après avoir réalisé un spectrographe intéressant à très haute dispersion (**42**), a indiqué récemment un montage des spectrographes astronomiques à pupille conjuguée. Dans ce montage, un miroir auxiliaire sphérique reforme une image non dispersée du collimateur sur l'objectif de chambre. Ceci permet de donner à cet objectif une ouverture qui correspond à l'ouverture efficace. Le réseau est monté en Littrow, ce qui permet d'employer les réseaux échelles, et d'utiliser de très hautes dispersions angulaires.

(*c*) *Optique complémentaire des instruments astronomiques au sol et dans l'espace*:

(*i*) Réducteur focal (**43**) du téléscope de 193 cm.

(*ii*) Système interférentiel à systèmes d'anneaux multiples (études extragalactiques en lumière monochromatique).

(*iii*) Filtre à bandes multiples.

(*iv*) Caméras à grand champ (catadioptrique, 66° × 120°) pour les observations astronomiques spatiales).

(*v*) Utilisation spectrographique du réducteur focal.

(*vi*) Spectromètre interférentiel pour l'étude des nébuleuses.

(*d*) Divers travaux ont été effectués dans le domaine de l'appareillage et des méthodes, et publiés pour la plupart dans les *Publications de l'Observatoire de Haute-Provence*.

VEB Carl Zeiss

This firm finished many new interesting instruments, in particular 800/1900/2400 mm Schmidt telescope field 5°15 × 5°15 (24 × 24 cm) with 4° objective prism for the Observatory of the Latvian Academy of Sciences, S.S.R., near Riga.

O. A. MELNIKOV
President of the Commission

BIBLIOGRAPHY

1. Vany, A. S. de 1966, *Appl. Opt.*, **5**, 867.
2. King, J. R. 1966, *Publ. astr. Soc. Pacif.*, **78**, 35.
3. Cox, R. E. 1966, *Rev. pop. Astr.*, **60**, 4.
4. Bowen, I. S. 1964, *Astr. J.*, **69**, 816.

5. Marchant, I. C., Millikan, A. G. 1965, *J. opt. Soc. Am.*, **55,** 907.
6. Report of Meeting on 'Photographic Plate Testing', Mt Wilson and Palomar Obs., 17–18 January 1966.
7. Sandage, A., Miller, W. C. 1966, *Astrophys. J.*, **144,** 1238.
8. Miller, W. C. 1966, *Publ. astr. Soc. Pacif.*, **78,** 128.
9. Stroke, G. W. 1965, *Astr. J.*, **70,** 693.
10. 1965, *New Technics in Astronomy*, Moscow. Ed. N. N. Michelson.
11. Öhman, Y. 1964, *Atti del Convegno sui campi magnetici solari*, Roma, in press.
12. Nilsson, S. E. 1966, *Stockholm Obs. Medd.*, no. 153.
13. Fredga, K. 1966, *Astrophys. J.*, **144,** 854.
14. Rydgren, B. 1966, *Stockholm Obs. Medd.*, no. 154.
15. Öhman, Y., Rydgren, B. 1963, *Stockholm Obs. Medd.*, no. 142.
16. Kusoffsky, U. 1966, *Stockholm Obs. Medd.*, no. 156.
17. Öhman, Y. 1965, *Stockholm Obs. Medd.*, nos. 146, 150, 151.
18. Öhman, Y., Kusoffsky, U. 1966, *Stockholm Obs. Medd.*, no. 157 = *Revue d'Optique*, **2,** 49.
19. Lodén, L. O. 1964, *Stockholm Obs. Ann.*, **22,** 7.
20. Wallenquist, A. 1965, *Sky Telesc.*, **29,** 136.
21. Lallemand, A. *et al.* 1966, *C. r. Acad. Sci. Paris*, **262,** 838.
22. Crawford, D. L. 1965, *Sky Telesc.*, **29,** 268.
23. Sugawa, Ch., Hurukawa, K., Okawa, H. 1966, On the Automatic Measuring Machine for the Photographic Plates of the Floating Zenith Telescope at Mizusawa. *Proc. Int. Latit. Obs. Mizusawa*, no. 6, 117 (in Japanese).
24. Sugawa, Ch., Hurukawa, K. 1966, Data Processing System for the Time Recording in the Astrolabe Observations. *Ibid.*, no. 6, 76 (in Japanese).
25. Ono, F. A new timing device of satellite tracking camera for geodetic purpose, *Rep. hydrogr. Res.*, no. 1, 63.
26. Ono, F. A simple device to determine personal equation, *Ibid.*, no. 2 (in press).
27. Tsubokawa, I. 1965, A precise satellite tracking camera with a photoelectric timing device, *Space Res.*, **5,** 916.
28. Lindsay, E. M. 1953, *Irish astr. J.*, **2,** 140 = *Armagh Obs. Leaflet*, no. 17.
29. Andrews, A. D., Dommanget, J. 1965, *Irish Astr. J.*, **7,** 73.
30. Roddier, F. 1965, *Ann. Astrophys.*, **28,** 463.
31. Blamont, J. E. 1953, *C. r. Acad. Sci. Paris*, **237,** 1320.
32. Blamont, J. E., Roddier, F. 1961, *Phys. Rev. Letters*, **7,** 437.
33. Blamont, J. E., Roddier, F. 1964, *C. r. Acad. Sci. Paris*, **258,** 449.
34. Roddier, F., Roussin, A. 1964, *C. r. Acad. Sci. Paris*, **259,** 4593.
35. Courtès, G., Fehrenbach, C., Hughes, E., Romand, J. 1966, *Appl. Opt.*, **5,** 1349.
36. Vany, A. S. de 1963, *Appl. Opt.*, **2,** 200.
37. Couder, A. 1960, *Ann. Astrophys.*, **23,** 311 = *Publ. Obs. Hte-Provence*, **5,** no. 21.
38. Fehrenbach, C. 1959, *Publ. Obs. Hte-Provence*, **5,** no. 1.
39. Fehrenbach, C., Rebeirot, E. 1963, *Publ. Obs. Hte-Provence*, **5,** no. 43.
40. Baranne, A. 1963, *C. r. Acad. Sci. Paris*, **257,** 3825 = *Publ. Obs. Hte-Provence*, **7,** no. 1.
41. Baranne, A. 1965, Thèse, Université de Marseille.
42. Baranne, A. 1965, *C. r. Acad. Sci. Paris*, **260,** 3283 = *Publ. Obs. Hte-Provence*, **7,** no. 43.
43. Courtès, G. 1960, *Ann. Astrophys.*, **23,** 115.

REPORTS FROM OBSERVATORIES OF THE U.S.S.R.

(prepared by N. N. Michelson)

I. Instruments

1. *Pulkovo Observatory of the U.S.S.R. Academy of Sciences*

(*a*) The new large stellar interferometer (with a base of 6 m) is in general completed. It is to be used for double star work.

(*b*) The second horizontal solar telescope with a diffraction spectrograph (diameter of mirror: 0·44 m) is completed in general.

(*c*) At the expedition in Chile the vertical circle (system of M. S. Zverev) is in operation and the 0·7 m double meniscus astrometric astrograph (system of D. D. Maksutov) is being mounted.

(*d*) The 0·45 m double channel television telescope is completed. It has an aperture of *f*/1·34 and also aperture from *f*/20 to *f*/270. The instrument is used for observations of the Moon and the study of seeing.

(*e*) At the Pulkovo Station near Kislovodsk, the 0·23 m astrometrical astrograph with *f*/10 is completed and will be used for observations of the Moon and planets.

(*f*) The astrolabe (system of A. Danjon) is completed.

(*g*) The 0·2 m refractor, with *f*/15, is completed.

2. *Crimean Astrophysical Observatory of the U.S.S.R. Academy of Sciences.*

The system of the Nasmith and coudé foci for spectroscopic observations with the 2·6 m reflector (memorial of J. A. Shayn) have been assembled.

3. *Sternberg Astronomical Institute of the Moscow University.*

(*a*) At the Southern Station in the Crimea, the 1·25 m reflector with numerous special apparatus (photometric, photographic and spectroscopic) was mounted in 1960 and is used for observations with apertures *f*/4 and *f*/17. In the Cassegrainian focus, there is a shortening system with *f*/2. Contact image tubes, spectrographs, etc. are widely used for different purposes.

(*b*) The 0·3 m Zeiss refractor was mounted in Moscow.

4. *Tartu Observatory.*

The new Tartu Observatory (memorial of W. Struve) of the Estonian Academy of Sciences was inaugurated in 1964. The main building, mechanical shop, two observing pavilions and several smaller ones are completed.

The following instruments have been mounted or are being mounted:

(*a*) the 0·7 m reflector with *f*/4, *f*/16 and *f*/40 (completed);

(*b*) three 0·48 m reflectors with *f*/4·5 and *f*/16, one of which is mounted in Tallin, are used for photoelectric observations with distance control;

(*c*) the 0·35 m reflector with *f*/21 (completed);

(*d*) the 0·2 m reflector with *f*/15 (completed);

(*e*) the 1·5 m reflector is being designed;

(*f*) an experimental plastic dome has been constructed (**4, 5, 6, 7**).

5. *The Astrophysical Institute of the Kazakhstan Academy of Sciences.*

The following instruments have been completed and mounted:

(*a*) the 0·8 m reflector;

(*b*) the 0·17 m Schmidt camera with *f*/1;

(*c*) the 0·34 m reflector with *f*/5·5 and *f*/3·4 with an optical magnifier (camera) for observations of planets. The instrument is mounted on the mounting of the 0·2 m reflector.

6. *Odessa Astronomical Observatory.*

(*a*) the 0·425 m reflector with the P. P. Argunov correcting system (*f*/10) is completed (**8**);

(*b*) the 0·5 m reflecting telescope (*f*/7) with an electrophotometer is completed;

(*c*) one sky patrol for observations of bolides and three for observations of meteors have been mounted.

7. *The Main Astronomical Observatory of the Ukrainian Academy of Sciences* (Goloseyevo near Kiev).

The following instruments have been mounted:

(*a*) the horizontal solar telescope with a 0·44 m mirror;

(*b*) the horizontal lunar telescope (*f*/60).

8. *The Abastumani Astrophysical Observatory of the Georgian Academy of Sciences.*

The following instruments have been mounted:

(*a*) the horizontal solar telescope with a 0·44 m mirror;

(*b*) the 0·12 m non-eclipse coronograph (design of I. A. Prokofyeva).

9. *Astronomical Station at Haute Sayannes.*

The 0·2 m coronograph (system of B. Lyot) has been mounted.

10. *The Astrophysical Laboratory of the Latvian Academy of Sciences.*

(*a*) The 0·55 m reflector (*f*/13·5) has been mounted;

(*b*) The large Schmidt telescope 0·8/1·2 m is being completed by the firm VEB, Carl Zeiss, Jena.

11. *Southern Station of the Leningrad University at Burakhan.*

The 0·48 m and 0·50 m reflecting telescopes with photoelectric photometers and other apparatus have been mounted (**9**).

12. *Astrophysical Observatory of the Azerbaijan Academy of Sciences at Shemaha* (*near Baku*).

The 2 m reflecting telescope made by the firm VEB, Carl Zeiss, Jena, has been mounted. The instrument is to be used together with spectroscopic, photoelectric, photographic and other apparatus for observations of nonstable stars, galaxies, old novae, variable stars, quasars (QSS, QSG, QSO) and other peculiar and normal objects.

13. *Astronomical Observatory of the Tadjikistan Academy of Sciences at Dushanbe.*

The 0·4 m astrograph (*f*/5) made by the firm Carl Zeiss, Jena, with a field of 8°.5 × 8°.5 has been mounted.

14. The series of *solar horizontal telescopes* with a 0·44 m mirror (partly quoted above) have been mounted at Pulkovo, Sverdlovsk, Shemaha, the Far East, Sayannes, Alma-Ata and Abastumani.

15. The series of 0·48 m *reflecting telescopes* (partly quoted above) have been mounted at the observatories in Lvov, Shemaha, Tartu, Kiev and the Southern Stations of the Leningrad and Moscow Universities.

16. The small series of 0·7 m *reflecting telescopes* (partly quoted above) are being used very successfully at the Simeis (Crimea), Dushanbe, Tartu and Kharkov (not mounted as yet) Observatories.

17. The 0·35 m *meniscus camera* have been mounted at the Engelhardt (Kazan) and Shemaha Observatories.

II. Scientific Work

1. *Pulkovo Observatory.*

(*a*) Numerical calculations of the 2·6 m (*f*/3·67) wide angle (2°.6) telescope with a hyperbolic prime mirror have been completed and a scheme for testing the latter elaborated (**10, 11**). A three-component afocal corrector is used in the convergent beam.

(*b*) Numerical calculations of the 0·3 m objective with an aperture of *f*/2 for the scheme of the 'concentric meniscus Cassegrain' with a 6° field have been completed. The aberration of the field is less than 3·5 microns at an asphericity of only 5 microns (**12**).

(*c*) The deformations of the large mirrors of telescopes are being investigated theoretically (by methods of the theory of elasticity, in particular by the photoelastic method) and experimentally (by the method of a dynamic scale model of epoxides resine and also by the stereometric method – igdontin) (**13–18**).

(*d*) The model of an automatic coordinate measuring machine with photoelectric setting on the star image and two-step reading of the coordinates has been constructed on the basis of a universal standard microscope (**19**).

(*e*) The coarse diffraction grating for the 0·65 m telescope to be used for diminishing the light of bright stars has been completed in the form of a rotating magnitude screen or 'jalousie' (**20**).

(*f*) An apparatus for measurements of the negatives of circle readings of the photographic vertical circle at the expedition in Chile has been constructed.

2. *The Crimea Astrophysical Observatory.*

(*a*) A method for air operated unloading of prime mirrors of telescopes has been developed (G. A. Monin).

(*b*) A series of various high-speed meniscus systems has been developed and computed numerically: an 80 mm system with *f*/0·6 for a camera spectrograph with a field of 36° and resolving power of 30 microns (for the 1·22 m reflecting telescope), a 100 mm system with *f*/5 and a field of 20°, a 100 mm system with *f*/0·4, etc. (**21**).

3. *Image converters, image intensifiers and other tubes* have had very significant and wide application at the Sternberg Astronomical Institute, the Crimea, Pulkovo and other Observatories (**27**).

4. At the *Tartu Observatory* great attention was devoted to the automatization of the observational process and the data processing of observations.

(*a*) Universal standard drive mechanisms have been assembled for small telescopes with motors for setting correction and the possibility of application of a photo-guiding system (**23**).

(*b*) An electrophotometer with a digit-printing system and a d.c. amplifier has been constructed for the 0·48 m reflector. It is possible to record the data by means of a self-recording (on paper) electric potentiometer or a digit printing accessory (**24**).

5. At the *Engelhardt Observatory* an iris photometer has been constructed on the basis of the MΦ–2 standard-type microphotometer (**25, 26**).

6. At the *Astrophysical Observatory near Alma-Ata* the system of Cassegrain has been introduced for the 0·5 m meniscus telescope, providing for *f*/6 and 10° field (**27**).

7. *Siberian Institute of Terrestrial Magnetism, Ionosphere and Propagation of Radio Wave.*

(*a*) A solar magnetograph has been constructed for recording the three vector components of the magnetic field strength (or intensity) and also radial velocities (**28**).

(*b*) An automatic scanner has been assembled for the horizontal solar telescope, and provides for the scanning of the solar disk on the slit of the spectrograph.

III. Additional Reports

1. *Crimean Astrophysical Observatory, U.S.S.R Academy of Sciences* (compiled by I. M. Kopylov):

A stellar spectrograph with an échelle grating was completed and mounted at the coudé focus of the 2·6 m reflector (memorial of G. A. Shajn) in 1963. The échelle operates in the 74–37 orders ($\lambda\,\lambda$ 3450–7000 Å). The camera provides reciprocal dispersions of 1, 1–2, 2 Å/mm and resolution of 0·66 Å. The pre-dispersion is obtained by a 22°5 light crown prism (**30**). The large coudé spectrograph for the 2·6 m reflector was put into operation in the summer of 1966. The diffraction grating (with a 320 × 280 mm surface and 600 lines per mm) is used in the second and third orders. Three Schmidt cameras of focal length 27 (69 cm), 52 (132 cm), and 131 (333 cm) inches are now being used. Reciprocal dispersion are respectively 12–8, 7·5–5 and 2·4–1·6 Å/mm.

2. *Institute of Terrestrial Magnetism, Ionosphere and Propagation of Radio-Wave* (*near Moscow*), U.S.S.R. Academy of Sciences (compiled by Professor N. P. Benkova):

The tower solar telescope 0·38/17/27 m is now in operation. The focal length of the collimator – camera (I) – camera (II) is 10 m, the diffractional grating 15 × 15 cm, 600 lines per mm (**31**). There is a photoelectric magnetograph: (*a*) One measures the total vector of photospheric magnetic field (all the Stokes parameters are measured simultaneously) (**32**) and the transversal component only (**33**). The radial velocity and the intensity of the selected point of the line profile is measured simultaneously. (*b*) Measurements of photospheric and chromospheric magnetic field are achieved simultaneously by two independent magnetographs (**34**) and two selected lines. During the years 1963–65, the series of observations of the magnetic field were obtained with the complex magnetograph for the collection of original observational data and the solution of several methodological problems (**35**). The design and construction of B. Lyot coronagraph with a stationary spectrograph is completed. The single-lens object glass has a diameter of 0·53 m and 8 m focal length and reciprocal dispersion of 1 Å/mm (**35**). An identical instrument has been completed for the Pulkovo Observatory and will be soon completed for several other observatories.

IV. General Remarks

1. The work of U.S.S.R. astronomers, during the three-year period since the last report of the IAU, in the fields of construction, engineering, assembling, mounting, etc. of telescopes was successful.

2. We regret that, during the period elapsed, two well-known astronomers working in the field covered by our Commission passed away: D. D. Maksutov (12 August 1964) – the famous specialist in astronomical optics, and N. I. Kutcherov (17 October 1964) – a specialist in the comparatively new and now very important problem of site testing and astroclimate.

BIBLIOGRAPHY

1. Boyarchuk, A. A., Esipov, V. F., Moroz, I. V. 1966, *Astr. Zu.*, **43**, 421.
2. Dibai, E. A., Esipov, V. F. 1965, *Astr. Zu.*, **42**, 281.
3. Dibai, E. A. 1966, *Astr. Zu.*, **43**, 52.
4. Vilman, Ch., Zhelnin, G., Einasto, R., Ergenson, R. 1964, Tartu Astronomical Observatory, Tallin.
5. Eelsaln, H. T., Kutusov, S. A. 1965, *Vestnik Akad. Nauk SSSR*, no. 9, 35, 68.
6. Einasto, J., Steinbach, M. 1965, *Sterne*, **41**, no. 7–8.
7. Kubar, T. E. 1965, *New Technics in Astronomy*, Moscow, no. 2, 61.
8. Argunov, P. P. 1965, *New Technics in Astronomy*, Moscow, no. 2, 8.
9. Dombrowsky, V. A., Gagen-Torn, V. A., Gutkevich, S. M., Polakova, T. A., Svechnikov, M. A., Shulov, O. S. 1965, *Uchen. Zap. Leningrad Univ.*, no. 328, 83.
10. Belorosova, T. S., Maksutov, D. D., Mermann, N. V., Sosnina, M. A. 1964, *Izv. glav. astr. Obs. Pulkove*, no. 175.
11. Sosina, M. A. 1966, *Izv. glav. astr. Obs. Pulkove*, no. 184.
12. Merman, N. V., Sosnina, M. A. 1965, *Izv. glav. astr. Obs. Pulkove*, no. 178.

13. Grosswald, E. G., Tavastsherna, K. S. 1964, *Izv. glav. astr. Obs. Pulkove*, no. 177.
14. Grosswald, E. G., Tavastsherna, K. S. 1964, *Izv. glav. astr. Obs. Pulkove*, no. 180.
15. Grosswald, E. G. 1965, *New Technics in Astronomy*, Moscow, no. 2, 31.
16. Chernina, V. S. 1964, *Izv. glav. astr. Obs. Pulkove*, no. 177.
17. Fridman, V. M. 1964, *Izv. glav. astr. Obs. Pulkove*, no. 177.
18. Budnikova, T. V., Fridman, V. M. 1964, *Izv. glav. astr. Obs. Pulkove*, no. 177.
19. Zaciorsky, L. M., Nicolaeva, L. V., Bubnov, G. A. Patent no. 420508.
20. Kanaev, I. I. 1964, *Izv. glav. astr. Obs. Pulkove*, no. 174.
21. Popov, G. M. 1965, *New Technics in Astronomy*, Moscow, no. 2, 5.
22. Scheglov, P. V. 1965, *New Technics in Astronomy*, Moscow, no. 2, 42.
23. Veisman, U. K., Kubar, T. E. 1965, *New Technics in Astronomy*, Moscow, no. 2, 48.
24. Veisman, U. K. 1965, *New Technics in Astronomy*, Moscow, no. 2, 40.
25. Urasin, U. N. 1965, *New Technics in Astronomy*, Moscow, no. 2, 48.
26. Urasin, U. N. 1964, *Bjull. astr. Obs. V. P. Engel'gardta*, no. 38.
27. Rozhkowsky, D. A., Gluschkov, U. N., Kurchakov, A. V. 1963, *Izv. Akad. Nauk KazSSR*, Ser. Fiz.-Matem., **16**, 52.
28. Stepanov, E. V., Knulin, G. V., Kuznecov, D. A. 1965, *Solar Activity*, Moscow, no. 2.
29. Alexandrovich, D. A., Kuznetcov, D. A., Maksutov, D. D. 1965, *Solar Activity*, Moscow, no. 2.
30. Kopylov, I. M., Steschenko, N. V. 1965, *Izv. Krym. astr. Obs.*, **33**, 208.
31. Mogilevsky, E. I., Zhulin, I. A., Yoshpa, B. A. 1965, *Solar Activity* (sbornik), no. 2, ed. by 'Science', Moscow; B. A. Yoshpa, I. A. Zhulin, E. I. Mogilevsky, Proc. Symp. Solar magn. fields, Rome, Sept. 1964.
32. Yoshpa, B. A., Obridko, V. N. *Astr. Zu.*, **41**, no. 6, 1964; *Solar Activity* (sbornik), no. 2, 1965, ed. by 'Science', Moscow; Proc. Symp. Solar magn. field, Rome, Sept. 1964.
33. Yoshpa, B. A., Mogilevsky, E. I. 1965, *Solar Activity* (sbornik), no. 2, ed. by 'Science', Moscow.
34. Zhulin, I. A., Mogilevsky, E. I. 1965, *Solar Activity* (sbornik), no. 2, ed. by 'Science', Moscow.
35. Yoshpa, B. A., Obridko, V. N. *Solar Data*, no. 5, 1965; Obridko, V. N., Shilova, N. S., *Solar Activity*, no. 3, 1966 (in press).
36. Nicolsky, G. M., Sasonov, A. A. 1966, *Astr. Zu.*, **43** (in press). Sasonov, A. A., 1966, *Nature*, U.S.S.R. Acad. of Sci., no. 9.

APPENDIX I. WORKING GROUP ON IMAGE TUBES FOR ASTRONOMY

(prepared by J. D. McGee, Chairman)

In the following Draft Report the subject matter is presented under headings indicating the place where the work was done rather than the method used.

This is considered more appropriate in view of the volume of work being done and reported and the inherent difficulty of extracting and summarizing the individual reports to give a balanced account of the work. It is considered better to let the individual authors describe their own work.

Every effort has been made to obtain a report from known workers in this field. If any report has been overlooked, or not sent in in time, it is hoped that it will be submitted at the IAU General Assembly in Prague, in August 1967.

A. Lallemand, Observatoire de Paris, Paris

La photographie électronique permet de réaliser un récepteur d'images plus sensible que la photographie classique. Dans le domaine des grandes longueurs d'onde, le gain peut être considérable et il est possible d'obtenir des images d'intérêt astronomique pour des longueurs d'onde inaccessibles à la photographie classique, par exemple vers 14 000 Å.

Nous avons, au cours de ces dernières années, développé des procédés de fabrication des couches photosensibles destinées à être utilisées dans la caméra électronique et sensibles au proche infrarouge. Elles permettent d'enregistrer des spectres avec plusieurs heures de pose et avec un rapport signal-bruit satisfaisant au-delà de 14 000 Å.

Un autre aspect de la photographie électronique, que nous considérons aujourd'hui comme peut-être le plus important, a été étudié; c'est la possibilité d'obtenir des mesures photométriques de sources extrêmement faibles et ponctuelles (étoiles, quasars, etc.) sans avoir besoin d'utiliser des standards dans la gamme des magnitudes considérées (1).

La caméra électronique permet, en utilisant convenablement la méthode de Schilt dans le cas d'objets de magnitudes élevées, une détermination facile des magnitudes les plus élevées enregistrées par la plaque à électrons. Il suffira de connaître la magnitude de quelques étoiles, les plus brillantes du cliché, pour étalonner le récepteur. D'autre part, la caméra électronique reproduisant l'image des objets qu'on mesure, les erreurs d'identification sont beaucoup plus faciles à éviter que dans le cas des mesures faites avec des photomultiplicateurs, la correction du fond du ciel nocturne est beaucoup plus aisée, sans risque d'introduire une autre étoile dans le champ de l'appareil de mesures. On obtient dans le même temps de pose toutes les étoiles ou objets enregistrés sur le cliché.

Les photocathodes utilisées dans la caméra électronique étant de même nature que celles utilisées dans les photomultiplicateurs, le rattachement aux standards offre le maximum de facilités, en particulier dans le système *UBV*.

M. Duchesne et ses collaborateurs, Observatoire de Paris, Paris

Le gain en sensibilité de la photographie électronique, par rapport à la photographie classique, a été déterminé dans le domaine visible, pour différentes bandes spectrales, par M. Duchesne et A. Cosson. Ils ont montré que les gains maximaux étaient obtenus pour les faibles densités photographiques et que les poses de longues durées favorisaient la photographie électronique. Des gains de l'ordre de 200 ont pu être réalisés vers 5400 Å. Ce travail a été poursuivi dans le domaine infra-rouge, entre 11 000 et 12 000 Å; des gains très importants, de l'ordre de 200 à 400, ont été obtenus par rapport à la plaque 1Z Kodak sensibilisée.

Les photocathodes utilisées dans la caméra électronique sont fabriquées avec un excès de césium; cet excès de césium produit une instabilité des couches photoémissives qui peuvent perdre une partie importante de leur sensibilité pendant le stockage. M. Duchesne (2) a montré qu'une illumination intense permet de restituer la sensibilité initiale. Cette sensibilisation s'explique, en partie, par la sublimation du césium superficiel; il y a équilibre, par l'intermédiaire de la tension superficielle du césium, entre le césium libre présent à la surface de la couche photoémissive et celui qui recouvre la paroi interne de l'ampoule. Dans la caméra électronique, les photocathodes sensibilisées ont un comportement identique à celui des cathodes stables.

M. Duchesne, M. Feissel et B. Guinot (3) ont terminé l'étude systématique de la distorsion en coussinet introduite par l'optique electronique de la camera électronique. Cette étude a montré que les mesures astrométriques pouvaient être faites avec une précision de l'ordre de 1μ, précision nécessaire à la réduction des clichés de Mercure en cours d'exploitation pour la détermination de la constante de l'aberration.

Dans le but de remplacer par des photocathodes planes les photocathodes sphériques actuellement utilisées, C. Hézard (4) a commencé l'étude d'un objectif à immersion électrostatique à symétrie cylindrique. Dans le cas particulier d'un objectif à fentes croisées, il a déterminé expérimentalement la valeur des aberrations de champ.

M. Duchesne et B. Guinot ont poursuivi l'enregistrement de spectres de Mercure à l'aide du télescope de 193 cm de l'Observatoire de Haute-Provence, du spectrographe spécialement conçu pour ce travail et de la caméra électronique. Plusieurs missions seront encore nécessaires pour la détermination de la constante de l'aberration avec la précision excellente que laissent espérer les clichés déjà exploités.

M. Duchesne, en collaboration avec A. Baranne et J. M. Lecontel, a procédé aux réglages nécessaires à l'adaptation de la caméra électronique à un spectrographe à très grande résolution placé au foyer coudé du télescope de 193 cm. Un dispositif spécialement étudié permet de mettre aisément et avec sécurité la caméra électronique en position de travail. En 1966, des recherches portant sur deux programmes ont pu être entreprises:

1. Recherches des composantes interstellaires des raies D_1D_2 du sodium et de la raie Ca II 3933. Les spectres obtenus avec plusieurs étoiles ont permis de tester les possibilités offertes par l'association des deux appareils.

2. Etude de la raie Hβ d'étoiles Be. Ce programme permet de préciser des observations effectuées sur des spectres pris en photographie classique avec les chambres IV et V du spectrographe placé au foyer coudé du télescope de 193 cm. Ces études seront poursuivies et étendues à l'observation de certaines étoiles variables du type β Canis Majoris.

G. Wlérick et ses collaborateurs, Observatoire de Paris, Meudon, France

En liaison avec le Professeur A. Lallemand et son laboratoire, les recherches suivantes ont été entreprises:

(*a*) Continuation à Meudon du programme de photométrie précise avec la caméra électronique (G. Wlérick, M. Combes, L. Vapillon). La source de lumière uniforme qui sert pour déterminer la sensibilité locale de la photocathode a été contrôlée. Son défaut d'uniformité est inférieur à 0·5%. Cette source a été utilisée régulièrement dans les divers programmes de photographie électronique. La précision avec laquelle il faut faire correspondre les passages au microphotomètre pour un cliché astronomique et pour un cliché de lumière uniforme a été déterminée: elle est de l'ordre de 100 microns si on désire une précision supérieure à 1%.

(*b*) Continuation à l'Observatoire du Pic du Midi du programme de photographie électronique des planètes Jupiter et Saturne dans les 3 couleurs *U*, *B*, *V* (G. Wlérick et M. Combes).

L'exploitation des clichés de Jupiter a servi de base à la thèse de 3$^{\text{ème}}$ cycle de Combes sur les propriétés physiques de l'atmosphère de cette planète (5).

(*c*) Adaptation d'une caméra électronique à un spectrographe stellaire ouvert à *f*/2 et destiné au foyer coudé du télescope de 1·93 mètre de l'Observatoire de Haute-Provence (J. P. Picat, F. Gex, G. Wlérick). Une mise au point satisfaisante a été obtenue pour l'ensemble de l'intervalle spectral utilisé (3900–5100 Å). Les premiers spectres ont été obtenus en Octobre 1966.

(*d*) Préparation d'un dispositif permettant de prendre des photographies électroniques au foyer Newton du télescope de 193 cm de l'Observatoire de Haute-Provence (G. Wlérick, F. Gex).

Le but des observations projetées est de mesurer des astres très faibles, de magnitude supérieure à 22. La mise en service est prévue en 1967.

M. Walker, Lick Observatory, California, U.S.A.

Since the last Draft Report, work has continued with the Lallemand electronic camera. This work has comprised both laboratory tests and improvements, together with related optical developments, and observations with the tube at the focus of the coudé spectrograph of the 120-inch (305 cm) reflector.

I. Improvements in Technique

A. The tube has been fitted experimentally with a metal valve, to eliminate the grease in the glass stopcock used previously. That grease remains at room temperature during operation of the tube and probably sets the limit to the vacuum attainable. Preliminary experiments with a modified Veeco valve having a teflon seat indicate that indeed a substantially lower pressure may be achieved in the tube when the valve is used.

B. A new preparation stand has been constructed for the electronic camera, employing absorption pump and large ion pump instead of the usual diffusion pump and cold trap. The new system is virtually oil-free and eliminates the danger of back streaming from the diffusion pump or cold trap. Tests indicate that the pumping speed is somewhat lower than with the regular system, but that the ultimate vacuum obtained is substantially better.

C. Experiments have been made replacing the activated charcoal used by Lallemand *et al.*, as a getter in the tube with zeolite ('molecular sieve'). This material has the advantage of being a dielectric so that small particles falling into the insulating ('triple-seal') section of the tube do not induce electrical discharges as is the case with the charcoal. In addition, there is evidence that the ultimate vacuum obtained with the zeolite getter is substantially better than with the activated charcoal.

D. The preparation procedure has been still further elaborated since the last report to improve the ultimate vacuum and hence cathode life. At present, a preliminary 5-hour bake at 350°C is given upon sealing the new plates and cathode ampoule in the tube. Then, the tube is cooled and tested for electrical discharges under a total voltage of 46 kV (operating potential being 26 kV). Then, before use a second 5-hour bake at 350° is given, followed by liquid air cooling, cathode placement, and the 24-hour ageing process before beginning observations at the telescope. Cathode life with Sb–Cs cathodes (S–11) is now very long. Usually, no change is found at the end of a two-night run, so that in principle the tube could probably be used for one or two weeks if kept constantly refrigerated with liquid air.

II. Instrumentation

A. Image tube. Since the last report, Lallemand has succeeded in preparing S–1 photocathodes for use in the electronic camera. These cathodes are chemically more active than the S–11 and hence harder to preserve in the tube. However, by means of the techniques described in this and the preceding reports, it is possible to preserve them for a maximum of about two days. This is important as tests have shown that the same ageing process used with the S–11 to reduce background is required with the S–1. Several runs have been made at the telescope using these cathodes and the results are outlined below.

B. Optical. As indicated in the last report, the fact that the information gain, at least in the blue region of the spectrum, is only about 15 instead of the much higher values quoted earlier, means that every effort must be made to optimize the efficiency of the optical system ahead of the tube. In general, this means going to a very fast spectrograph camera and this is difficult to do using ordinary Schmidt optics because of the size of existing image tubes. A new type of camera has now been designed by Dr I. Bowen to fill this need. It employs two concentric spherical mirrors and operates as an 'inverse Cassegrain', with the (collimated) beam first striking the smaller convex mirror, then diverging to fill the large concave mirror, and coming to a focus beyond the convex. The advantage of this system is that the focal plane is completely accessible. Also, it is completely achromatic, as no corrector is used. By choosing the ratio of the radii of the two mirrors properly, the 3rd order aberrations are completely eliminated, while by re-introducing some 3rd order aberrations, these may be used to balance off 5th and 7th order terms, so that very good definition may be obtained at a focal ratio of $f/1$. Disadvantages are the small field (not too important for low-dispersion applications) and the fact that the field is curved, concave toward the incoming beam.

Such a camera for a beam diameter of 6½ inches (16·5 cm) and having a speed of $f/1{\cdot}1$, has now been constructed at Lick. Preliminary optical tests were carried so far to the point of obtaining an axial resolution of 20 microns, and it is expected that with final adjustment the resolution will be appreciably closer to the calculated value of 12 microns.

III. Scientific Programme.

A. Using Sb–Cs cathodes. 1. The programme of measurement of line intensities in planetary nebulae mentioned in the last report has been continued in collaboration with Dr. Aller. Following the completion of the first programme in the blue region, a new programme was undertaken covering the wavelength region from 4600 Å to 5900 Å. The first programme served to indicate the possibilities of the tube in spectrophotometric work since a number of the nebulae had independent determinations of line intensities in the blue region. The present programme takes advantage of the large information gain of the tube in the green-yellow region (in the range of 50 to 100 over Kodak 103aD at 5500 Å) to permit us to observe faint lines not otherwise observable in these objects. As before, advantage is taken of the linear relationship between intensity and plate density and calibration was obtained from observations of a very hot star of known energy distribution.

2. High time-resolution spectroscopy of variable stars. Using a single trail technique, it has proved possible to obtain continuous coverage of the spectroscopic variations in a rapid variable during one or two nights. The time resolution obtainable depends upon the brightness of the star and the quality of the seeing. In good seeing, a time resolution of about five minutes is possible for photographic magnitude 12·5, at a dispersion of 48 Å/mm on the photocathode. Using this technique, new observations of the rapidly varying, short-period spectroscopic binary AE Aqr have been obtained which show a wealth of detail. Observations of this type have also been obtained of SS Cyg. McRae + 43°1, T CrB, RW Tri, and UX UMa.

3. *Nuclei of galaxies.* Observations have been obtained of the nuclear regions of a number of galaxies, with interesting results. Here, advantage is taken of the speed-gain of the tube to permit use of the large scale of the coudé to study the spectroscopic details in the nuclei of rather faint galaxies. Comparison with spectra of the same objects taken with the conventional prime-focus spectrograph shows that the increased scale at the coudé does bring out detail otherwise not detectable. The linear response of the tube has been used to derive energy curves for the nuclei of several galaxies, comparing them to a hot star of known energy distribution.

4. *High dispersion spectroscopy.* Some tests have been made with the tube mounted at the focus of the 160-inch (406 cm) camera and a dispersion of 2 Å/mm on the cathode. Observations were made of the K line of several stars in which structure of the interstellar K line was known to exist. The known structure plus some new features were detected, and the application shows promise.

B. Using S–1 cathodes. Several runs have now been made using the tube at the focus of the 20-inch (51 cm) Schmidt and a grating giving a dispersion of 32 Å/mm on the cathode. Observations have been made of Jupiter, Saturn, and Venus, of a number of Mira stars at minimum light and several of the so-called 'dark brown stars' found by Leighton *et al.*, at Mt Wilson. In Jupiter, very good observations were obtained of the methane band at 10 900 Å which should lead to a temperature determination. Venus has been observed out to 13 000 Å which shows well resolved $C^{12}O^{16}_2$ and $C^{13}O_2{}^6$ bands in the region of 12 200 Å. One experiment has also been made of photographing Venus at 10 500 Å at the 160-inch camera with a dispersion of 4 Å/mm. Here, a 3-hour exposure shows the band system of CO_2, with enough dispersion that line widths of individual rotation-vibration levels can be determined, leading to a determination of atmospheric pressure. The speed-gain of the S–1 cathode over Kodak 1Z (ammoniated) was measured to be 100–300 at 9400 Å at Lick, depending upon cathode sensitivity as described elsewhere (**6**).

C. Application of Electronography to Stellar Photometry. Dr Kron and I have used this tube at the 61-inch astrometric reflector of the U.S. Naval Observatory, Flagstaff, to verify Lallemand's result that electronographic plates of star fields can be used for photometry and give a linear relation between star intensity and plate density as measured in a Schilt-type photometer. We find that if the plate (Ilford G5, developed five minutes in D–19) is traced in a microphotometer operated as a densitometer and one integrates the areas under the star-image intensity-profiles, a linear relationship exists between $-5/2 \log$ (area) and magnitude over a range from the plate limit to at least five magnitudes over the plate limit. The importance of this result for stellar photometry is obvious. Using electronography, it is not necessary to have a photoelectric sequence to calibrate photographic photometry, as is usually done. All that is required is to set up in the field a few bright stars by photoelectric transfer. Then, the magnitudes of all fainter stars can be determined directly from the electronographic plates. The speed of the electronographic process means that very faint stars—heretofore accessible only to the largest telescopes—can be reached with moderate sized instruments of long focus, for example a 60-inch (150 cm) Cassegrain. Also, a 'photoelectric sky' is not required except during the setting up of the bright standards, a real advantage to many observers located in less than the best climatic conditions.

Finally, under the best conditions, one may expect by this technique to obtain higher accuracy and to observe to a fainter limit than is possible photographically owing to the finer 'grain' (track size) of the electronographic plates.

C. R. Lynds and W. C. Livingston, Kitt Peak National Observatory, Tucson, U.S.A.

Activity of the past two years have been primarily in the use of the TSE and Cascade type tubes for actual astronomical observation and with a minimum of laboratory experimentation and tube evaluation work.

As reported in London (**7**) Lynds is regularly (three scheduled nights a month) using a TSE tube made by English Electric Valve Co., England, in connection with the 84-inch (213 cm) telescope for the spectroscopic observation of quasi-stellar objects. This programme continues (**8**). A significant improvement in the system was made by Lynds and Villere with the development of an *f*/2 semi-solid fused quartz Schmidt spectrograph camera. Approximately 4½ inches (11·4 cm) in diameter this camera fits into the tube focusing solenoid. Superior imagery, now limited mainly by the transfer lens, plus response to 3200 Å is achieved.

On the very high dispersion spectrograph of the McMath Solar Telescope, guest investigators have used an RCA-Carnegie cascade tube for interstellar and emission line problems (**9**).

In the laboratory Livingston studied the granularity as a function of sample size of photographic materials and available image tube recordings (**10**). The results show that, while modern phosphor output tubes have a substantially finer 'grain' than competing photographic materials, the effective granularity of the image tube record increases over the photographic emulsion at low spatial frequencies. This large scale granularity function must be taken into account when predicting the S/N of an observational record.

Plans for the future include special image tube Cassegrain spectrographs for the 84- and 150-inch (213 cm and 381 cm) telescopes and an alternate horizontal spectrograph at the solar telescope. The latter should prove of special value for tube evaluation. Being a fixed installation, laboratory type tests can be conducted on actual stellar objects. In the past, conflict with daytime work has seriously limited image tube experiments. Now an image tube system can remain intact for the prolonged intervals required for the development of equipment.

J. D. McGee and colleagues, Applied Physics Department, Imperial College, London

Electronographic tube—The Spectracon

The development of the Spectracon—a mica-window, single-stage, electronographic image tube for recording spectra has continued (11). The following features have been investigated:

1. Introduction of pre-prepared photocathodes has been well established of S.9, S.11 and S.1 photocathode types but the S.20 cathode tends to deteriorate after this operation. Detailed study of the reasons for this exceptional behaviour of the S.20 cathodes have been carried on without any conclusive findings.

2. Improvements in the electrostatic electron accelerating electrode system in the tube and of the solenoid producing the focusing magnetic field have resulted in improved image resolution and geometry.

3. A pneumatic device for pressing the emulsion-coated Melinex film against the mica window has been investigated and after lengthy tests a compromise between the rubber-coated roller and the pneumatic system appears the most satisfactory.

4. Tubes with S.1 cathodes were tested and compared with Kodak Z-type emulsions. For exposure times of about 10 minutes, the background due to tube thermal emission was acceptable while the speed was from 500 to 5000 times greater than the Z-type emulsion as the wave length varied from 8000 to 12 000 Å.

Other tests showed that the Spectracon tube can be cooled at the cathode end to − 50°C or lower quite safely and under these circumstances the background from S.1 cathodes should be greatly reduced. These tests are continuing.

5. Screening to exclude the effects of stray magnetic fields on the image resolution by transverse deflection has shown that it is quite feasible to reduce this effect sufficiently that a variation of about 0·5 gauss in the worst direction produces a negligible deterioration of the image resolution.

6. Telescope trials with Spectracon tubes have been carried out in co-operation with the staff of the Royal Greenwich Observatory, Herstmonceux, using a spectrograph at the coudé focus of the 30-inch (76 cm) telescope. These have confirmed the earlier tests at Mt Wilson and in the laboratory that the gain in speed over direct photography using baked IIa–O is about 10 times when Ilford G5 emulsion is used.

7. The transmission of electrons through mica sheets (12) comparable to Spectracon windows has been measured by yet another method and the results confirm those already reported. In summary it may be stated that the Spectracon operating at 40 kV with a 4μm window is as 'fast' as a direct electronographic recording system operating at 25 kV and that the signal/noise ratios of images recorded under these two conditions are indistinguishable.

8. As it became clear that, in practice, much of the inherent gain in speed of the image tube system was lost because it had to be used with inferior optical systems it was decided that a special optical system designed to operate at *f*/1 with the Spectracon, should be designed and built. This is in the early design stages which is a joint project between the staff of the Royal Greenwich Observatory, the Applied Optics Section (Drs C. G. Wynne and W. T. Welford) and The Applied Physics Section of Imperial College.

9. A shortened tube, 15 cm instead of 28 cm long, has been made successfully and preliminary assessment of its characteristics are promising. With such a tube the complete image tube and focus coil unit can be about 10 cm in diameter and 25 cm long and weigh about 7 kg.

Cascade Image Intensifier

The development of the cascade image intensifier (13) has continued and tubes of very satisfactory performance can now be made. The performance may be summarized as follows:

three-stage tube with 38 mm diameter useful field. Gain $\sim 10^6$ (blue light), S.9 or S.11 cathodes, (50 to 100μA/l m). Resolution 50 lines per mm at centre and remaining > 30 lines per mm over field of 30 mm diameter. Background so low that exposures of about one hour are practicable with transfer optics which give a speed gain of about 100 times.

Probably the outstanding defect of these tubes is the presence of bright scintillations, as appears to be the case in all tubes of this type. These spurious signals produce a background which would be objectionable in high quality images. Investigations continue into the causes and possible means of removal of these signals.

Similar three-stage cascade tubes are being made with S.1 or S.20 primary photocathodes.

T. Dunham, Jr., Mt Stromlo Observatory

A five-stage secondary-emission image intensifying tube has been mounted in the coudé spectrograph of the 74-inch (188 cm) telescope, at the focus of the 120-inch (305 cm) camera. The optical axis of the camera is 26 inches (66 cm) above the heavy steel frame of the instrument, and measurements show that distortion of the field of the 400-gauss permanent magnet in which the tube is mounted is insignificant. The tube was carefully selected by 20th Century Electronics to have a very low dark count (less than 50 scintillations $\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$). The resolving power, measured with a Baum microprojector is 25–30 line-pairs per mm. The display at the output was photographed with a transfer lens on stationary 35 mm film, and also on moving film to record individual scintillations (**14**). Due to the wide range in brightness of the scintillations, granularity is severe unless the aperture ratio of the transfer system is held to *f*/8 to *f*/11. Under these conditions the image tube showed only a moderate gain over direct photography. The moving film scintillation counting technique, however, allows use of the full aperture (*f*/1·9) of the transfer system. Performance is being compared with that for the stationary film technique. A Fabry-Pérot étalon in the collimated beam of the spectrograph has been provided with mechanical scanning, synchronized with a precision grating drive, so that approximately 50 fringes can be recorded simultaneously with the image tube (**15**). The spectra of stars to 4·0 magnitudes have been recorded at 1·8 Å/mm in 20 minutes.

M. J. Smyth and P. W. J. L. Brand, Royal Observatory, Edinburgh, Scotland

A Lenard window image tube (Spectracon) constructed at Imperial College is being evaluated as a spectrophotometric detector, in the Cassegrain spectrograph of the 36-inch (91 cm) reflector (**16**).

A suitable environment for the image tube on the telescope, free from electrical discharge due to damp air, has been achieved by the use of airtight compartments for the high voltage components, and a thermo-electric cold trap between the spectrograph camera and the tube cathode; and the image shift caused by motion of the tube with respect to the geomagnetic field had been investigated. The equivalent quantum efficiency of the tube is being determined, as a function of absolute spectral sensitivity, spatial frequency response, and granularity noise. Granularity is derived from computer analysis of density measurements made with a digitized microphotometer. A calibrated tungsten lamp is used for sensitivity determination, and the modulation transfer function is also being studied. The methods being developed will be immediately applicable to other types of image tube, and to conventional photography.

The tube is being used in a stellar spectrophotometric programme that is also being carried out by direct photography, thus enabling a comparison of photometric effectiveness to be made.

D. J. Bradley, Physics Dept., Queen's University, Belfast

1. The performance of image tubes for recording high resolution spectrograms has been evaluated (**17**). Tubes tested include a five-stage T.S.E.M. tube (**18**), single and three-stage

phosphor-photocathode tubes (**19**) and a Lenard window tube (**20**). For spectroscopy in general the Lenard window tube has outstanding signal-to-noise performance with, in addition, the great advantage of a linear density-exposure relationship. Signal induced background, at an overall voltage of 40 kV, was found to be negligible and absorption lines were faithfully recorded.

Operating with a voltage of only 26 kV, the signal-induced background and noise of the T.S.E.M. tube, and the wide spread in the multiplication factor for individual photoelectrons, resulted in such a decrease in the effective signal-to-noise ratio in the recorded image as to make it unsuitable for quantitative spectroscopy.

The signal-to-noise performance of the cascaded phosphor-photocathode tube was much superior to that of the T.S.E.M. tube.

2. A single stage magnetically focused image converter with a 'Spectrosil' window, S–9 photocathode and a phosphor screen output has been employed to record Fabry-Pérot interferograms of λ 1849 Å of Hg I for the first time (**21**). The performance of the image tube at this wavelength was entirely satisfactory. Cs-I photocathodes have been tested in photocells before employing them in solar blind tubes.

3. A development channelled image intensifier (**22**) has also been tested for spectral recording. With channels 0·5 mm diameter and an effective resolving limit of 1–2 line pairs per mm, a spectral resolving power of 10^4 was obtained (**23**) for a camera focal length of 30 cm, employing the second ring of a Fabry-Pérot étalon with an effective finesse of 10. Such a combination of interferometer-channelled image intensifier would be particularly useful for rocket and satellite spectroscopy of extended sources.

W. A. Hiltner, Yerkes Observatory, University of Chicago, U.S.A.

Experimental work on image tubes has been discontinued here, principally because of lack of time, certainly not because of any lack of faith in the electronographic process. When opportunity presents itself, I want to apply a system to astronomical research.

Something over one year ago Drs Kron and Kent Ford and I intercompared several methods of image intensification. Our conclusion at that time was that the gain of electronography over classical photography in the blue is set at near one times the quantum efficiency of the photocathode in percent, in agreement with measurements of the quantum efficiency of photographic emulsions, and probably slightly less for the cascaded image tube although any loss is essentially compensated for by easier and more efficient operation of the cascaded tube.

During the past year we built a spectrograph for the cascaded image tube. It has a *f*/2 Schmidt camera with field flattener. We used it on the McDonald 82-inch reflector for the observation of quasi-stellar and Haro-Luyten objects. Spectrograms of 200 Å/mm were obtained of 18·4 magnitude objects (about the limit of visual setting) in about two hours when unbaked Kodak IIa-O emulsion was used (**24**). The spectrograms were quite satisfactory for radial velocity measurements. We will use the spectrograph again at the next opportunity.

Dr W. Kent Ford, Carnegie Institution of Washington, U.S.A.

The Carnegie Image Tube Committee, with support from the National Science Foundation, has sponsored the development of a two-stage, cascaded image intensifier at RCA. The tubes have multialkali photocathodes, 38 mm diameter useful areas, and provide information gains of 10 over conventional photography. Several dozen tubes have been fabricated by RCA for the Carnegie Committee. These are being distributed with the necessary auxiliary equipment to various observatories. Thus far, sets have been installed at Yerkes, Kitt Peak, Mt Wilson, Lick, Lowell, University of Texas, Naval Observatory, Dominion Astrophysical, Palomar, University of Arizona, and Mt Stromlo.

Dr R. E. Danielson and colleagues, Princeton University Observatory, U.S.A.

RCA engineers and members of the Princeton Observatory are currently completing tests of an image orthicon camera system for use on the Stratoscope II Program (**25**, **26**). Uncooled high resistivity glass target tubes with 0·001 mesh spacing have yielded integration periods in excess of ten minutes. Sensitivity comparison, using stellar sources, indicates at least a factor of ten improvement in speed over 103a–G film used in Stratoscope II. Tests now in progress, operating the image orthicon in the 'isocon' mode, indicates further improvement. Analysis of the data also indicates good linearity of exposure versus the volume of the video pulse.

Within the next year the Princeton Observatory expects to operate a SEC Vidicon, built by Westinghouse, comparable in image and target size to the 3-inch (7·6 cm) image orthicon, under the similar test conditions. The SEC Vidicon tests will also involve cooled operation and spectral readout.

M. F. Ingham, the Department of Astrophysics, Oxford

Mr J. E. Beckman investigated the usefulness of image intensifier tubes to astronomy (**27**). Two types of tube were evaluated: an English Electric Valve Co. transmission secondary emission tube (the so-called Imaging Photomultiplier) and one of the Lenard window type. For both tubes the gain, spectral sensitivity, resolution and dark emission were measured. The distortion introduced by the secondary-emission tube was also studied. Finally, the English Electric tube was used in conjunction with the solar spectrograph to obtain high dispersion (4·2 mm/Å) spectra of Venus and Jupiter. With these spectra it was possible to place an upper limit on the abundance of oxygen in the atmosphere of Venus and to measure the abundance of hydrogen in the atmosphere of Jupiter.

At the Atomic Energy Research Establishment at Harwell, Mr A. V. Hewitt of this Department, and Dr W. N. Charman have been conducting similar experiments with an E.M.I. cascade tube (**28**) which they will shortly use with the 30-inch (76 cm) telescope at the Royal Greenwich Observatory Herstmonceux for experiments in stellar spectroscopy.

Dr R. J. Davis, Project Celescope, Astrophysical Observatory, Smithsonian Institution, Cambridge, U.S.A.

A special-purpose television camera tube (the Uvicon) and associated optics and digital television system (the Celescope) have been developed to meet the Smithsonian Astrophysical Observatory's requirement for measuring the ultraviolet brightnesses and the positions of a very large number of objects throughout the sky. The wavelength region of interest, from 1000 to 3000 Å, is observable only from above the Earth's atmosphere, thus precluding our utilization in this wavelength region of the well-developed photometric techniques used in ground-based astronomy.

The unique characteristic of the Uvicon tube is its combination of accurate photometric measurement ability, ultraviolet sensitivity and ruggedness of construction. In order to achieve the necessary photometric accuracy, range and sensitivity the Uvicon incorporates a secondary electron conduction (SEC) target to amplify and store the photoelectric image from the photocathode. The tube is available with two photocathode materials: caesium iodide, which is insensitive to wavelengths longer than about 2000 Å, and caesium telluride, insensitive to wavelengths longer than about 3000 Å. The short wavelength cut-off is that of the lithium-fluoride face-plate (1050 Å at room temperature). The basic design of the tube allows considerable flexibility in regard to its geometrical and electrical configuration; in the case of the Uvicon, the face-plate is incorporated as a refractive element in the optical design of the telescope system, and both the imaging section and the electron scanning gun utilize only electrostatic focusing and scanning techniques. The Uvicon was developed and manufactured by Westinghouse Electric Corporation under contract to the Smithsonian Astrophysical Observatory. Another Westinghouse tube, an LEM camera tube developed for the Lunar Excursion Module, if modified to provide ultraviolet sensitivity, would provide improved performance over the existing Uvicon configuration.

In order to achieve full photometric accuracy, all operating parameters of the tube must be very carefully controlled – including the timing of the voltage variations required for operating the tube. In this way, we have been able to achieve a photometric precision of ± 5% in the measurement of laboratory light sources during calibration of the Celescope experiment. Our investigation has also indicated that this accuracy can be improved, by a significant but unknown amount, by more careful control of operating voltages and sequences. In order to achieve full photometric accuracy, the Uvicon must be calibrated under conditions as near as possible to those under which it is to be used. The transfer function is far from linear, and varies from one part of the raster to another. Variations with temperature are less severe, but must also be determined by individual calibration if the tube is to be used outside of the range + 30° to + 10°C. There is, fortunately, no reciprocity failure, total exposure being exactly proportional to the product of intensity and exposure time between one and 150 seconds.

Typical operating characteristics of the Celescope system, utilizing the Uvicon, are as follows:

	A-Type	D-Type
Photocathode Quantum Efficiency	3% at 2000 Å	8% at 1400 Å
Spectral passband	1050 to 3200 Å	1050 to 1900 Å
Photometric Range	6×10^{-16}	to 6×10^{-12} ampere
Photometric accuracy	± 5%	
Field of view*	1·1 inch (2·8 cm) diameter circle at photocathode	
Positional measurement accuracy*	0·01 inch (0·25 mm) at photocathode	
Limiting resolution*	0·01 inch (0·25 mm) at photocathode	

*These characteristics were not critical to the Celescope experiment, and can fairly easily be improved if required for other experiments.

In order to take full advantage of the speed and accuracy with which a television system such as this can generate data, the signal must be analysed by a high-speed digital computer. We attain our highest accuracy by using digital techniques to control the Uvicon and digitize its output signal before transmission. By generating our video signal in digital form, it can be recorded on magnetic tape in a format acceptable as input to a digital computer. The equipment and techniques required for operating the Uvicon as a stellar photometer have been developed by Electro-Mechanical Research Inc., under contract to the Smithsonian Astrophysical Observatory.

This research has been supported in part by Contract NAS 5–1535 from the National Aeronautics and Space Administration.

L. W. Frederick, Leander McCormick Observatory, University of Virginia,
Charlottesville, U.S.A.

The mica window S–1 tube has been completely remounted so that it can be operated with the potential on. The system is in excellent operating order and is being used to continue the late-type stellar studies previously reported. Some 380 additional plates have been taken on the new McCormick reflector primarily by George Lockwood, a graduate student here.

A cascade S–1 image intensifier converter is currently being mounted and will use a circulatory slush cooling system. This tube appears to be an excellent tube.

An eight-foot non-magnetic optical bench has been fabricated to assist in the aligning and testing of our equipment. A Baum type pattern projector has been purchased from Hobbs, Ltd. to assist in the evaluation of tubes.

Our primary objective is to apply the Carnegie tubes to astronomical problems. Hence, we do very little experimental and development work.

BIBLIOGRAPHY

1. Lallemand, A., *et al.* 1966, *C. r. Acad. Sci. Paris*, **262**, 838.
2. Duchesne, M. 1965, *J. Phys.*, **26**, 117.
3. Duchesne, M., Feissel, M., Guinot, B. 1965, *Notes Inf. Publ. Obs. Paris*, fasc. 26.
4. Hézard, C. 1965, Thèse de 3ème cycle, Paris.
5. Combes, M. 1966, Contribution à l'étude de l'atmosphère de Jupiter, Thèse de 3ème cycle, Paris.
6. 1966, *Adv. Electronics Electron Phys.*, Academic Press, **22A**, 761.
7. Livingston, W. C., Lynds, C. R., Doe, L. A. 1966, Recent Astronomical Research Utilizing a High Gain Image Intensifier Tube. *Adv. Electronics Electron Phys.*, ed. L. Marton (New York and London: Academic Press), **22B**, 705.
8. Lynds, C. R., Stockton, A. N., Livingston, W. C. 1965, New Spectroscopic Observations of Quasi-Stellar Sources, *Astrophys. J.*, **142**, 1667.
   Lynds, C. R., Stockton, A. N. 1966, The Large Redshift of the Quasi-Stellar Source 1116 + 12, *Astrophys. J.*, **144**, 446.
   Lynds, C. R., Hill, S. J., Heere, K., Stockton, A. N. 1966, New Spectroscopic Observations of Fourteen Quasi-Stellar Sources, *Astrophys. J.*, **144**, 1244.
9. Thaddeus, P., Clauser, J. F. 1966, Cosmic Microwave Radiation at 2·63 mm from Observations of Interstellar CN, *Phys. Rev. Letters*, **16**, 819.
10. Livingston, W. C. *Adv. Electronics Electron Phys.*, ed. L. Marton (New York and London: Academic Press), **23**, in press.
11. McGee, J. D., Khogali, A., Ganson, A., Baum, W. A. 1966, *Adv. Electronics Electron Phys.*, Academic Press, London, **22A**, 11.
12. McGee, J. D., Khogali, A., Ganson, A. 1966, *Adv. Electronics Electron Phys.*, Academic Press, London, **22A**, 31.
    Jeffers, S., McGee, J. D. 1966, *Adv. Electronics Electron Phys.*, Academic Press, London, **22A**, 41.
13. McGee, J. D., Airey, R. W., Aslam, M., Powell, J. R., Catchpole, C. E. 1966, *Adv. Electronics Electron Phys.*, Academic Press, London, **22A**, 113.
14. Dunham, T. 1960, *J. opt. Soc. Amer.*, **50**, 1129.
15. Dunham, T. 1962, *Astr. J.*, **67**, 575.
16. Brand, P. W. J. L., Smyth, M. J. 1966, Use of a Lenard-window image tube for astronomical spectrophotometry, *Adv. Electronics Electron Phys.*, **22B**, 741.
17. Bradley, D. J., Bates, B., Juulman, C. O. L., Majumdar, S. 1964, *Appl. Opt.*, **3**, 1461.
18. Wilcock, W. L., Emberson, D. L. Weekley, B. 1960, *Nature*, **185**, 370.
19. McGee, J. D., Catchpole, C. E. 1962, *British IEE Conf. Rept.*, Series 5, p. 182.
20. McGee, J. D., Wheeler, B. E. 1962, *Adv. Electronics Electron Phys.*, Academic Press, London, **16**, 47.
21. Bradley, D. J., Bates, B., Juulman, C. O. L., Majumdar, S. 1964, *Nature*, **202**, 579.
22. McGee, J. D. 1961, *Rep. Progr. Phys.*, **24**, 167.
23. Bradley, D. J. 1966, *Sciences et Industries Spatiales*, no. 7/8.
24. Hiltner, W. A., Cowley, A. P., Schild, R. E. 1966, *Publ. astr. Soc. Pacif.*, **78**, 464.
25. Cope, A. D., Luedicke, E. 1965, *Adv. Electronics Electron Phys.*, Academic Press, London, **22A**, 175.

26. Flory, L. E., Pike, W. S., Morgan, J. M., Boyer, L. A. 1966, *Adv. Electronics Electron Phys.*, Academic Press, London, **22B,** 885.
27. 1966, *Adv. Electronics Electron Phys.*, Academic Press, London, **22A,** 369.
28. 1966, *Adv. Electronics Electron Phys.*, Academic Press, London, **22A,** 101.

APPENDICE 2. GROUPE DE TRAVAIL SUR LA QUALITÉ DES IMAGES ET LE CHOIX DES SITES

(préparé par J. Rösch, président)

La dénomination de ce groupe pourrait, à la rigueur, ne mentionner que le Choix des Sites, car le rôle de la qualité des images dans presque tous les genres d'observation est suffisamment reconnu maintenant pour que toute opération de prospection en tienne compte, parmi un certain nombre d'autres facteurs; et par contre, toute étude sur la qualité des images est destinée, directement ou indirectement, à rendre plus efficace la recherche des sites les meilleurs.

Les méthodes appliquées à la sélection des sites ne se codifient que lentement, sans doute parce qu'en général, jusqu'ici, le temps disponible pour chaque opération a été limité par la hâte de passer à l'implantation de l'observatoire projeté. Cet état de choses a aussi pour conséquence que faute de conclusions de portée générale certaine, la littérature est assez pauvre en publications dans ce domaine, et les résultats des prospections restent souvent consignés dans des documents peu diffusés en dehors des organismes responsables des opérations. Le présent rapport sera donc limité aux travaux parvenus à la connaissance de l'auteur et ne saurait prétendre être exhaustif.

La délimitation préliminaire des régions propres à l'implantation d'un observatoire de programme déterminé s'oriente progressivement vers une utilisation plus approfondie des données météorologiques et des quelques principes dont la validité se précise, notamment l'intérêt des altitudes d'au moins 2000 mètres pour la photométrie, l'importance significative de la faiblesse des écarts des températures diurne et nocturne, l'avantage des sommets isolés pour la stabilité de la température nocturne, le rôle néfaste des inhomogénéités dans les couches voisines du sol.

La publication d'études de ce genre sur des régions limitées, telles que celle de Hansen *et al.* pour les Iles Hawaï (**1**), celle qui paraîtra prochaînement sur les campagnes de l'ESO en Afrique du Sud (**2**) ou celles en cours en France et en Espagne, et au Brésil, constituera, par confrontation avec les résultats obtenus dans les observatoires futurs, une source précieuse pour la compréhension des phénomènes.

L'un des problèmes les plus irritants dans les débuts d'une prospection reste l'évaluation de la nébulosité nocturne. J. Saissac a tenté, pour le Sud de la France, de dresser une carte du nombre d'heures utilisables en partant du nombre de jours de pluie relevé dans les stations seulement pluviométriques dont le réseau est dense, et des corrélations établies entre ce nombre et le nombre d'heures utilisables pour les stations météorologiques complètes qui sont beaucoup moins nombreuses (**3**). Pour un travail plus direct, R. de Freitas-Mourao a réalisé, selon les suggestions faites au Symposium no. 19 de l'UAI, une chambre 'tout-ciel' susceptible d'une autonomie de plusieurs jours et permettant, sur des images exposées environ 1 minute, de mesurer l'absorption par les magnitudes limites atteintes (**4**).

Après le nombre d'heures photométriquement utilisables dans l'année, l'élément essentiel (à part le point particulier de la diffusion atmosphérique pour les observations de la couronne solaire) est la qualité des images. Devant la difficulté pratique (surtout en campagne) d'obtenir un spectre de Fourier à deux dimensions des déformations de la surface d'onde, on se contente d'un simple nombre, dont on cherche cependant une valeur objective attachée à une interprétation bien définie. C'est le but de l'ASM (Automatic Seeing Monitor) de Babcock (**5**) ou de la lunette polaire de Walker (**6**). Dans le premier cas, on obtient directement une mesure de l'agitation, donc de la fluctuation de la direction de la normale à la surface d'onde. L'ASM a été largement utilisé au Chili (Cerros Tololo, Morado, Pachon, La Silla), où Irwin a notamment étudié la variation de la quantité mesurée avec la distance zénithale (**7**), ainsi qu'au Mt Palomar et à Siding Spring (Australie) (**8, 9**). Dans le cas de la lunette polaire, on pourrait obtenir la même donnée, mais moyennant un procédé d'exploitation quantitative des traînées photographiques ou une traduction photoélectrique directe de l'agitation. Un travail dans ce sens est en cours à l'Observatoire du Pic du Midi.

Une telle estimation de la valeur d'un site, quant à la qualité des images, repose sur le postulat que les spectres de Fourier des déformations des surfaces d'onde réelles appartiennent à une famille à un seul paramètre. Le moyen le plus simple de s'assurer de la légitimité de la prévision de la qualité des images dans un grand instrument à partir de mesures d'agitation est d'établir empiriquement une corrélation entre les deux phénomènes; c'est ce qui a été entrepris à l'Observatoire du Pic du Midi par des mesures quasi-simultanées d'une part, au moyen de *l'imagemètre*, du diamètre équivalent de l'image d'une étoile donnée par un réflecteur de 105 cm, d'autre part, au moyen du chercheur du même instrument, de l'agitation fournie par des traînées photographiques.

Une étude observationnelle des corrélations s'impose encore plus si l'on veut prévoir une qualité d'image d'après des mesures de fluctuations ou de gradients de température dans les premières dizaines de mètres de l'atmosphère au-dessus du sol. Un travail de ce genre fait à l'Observatoire de Haute-Provence (**10**) montre bien une corrélation limite entre les fluctuations à une hauteur égale à celle de l'ouverture du télescope de 193 cm et le diamètre estimé de l'image observée dans ce même instrument, du moins jusqu'à une certaine valeur de ce diamètre; mais on trouve aussi des diamètres de l'image *plus grands* que ceux qui suivent la corrélation, ce qui révèle des détériorations dans des couches plus élevées que la prise de température. Un tel résultat ne peut que confirmer que la solution la plus sûre consisterait à faire un prélèvement optique à un niveau élevé aussi proche que possible de celui auquel se trouvera, en moyenne, l'ouverture du futur instrument.

RÉFÉRENCES

1. Hansen, R. T., Hansen, S. F., Price, S. 1966, *Publ. astr. Soc. Pacif.*, **78**, 14.
2. *Publ. Obs. austr. Européen* (à paraître).
3. Saissac, J. 1966, Documents du Comité National Français d'Astronomie.
4. Freitas Mourao, R. R. de Thèse, Université de Paris (à paraître).
5. Babcock, H. W. 1963, Mt Wilson and Palomar Observatories.
6. Harlan, E. A., Walker, M. F. 1965, *Publ. astr. Soc. Pacif.*, **77**, 246.
7. Irwin, J. B. 1966, *Astr. J.*, **71**, 28.
8. *A. Rep. Dir. Mt Wilson Palomar Obs.*, 1963–64, et 1964–65.
9. 1966, *CARSO Rep.*, Carnegie Institution of Washington.
10. Bourlon, Ph. 1966, Documents du Comité National Français d'Astronomie.
11. Bateson, F. M. 1964, *Publ. Univ. Pennsylvania*, **10**, 1–139.
12. Matsushima, S. 1964, *Publ. astr. Soc. Pacif.*, **76**, 224.
13. Hogg, A. R. 1965, *Mt Stromlo Publ.*, AST. 65/169.