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PDV-6 PUMP & POWER SUPPLY

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<td>0 to 50</td>
<td>0 to 50</td>
<td>millivolts</td>
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Electrons available from stock; evolution in cathodes
Condensed from a paper by Dr. P. Zalm

The development of electron tubes for higher frequencies and energy output creates an ever increasing demand for better cathodes. Today's magnetrons and other microwave tubes could never have been developed, had not the spectacular evolution of thermionic cathodes led to impressive possibilities. Of particular importance in this connection are the dispenser-type cathodes, on the subject of which we here set down a few stray thoughts.

It is to the credit of the late H. J. Lemmens, of the Philips Research Laboratories, a creative investigator with exceptional intuition, that he proceeded from a fundamental separation of functions in cathodes. Whereas for a long time the functions of "heating" and "emission" in oxide-coated cathodes had been separated, he applied separation of the "electron-emission" and "barium-supply" functions as well. He thus indicated ways of solving the problem of the limited current density of oxide-coated cathodes. In the normal oxide-coated cathode the average current density must not exceed 0.5 to 1 A per cm², since otherwise, owing to the layer's resistance, so much heat would be generated in it that damage would occur. One of the factors determining the resistance in the layer and with which the life of the cathode is also linked, is its thickness (approx. 80 microns). If the layer is made very thin (say 5 to 20 microns), then, for the same current density the cathode's life will be short.

In the case of normal barium-strontium oxide cathodes the emitting layer consists of small (Ba, Sr)O crystals. These owe their low work function (thus good emission at not too high temperatures) to the absorption of barium. Barium evaporates, however, and has to be replenished. This occurs through reaction of the BaO with the reducing agent added to the nickel of the cathode; Al, Mg or Si etc. In L-cathodes (L for Lemmens) and other dispenser-type cathodes the necessary barium is replenished not from the layer, but from a separate, small supply chamber shut off by a "lid" of porous tungsten; this results in a good separation of functions between emitting layer and barium supply. Hence the emitting surface consists of the porous tungsten on which a film of barium of atomic thickness has been adsorbed; the series resistance is then extremely low. A pleasing aspect of this development is that the substrate (the metal "lid" on the supply chamber) can be varied at will. Frequent use is now made of this degree of freedom.

More recent developments in these cathodes disclosed an interesting paradox. When a study is made of the question as to how the work function of metals is influenced by adsorption of electropositive elements such as barium, it is found that at tungsten-barium interface a change in potential occurs, due to formation of a dipole layer as a result of polarization of barium atoms. This dipole layer reduces the work function. It is possible to calculate that for a higher work function of the base material the number of barium atoms which can be absorbed in such a state of polarization is greater. This increase is so sharp that the paradoxical effect is obtained that the higher work function of the base metal is more than compensated.

This calculation has been confirmed in practice. So we looked for the base material among metals with high work functions. These are to be found especially in the platinum group. For a number of applications osmium was chosen from this group. The Os-cathode, as every other normal dispenser-type cathode, can withstand temperatures of up to 1,100 °C.

For professional purposes, particularly in communications engineering, it excels on account of high current densities (up to 50 A/cm²) and long life (10⁸ hours at 1 A/cm²).

Therefore it can truly be said that here many electrons are available from stock, and will be for a very long time.

Scientific & Industrial Equipment

PHILIPS

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The past fifteen years have witnessed the development and widespread application of new techniques of chemical analysis based on atomic absorption measurements. Since these developments have been largely the result of work carried out in Australia and New Zealand it may be appropriate for an address to the Australian Institute of Physics to recall how work in this field in Australia was initiated, to describe some of the factors which resulted in the commencement of commercial production of atomic absorption equipment in Australia, and to outline some of the current Australian research in this rapidly developing branch of applied spectroscopy.

The first application of atomic absorption spectra to chemical analysis was reported 100 years ago by Kirchhoff who used the atomic absorption lines in the Fraunhofer spectrum of the sun to deduce the presence of certain elements in the solar atmosphere. Shortly afterwards, Kirchhoff and Bunsen described their celebrated experiments which clearly showed that atomic spectra, either in emission or absorption, could be the basis of powerful methods of chemical analysis. From that time onwards emission methods of spectrochemical analysis were gradually developed and during the Second World War culminated in direct reading spectrophotographs of the type now in widespread use. It is a curious feature of the history of spectrochemical analysis that whilst all these developments in emission methods were taking place the potentialities of analytical methods based on atomic absorption spectra were almost completely ignored. This neglect is particularly surprising in view of the well known applications of atomic absorption measurements in spectroscopic research work: e.g., in studies of furnace spectra; in investigations of hyperfine structure by means of atomic beams; and in many experiments associated with the measurement of resonance radiation from atomic vapours. As a purely analytical tool, however, the absorption method was largely confined to studies of the compositions of the solar and stellar atmospheres, and to the special case of determining the contamination of laboratory atmosphere by mercury vapour. During this period it seems always to have been tacitly assumed that the various limitations of emission methods would necessarily have their counterparts in absorption methods.

Early in 1952, as a member of a small spectroscopic group working in the Chemical Physics Section (now Division of Chemical Physics) of the C.S.I.R.O. Division of Industrial Chemistry, I began to wonder why molecular spectra were almost invariably obtained in absorption, whereas the small amount of atomic spectroscopy which was carried out was invariably by means of emission measurements. Now the reason molecular spectroscopy is largely based on absorption measurements is simply due to the fact that it is generally extremely difficult to make a molecule emit light without dissociating the molecule. In the case of atomic spectra, however, the following simple arguments seemed to indicate that absorption measurements would have many vital advantages.

Consider an atomic vapour in thermal equilibrium at temperature $T$. The number of atoms in an excited state $j$, of excitation energy $E_j$, is given by

$$N_j = N_0 \left( \frac{P_j}{P_0} \right) \exp \left( -\frac{E_j}{kT} \right)$$

where $N_0$ is the number of atoms in the ground state and $P_j$ and $P_0$ are the statistical weights of the excited and ground states respectively. The intensity of a given line is proportional to the number of excited atoms and therefore depends critically on $T$ and $E_j$ (which for resonance lines, involving transitions to the ground state, is inverse-
TABLE 1
Values of $N_l/N_o$ for various resonance lines

<table>
<thead>
<tr>
<th>Resonance line</th>
<th>Transition</th>
<th>$P_l/P_o$</th>
<th>$N_l/N_o$ at $T = 2000^\circ K$</th>
<th>$N_l/N_o$ at $T = 3000^\circ K$</th>
<th>$N_l/N_o$ at $T = 4000^\circ K$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cs 8521Å</td>
<td>$^2S_{1/2} - ^2P_{3/2}$</td>
<td>2</td>
<td>$4.44 \times 10^{-4}$</td>
<td>$7.24 \times 10^{-3}$</td>
<td>$2.98 \times 10^{-2}$</td>
</tr>
<tr>
<td>Na 5890Å</td>
<td>$^2S_{1/2} - ^2P_{3/2}$</td>
<td>2</td>
<td>$9.86 \times 10^{-6}$</td>
<td>$5.88 \times 10^{-4}$</td>
<td>$4.44 \times 10^{-3}$</td>
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<tr>
<td>Ca 4227Å</td>
<td>$^1S_0 - ^1P_1$</td>
<td>3</td>
<td>$1.21 \times 10^{-7}$</td>
<td>$3.69 \times 10^{-5}$</td>
<td>$6.03 \times 10^{-4}$</td>
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<tr>
<td>Zn 2139Å</td>
<td>$^1S_0 - ^1P_1$</td>
<td>3</td>
<td>$7.29 \times 10^{-15}$</td>
<td>$5.58 \times 10^{-10}$</td>
<td>$1.48 \times 10^{-7}$</td>
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ly proportional to the wavelength of the line). Examples of the variation of $N_l/N_o$ with $T$ and $E_l$ (or $\lambda^{-1}$) for various elements are given in Table 1. This table not only illustrates the critical dependence of $N_l/N_o$, and therefore of intensity, in temperature and excitation potential but also shows that for temperatures less than $4000^\circ K$ the number of excited atoms is a very small fraction of the total number of atoms. In other words, most of the atoms are in the ground state. This immediately suggests that, in contrast with emission intensity, atomic absorption is essentially independent of temperature and excitation potential. For example, a low temperature flame will emit a strong spectrum of elements, such as the alkali metals, which have a low excitation potential, but produces a negligible emission spectrum for elements such as zinc and cadmium having a much higher excitation potential: the absorption measurement, however, depends only on the number of atoms in the ground state and could be expected to be as sensitive for zinc and cadmium as for the alkali metals. This was one of the predicted attractive features of the absorption method which encouraged its further investigation. There was one other incentive. In the ease of electrical discharges the emission intensity of a given element depends critically on the presence of other elements. A striking example is given by a sodium street lamp in which the sodium vapour eventually suppresses the neon spectrum; there would be no corresponding effect in absorption.

These were the main reasons for investigating the absorption method and attention was directed to developing methods of spectrochemical analysis in which the sample was atomized in a flame and the absorption at specific wavelengths was measured. Now the width of an atomic absorption line under the conditions prevailing in a flame is of the order of $0.04-0.1$ Å and the resolution required to accurately record the profiles of such absorption lines is beyond the performance of most monochromators. It was decided to circumvent this difficulty by measuring the absorption coefficient at the centre of the line, using an atomic line source which emits lines having a much smaller half width than the absorption lines so that to a good approximation a measurement can be made of the peak absorption coefficient. It was necessary to develop such sharp line sources and initially these were sealed-off hollow-cathode lamps which emitted resonance lines having a half-width of the order of $0.01$ Å. This high effective resolution is an essential feature of the absorption technique and yields a further important advantage over emission methods in which the resolution is much lower since it is determined by the optical performance of the monochromator. Thus radiation interference effects which in emission spectroscopy are due to the monochromator being unable to isolate the required line from neighbouring lines or background have little or no counterpart in absorption methods. Another feature of the experimental arrangement in the absorption method is the provision of means for compensating for any radiation emitted by the sample at the wavelength at which the absorption measurement is to be made. The simplest method for achieving this is by modulating the radiation from the source

Figure 1
Photograph of atomic absorption spectrophotometer exhibited at Institute of Physics Exhibition of Scientific Instruments, Melbourne, March 1954.
before it passes through the atomic vapour and amplifying the output of the detector by an amplifier tuned to this modulation frequency. Thus any radiation emitted by the atomic vapour which is not modulated produces no signal at the output of the amplifier.

By mid 1953 sufficient measurements on flames had been made to indicate the high potential of absorption methods. The technique developed was patented and discussions began with Hilger and Watts Limited, London, regarding the licensed manufacture of this type of equipment. In March 1954, a working atomic absorption spectrophotometer, shown in Figure 1, was exhibited at the Institute of Physics Exhibition of Scientific Instruments in Melbourne where it created virtually no interest of any sort!

In 1958, J. E. Allan of the Department of Agriculture, New Zealand, and D. J. David in the C.S.I.R.O. Division of Plant Industry published reports of the application of atomic absorption technique to the determination of magnesium and zinc in agricultural materials and plants and their results convincingly demonstrated the power of the atomic absorption method.

By 1959 various laboratories in Australia were interested in trying out the method and at this stage C.S.I.R.O. decided to arrange for the local manufacture of some of the necessary components. It was arranged for one small firm to manufacture the lamps, another to manufacture the burner and other mechanical items, and a third to manufacture the electronic equipment. Monochromators were imported and the apparatus assembled according to a set of instructions prepared by C.S.I.R.O. During the next three years some 30 laboratories in Australia were equipped with this type of do-it-yourself kit. Figure 2 illustrates the type of apparatus assembled in this way.

In 1962 Techtron Pty Ltd which had been manufacturing the electronic components decided to market an integrated atomic absorption spectrophotometer. Their success can be judged from the fact that their exports are now valued at $1,000,000 per annum.

In the meantime workers overseas were in general slow to appreciate the merits of the atomic absorption method and it was not until 1963 that the method became firmly established. The growth of the method since that time is illustrated by the increase in commercial production of atomic absorption spectrophotometers from less than one hundred in 1963 to more than two thousand in 1967.

Recent Advances

Some of the recent advances and current research in atomic absorption can conveniently be described in relation to the three main components of a typical atomic absorption spectrophotometer; viz., the flame for converting some of the sample solution into an atomic vapour, the atomic spectral lamp which emits the spectrum of the element to be determined, and the equipment for the isolation and measurement of one or more of the resonance lines emitted by the lamp.

(a) Nitrous oxide-acetylene flame. Undoubtedly the most important development of the past few years has been the introduction of the nitrous oxide-acetylene flame, following the work of M. D. Amos and P. E. Thomas (Sulphide Corporation, N.S.W.), and J. B. Willis (C.S.I.R.O. Division of Chemical Physics). This flame permits the determination of a further 25 elements including aluminium, silicon, and zirconium which form...
refractory compounds in the acetylene flames which had previously been used and thus provided no free atoms for absorption. The flame also reduces many chemical interferences and most atomic absorption spectrophotometers provide facilities for its use.

(b) Boosted hollow-cathode lamps Conventional hollow-cathode lamps are now available for the 60 elements which can be determined by atomic absorption methods and their performance is generally satisfactory. The basic limitation in intensity of this type of lamp arises from the fact that one electrical discharge is used to produce the required atomic vapour by cathodic sputtering and also to excite this vapour. Consequently any attempt to increase the excitation, as, for example, by means of a higher current or lower pressure of the filler gas, is generally accompanied by a higher pressure of metal vapour with the resultant danger of absorption broadening. This limitation can be overcome by using one electrical discharge to produce by cathodic sputtering the optimum pressure of atomic vapour and a second electrical discharge, electrically isolated from the first, to produce the necessary excitation.

A typical electrode assembly is shown in Figure 3 in which A and C are the anode and cathode respectively of the primary discharge whilst BB are the booster electrodes of the auxiliary discharge. The shields SS ensure that the boosting discharge passes through the openings OO and through the region at the mouth of and in the interior of the hollow-cathode where it effectively excites the atomic vapour produced from the walls of the hollow-cathode by cathodic sputtering. The cathode of the booster discharge is oxide-coated so that the boosting discharge operates at a low voltage of the order of 25 volts. With this type of lamp, increases in intensity by factors of 10 to 100 can be obtained without any broadening of the resonance line.

(c) Isolation of atomic resonance lines An essential feature of an atomic absorption spectrophotometer is the equipment for isolating and measuring the intensity of one or more of the lines in the spectrum emitted by the atomic spectral lamp. This is usually achieved by a dispersion monochromator. In recent years the possibilities of replacing this monochromator by alternative means have been explored at the C.S.I.R.O. Division of Chemical Physics.

The first of these methods, based on selective modulation, is illustrated schematically in Figure 4. Light from an unmodulated spectral lamp passes along the axis of a discharge tube, the open ended hollow-cathode of which consists of the element whose resonance line it is required to isolate. The power supply for the discharge is modulated and thus the concentration of atomic vapour within the cathode is pulsating. This provides modulation of the resonance lines emitted by the lamp. No other lines are modulated since they are not absorbed by the atomic vapour in the sputtering cell. The emerging light beam is passed through a low-resolution monochromator or filter and the detection system only gives an output signal for those lines which have been modulated. Some type of monochromator or filter is usually necessary since the output signal due to non-resonance lines emitted by the sputtering cell and the noise due to undetected radiation from the spectral lamp would be prohibitive. The attraction of this method is that it permits the use of a low-resolution monochromator and the requirements for the stability of the wavelength setting of the monochromator can be correspondingly relaxed.

![Diagram](image)

Figure 4
Schematic diagram illustrating the principle of isolating atomic resonance lines by selective modulation with a pulsating atomic vapour produced by cathodic sputtering.

![Diagram](image)

Figure 5
Spectra showing isolation of the nickel resonance line at 2320.03Å by selective modulation.
The performance of this type of selective modulation system is illustrated in Figure 5 which shows spectra obtained from a nickel high-intensity hollow-cathode lamp and from the same lamp when used in conjunction with a nickel modulator of the type described. The possibilities of exploiting this technique in fields other than atomic absorption spectroscopy are currently being investigated.

Another technique for isolating resonance lines is based on the phenomenon of resonance radiation. The technique is illustrated in Figure 6. Radiation from an atomic spectral lamp passes through the flame to a resonance lamp in which atomic vapours are produced thermally or by cathodic sputtering. This vapour absorbs the resonance line from the source and some of this absorbed energy is re-emitted as resonance radiation, some of which falls on a photomultiplier. In order to test the performance of systems of this type several units have been made in the C.S.I.R.O. Division of Chemical Physics and used under routine conditions in various laboratories. For example, an instrument for the determination of magnesium and calcium has been tested at the State Electricity Commission Laboratories in Melbourne, a unit for the determination of nickel has been in routine use for one year in the Australian Mineral Development Laboratories whilst a third unit for the determination of copper is currently undergoing tests by the Zinc Corporation at Broken Hill. The results obtained to date have been extremely encouraging. The attractive feature of this type of instrument is that unlike an optical monochromator a resonance detector cannot go out of adjustment and thus can be used under extremely rigorous conditions. At the present time plants for the simultaneous determination of several elements are being tested. In the meantime it is gratifying to report that the only commercial spectrophotometers incorporating resonance detectors are manufactured in Australia. Whether this type of instrument will become generally accepted depends largely on the costs involved in their manufacture.

### Notes and News

**Investigation of Stable Auroral Red Arcs**

A Geophysics Group Project

The Nuffield Foundation Advisory Committee recently announced a grant of £4000 to the Australian Institute of Physics, for a co-operative experiment to investigate mid-latitude red auroral arcs associated with geomagnetic storms. The project is under the control of a sub-committee of the Geophysics Group (comprising Professor K. D. Cole, Dr F. Jacka, Professor P. Schissler, and Dr J. A. Thomas) and a number of organizations have agreed to participate.

The project, to collate the efforts of many observatories, arose from a proposal by Cole (Australian Physicist, March 1966) that Australian geophysicists should take advantage of a unique opportunity to gather information concerning the intensity, movements, and temporal variations of sub-visual stable auroral red arcs (SAR-arcs) in middle latitudes. The emission observed is the 6300Å line of atomic oxygen. Such arcs have been detected only rarely and are associated with intense geomagnetic storms which are more prevalent during periods of high sunspot activity. The next predicted maximum of the sunspot cycle occurs during 1968 and 1969, and it is therefore desirable to have all equipment operational before that time. New equipment to be manufactured includes three automatic 16mm cameras fitted with a form of "fish-eye" lens and using sensitive film with time exposures, and a meridian scanning photometer. This equipment will supplement that already in use by a number of active workers in this field, and the table below gives some idea of the anticipated coverage for optical observations.

Some warning of possible events is available in that they occur in the recovery stage of large magnetic storms. Advantage will be taken of the "Warning" system operated by the Ionospheric Prediction Service and a second stage of warning will be provided by magnetometer records available at a few locations. The network of optical observatories will also provide data for comparative analyses of 6300Å airglow phenomena particularly in the northern magnetically conjugate regions and with similar data collected by the satellite OVI-10.

In addition to the optical observatories, close attention will be paid to the behaviour of the ionospheric electrons in the emitting region. All relevant types of radio observation of the F-region of the ionosphere will be examined for abnormal behaviour associated with the SAR-arcs. The pertinent observations include standard ionosonde recordings of both swept and fixed frequencies, oblique
back-scatter soundings of the region containing the arc, observations of radio scintillations produced by satellite transmissions passing through irregularities, and total electron content studies.

The aim of the project is to complement and bring together the efforts of researchers already working in this general area and to provide a framework of collective interpretation of the global and temporal aspects of the phenomenon and its environment.

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<th>EQUIPMENT</th>
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<td>Melbourne</td>
<td>Zenith Photometer, Meridian Scanning Photometer, 16mm All-sky Camera.</td>
</tr>
<tr>
<td>Hobart</td>
<td>16mm All-sky Camera.</td>
</tr>
<tr>
<td>Macquarie Island</td>
<td>Scanning Photometer (Manual), 6 channel Zenith, 16mm All-sky camera (Manual).</td>
</tr>
<tr>
<td>New Zealand</td>
<td>Meridian Scanning Photometer, 16mm All-sky Camera.</td>
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<td>Upper Atmosphere Section, C.S.I.R.O.</td>
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<td>Mawson Institute.</td>
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<td>Geophysical Observatory D.S.I.R.</td>
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The 1967 Physics Instruments Exhibition

Convener, J. L. William, demonstrates equipment to Exhibition Manager, A. K. Connor.

From 29 to 31 August this year, the Victorian Branch of the Australian Institute of Physics conducted the 1967 Physics Instruments Exhibition at the Royal Melbourne Institute of Technology. Over 150 instrument manufacturers were represented by 40 exhibitors, and more than one million dollars of scientific equipment was on display.

The exhibition was opened by Sir Ian McLennan, K.B.E., General Manager of The Broken Hill Pty Ltd, who spoke of the rapidly growing use of science and technology in every phase of Australia's development. He made the interesting point that, but for physics, the oil and gas deposits of Bass Strait would not have been discovered. The genesis of their discovery was the aerial magnetometer work, followed by the marine seismic work which enabled the drilling to be done so that the first hole struck gas. This is the first time in the world that a wild cat hole had been drilled out in the water without having some lead out from the land; in places like Louisiana, the Gulf, or the coast of California, the petroleum was discovered on shore and then followed out.

Professor J. M. Cowley, Chairman of the Victorian Branch, drew attention to the strong response of the exhibitors to the invitations to take part, thus providing evidence that these exhibitions play a valuable part in bringing new developments of the tools of science to the attention of those who must use them. The Australian President of the Institute, Dr A. Walsh, presented Sir Ian McLennan with a gold-plated diffraction grating as a memento of the occasion.

The Institute is pleased to observe the increasing range and sophistication of scientific instruments designed and produced in Australia. We believe we are witnessing the birth of an Australian scientific instrument industry which may be expected to play an increasing role in Australian technology.
Modern solar astronomy depends increasingly on high-resolution observations of various kinds—that is, on observations having a spatial resolution of 1" of arc or so, corresponding to a distance on the sun of about 450 miles. In fact, it is fair to say that observatories whose equipment fails to meet this rather stringent requirement may in future have to content themselves with playing a secondary role, because further insight into physical conditions and processes on the sun will continue to depend largely on observations of the fine detail. This is where the physics of the phenomena so often lies!

One good example is the granulation of the solar photosphere—the "white light" surface of the sun visible without special filters. For many years the photosphere was believed to be in a state of fully-developed aerodynamic turbulence, a view based on observations of inadequate resolution. Only recently have high-quality photographs revealed a clearly defined cellular pattern characteristic not of turbulence but of a basically laminar convective regime.

Over the past ten years we in Australia have played a leading part in developing high-resolution observing techniques, and our own work on the fine structure of sunspots and the photosphere, using telescopes of small size but high performance, has alerted several overseas observatories to the inherent capabilities of properly designed ground-based equipment.

The chief difficulty in observing fine detail on the sun arises from refractive index inhomogeneities produced by thermal disturbances in the earth's own atmosphere. In a solar telescope of conventional design, these image-spoiling currents originate from three main sources: (a) the heated ground in the immediate neighbourhood of the telescope; (b) the dome; and (c) those parts of the telescope itself directly exposed to the sun's rays. In addition, of course, there are thermal irregularities high in the atmosphere; however, apart from a sensible choice of site there is little one can do about these other than to resort to balloon-borne equipment.

The C.S.I.R.O. telescope and the 14-inch domeless coude refractor of Germany's Fraunhofer Institute are the only solar telescopes currently in use which adequately solve the problem of thermal control. Our telescope is located at the Culgoora Solar Observatory, which is operated jointly by the C.S.I.R.O. Divisions of Physics and Radiophysics, in flat, lightly grassed country some 370 miles northwest of Sydney, midway between Narrabri and Wee Waa. Its design has been carried out by the authors in collaboration with a number of colleagues at the Division of Physics, and its construction, with the exception of the 12-inch objective lens, has been the responsibility either of the Division's own workshops or of outside contractors in Sydney and Newcastle.

The telescope tower is a double structure and follows in principle, although not in detail, the design of the 150-foot solar tower at the Mt Wilson Observatory in California. Both inner and outer towers are of steel girder construction. The inner tower carries the telescope on top of a reinforced...
concrete pedestal which, in turn, is attached to a heavy concrete block providing a massive inertia against possible vibration. The outer tower carries the protective canopy (see below) and, beneath the concrete block, the control room. The inner and outer towers are everywhere separated by a gap of approximately 2-in, so that vibration of the outer tower cannot be communicated to the telescope. In addition, light gauge steel cladding attached to the outer tower protects the members of the inner tower from wind shake. There remains some possibility of wind vibration of the telescope itself; however, owing to the lattice-type construction of the telescope tube, this is small under normal weather conditions. The top of the telescope pedestal is nearly 50ft above ground level, while the maximum height attained by the objective lens is approximately 65ft.

When in use, the telescope is completely open to the air, as shown in Fig. 1—a very desirable feature from the thermal point of view. When not in use, the telescope is turned to the east-west direction and enclosed by a cylindrical canopy, which replaces the conventional dome. The canopy consists of four motor-driven leaves, two on the north side and two on the south, which can be fully retracted into the sides of the supporting structure. Thermal control of the telescope’s immediate environment is aided by drawing air downwards through holes in the floor of the observing platform surrounding the pedestal.

The supporting structure for the optical and mechanical parts, i.e., the telescope “tube”, is unusual in that it consists of two open triangular frameworks, one inside the other (see Fig. 2); both are constructed of welded steel tubing. The inner framework, 20ft long, carries the objective lens and the other telescope parts and is supported by the outer framework at points near the latter’s two ends. The purpose of this arrangement is to minimize flexure: when the points of support are properly chosen with due regard to the weight distribution, any residual flexure of the inner framework is much smaller than in the case of a conventional equatorial telescope supported solely at its centre of gravity. Any flexure of the outer framework, of course, no effect on the alignment of the telescope parts. The whole structure is attached to the tires of an open-fork equatorial mount and drive of conventional design by means of stub axles carried on the outer framework.

The telescope is kept directed towards the sun with the aid of a photoelectric guider fed by an auxiliary 4-in telescope carried on the inner framework. This forms a solar image on an occulting disk behind which are placed four photoelectric cells. Amplified signals from these cells are used to control small electric motors providing motion in hour angle and declination. A second identical telescope feeds a “seeing monitor” which is used to trigger the exposures at the moments of best definition, the triggering level being manually adjustable from the control room. The principle of operation of the seeing monitor is to measure photoelectrically the magnitude of the fluctuations in light intensity due to image distortion of two narrow segments of the solar limb at opposite ends of an image diameter. The effect of any momentary guiding errors or wind shake on the seeing signal is minimized by adding the outputs of the two photocells receiving light from the two limb segments.

Fig. 3 shows a schematic layout of the optical system. $D_1$ is a hollow aluminium shield which protects the telescope from solar heating by covering the entire front area, excluding the objective lens, and the two auxiliary telescopes feeding the photoelectric guider and seeing monitor. The front surface of $D_1$ contains numerous perforations through which air is continually drawn by a suction system. The temperature of the shield is thus kept close to the ambient value, and it performs its function of keeping the sun’s rays off other parts of the telescope without itself giving rise to damaging convection currents. The 12-in objective lens $L_1$ is a high-quality, air-spaced doublet of 10ft.

![Figure 2](image_url)

*Standing at lower end of telescope arc, from left to right, R. E. Loughhead, E. J. Tappere, J. Winter, and R. J. Bray.*
focal length, which gives excellent performance in both the red and green regions of the spectrum.

$L_1$ forms a 28-mm solar image on a prime-focus diaphragm $D_3$, which, like $D_4$, is air-cooled. The portion of the image corresponding to the aperture in $D_3$ is re-imaged with the aid of two auxiliary lenses $L_2$ and $L_3$ to produce an enlarged image on the gate of a 35-mm camera $C$, the effective diameter of the final image being 17 cm; the camera is preceded by a birefringent (Lytot) filter $F$ and a reflex viewing system $R$. The filter $F$ has a passband of 0.5 A centred on the strong Hα line of hydrogen (6563 Å), which originates in the solar chromosphere. This is a layer of the sun’s atmosphere roughly 5000 miles thick lying directly above the photosphere and is the site of flares and other manifestations of solar activity.

$L_4$ is fixed in such a position that its focus coincides with the image of $L_3$ produced by $L_5$. This ensures that all rays coming from any given point of $L_4$ are parallel as they pass through the filter $F$, so that the “spectral purity” is the same for all points of the final image. $L_5$, on the other hand, is provided with screws giving motions in two directions at right angles to the optical axis, so that any desired region of the solar image can be brought onto the camera gate. (The optical system is designed to keep any off-axis aberrations introduced by shifting $L_5$ away from the optical axis of the objective within the Rayleigh limit.)

The shutter unit is mounted in front of the prime-focus diaphragm $D_5$ and consists of a solenoid-operated blade shutter $S_1$ and a rotating sector-disk shutter $S_2$, driven by an electric motor $M$. In order to obtain exposures of uniform density regardless of varying sky transparency or solar zenith distance, the speed of $M$ is servo-controlled to within an accuracy of 1 per cent, the necessary correction signal being derived from a photocell which monitors the brightness at the centre of the solar image produced by the guider telescope.

All operations involved in taking exposures are sequenced automatically by an electronic programme controller situated inside the control room. The triggering pulse is initiated either by the seeing monitor or, alternatively, by a timing mechanism giving pulses at intervals which can be varied from 5 to 120 s. The image of a clock ($W$ in Fig. 3), together with the date, is recorded in a corner of each frame.

Figs 4 and 5 show two recent photographs which give some idea of the performance of the instrument and of the nature of the fine detail visible in the chromosphere. The best resolution achieved to date is 0.8” of arc, a figure satisfactorily close to theoretical resolution limit of 0.55” for the size of objective lens used. Similar results have been obtained by workers at the Fraunhofer Institute. In both cases the resolution attained represents a marked improvement over earlier photographs of the chromosphere.

The authors are very conscious of their indebtedness to numerous colleagues and to several Australian firms, whose contributions will be specifically acknowledged in a longer description of the telescope now in preparation.

References
Further information on high-resolution solar observing techniques may be found in the following sources:
Figure 5
Small sunspot showing extensive disturbances in the surrounding regions of the chromosphere.
Institute Affairs

NOTES FROM YOUR HONORARY REGISTRAR — A MISCELLANY

Those Addresses

The change-over of addresses to include postcodes is proceeding steadily and is, incidentally, disclosing a number of minor errors that need correction. There is, furthermore, a pleasing increase in the use of professional addresses. May I appeal to all those who have not yet returned a change-of-address form to please do so, using the form published in either the August or the October Physicist. If it is more convenient, these can be sent to me via the Treasurer, along with your subscription.

A by-product of this exercise was the disturbing discovery that a list of changes of address had been lost in the mail between the Registrar and the Editor early in July. Needless to say, this error has been corrected but, on behalf of the Institute, I do apologise to those affected, and I am sure the Editor will do his best to make up any deficiencies, if sufficient copies are still available.

Changes of Grade

As the end of the year approaches, so does graduation day, and this seems a suitable time to remind students as to when they can and when they should seek transfer to Graduate status. This matter was discussed in detail in the June and July issues of the Physicist and the main points were:

(a) a Student becomes eligible to transfer on completion of one year's suitable experience after obtaining a pass degree or equivalent qualification and an Honours year is one form of suitable experience;
(b) the By-laws stipulate that a Student may not continue as a Student beyond the end of the year in which he becomes eligible to transfer; and
(c) application for transfer must be made on the appropriate Institute form, i.e., it cannot be effected automatically.

This may also be a logical time to suggest that Graduates and Associates consider whether their gradings in the Institute are appropriate and, if not, that they apply for transfer to a higher grade. Articles in the September and October issues should, I hope, give some guidance to the level of attainment looked for at each level.

Resignations

The Articles of Association stipulate that a member wishing to resign shall give one month's notice in writing to the Honorary Registrar. Thus, if you feel you must resign, and I do hope you will not, then please let me know rather than just ignoring your subscription notice and waiting for us to find out. Thank you.

Information Please

Does anyone know where the following members are now?
Mr H. D. Cone—A.N.U., sometime.
Mr E. T. Kyminas—Uni. of N.S.W., 1965.
If so, would you please tell the Registrar.

The Register

CHANGES IN MEMBERSHIP FROM 22.9.1967 TO 19.10.1967

ASSOCIATESHIP
(a) Transferred
Parnell, T. M., University of Queensland, Qld.
(b) New Elections
Ashby, R. A., N.S.W. Institute of Technology, N.S.W.
Gauld, C. F., Cranbrook School, N.S.W.
Henderson, D. M. H., Sydney Teachers' College, N.S.W.
Liesegang, J., La Trobe University, Vic.
(c) Resigned
Delvecchio, M. (Overseas) Prichard, J. A. (Tas.)
Rogers, C. B. (S.A.).

GRADUATESHIP
(a) Transferred
Edwards, T. J., University of W.A., W.A.
Lowe, L., Kingsgrove High School, N.S.W.
Schilizzi, R. T., University of Sydney, N.S.W.
Steven, L. W., Peter MacCallum Clinic, Launcesto
(d) Resigned
Taylor, K. J., University of W.A., W.A.
Taylor, R., Elwood, Vic.
Kurrle, R. (W.A.).

STUDENTS
(a) Admitted
Barker, P. R. (Vic.) Strain, J. J. G. (Vic.)
Wickham, B. A. (N.S.W.) Willett, P. R. (Vic.)
(b) Resigned
Thues, J. G. (S.A.).

SUBSCRIBERS
(a) Admitted
Costello, D. J. (W.A.).
(b) Resigned
Prior, J. W. (N.S.W.) Stanford, E. B. (N.S.W.)

Note to all new members: The return of your obligation form is necessary for formal completion of admission. Its receipt by the Registrar serves also as an acknowledgement of the letter of admission.

THE AUSTRALIAN PHYSICIST, NOVEMBER, 1967 195
Book Review


Reviewed by Dr R. G. Storer, School of Physical Sciences, The Flinders University of South Australia.

This book is a collection of the statistical-mechanical and kinetic-theory foundations which the authors propose to apply to the theory of classical plasmas. Most of the theory discussed here, e.g., the principles of statistical mechanics, the BBGKY equations, Boltzmann's equation and the various approaches to its solution could be applied equally well to any rarefied gas. In fact this volume could act as an excellent reference book for a study of kinetic theory in general. For example, Ch. 8 and the appendices are a useful collection of mathematical methods and results associated with the theory of Boltzmann's equation.

As a book concerned specifically with the "Electrodynamics of Plasmas", however, this volume has rather limited application, for the authors leave to Volume 2 most of the direct applications to plasmas and any detailed discussion of long-range collective behaviour and its relation to recent derivations of kinetic equations for plasmas. The main discussions concerned directly with plasmas are a summary of the properties and parameters encountered in plasma physics and ionization phenomena (Chapter 1), a clear description of the motion of charged particles in electric and uniform and non-uniform magnetic fields (Chapter 4), and a derivation from kinetic theory of the equations of magnetohydrodynamics, including collision effects, (Chapter 6). While it may be a comprehensive study of those parts of plasma theory which can be reasonably described using Boltzmann's equation, this volume gives a rather restricted view of the variety of approaches used in plasma physics.

MSA
No information is disclosed to clients until candidates have given permission after personal discussion.

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The Company will be known to instrument users as the Australian company of the Perkin-Elmer Corporation which makes and markets the largest range of advanced analytic instruments in the world. Instruments are sold to industrial organisations, medical, educational and research institutions, universities, government departments etc., wherever advanced laboratory facilities exist.

The man appointed will be thoroughly trained in product knowledge and the marketing and service operation and will be advanced through technical selling to regional sales management. Location: Initially Melbourne, Interstate and occasional overseas travel.

Remuneration includes an incentive component which should take it to about $10,000 p.a. when he is fully operating. Car. Superannuation.

Applicants should have a degree in chemistry or other science, or equivalent professional qualifications. Knowledge of organic chemistry and chemical analysis would be advantageous. Experience of similar or related technical selling would weigh substantially in selection. Age: about 30-40.

Please send brief information, quoting reference AP/196, to Dr. F. P. Kessell,
MANAGEMENT SELECTION AUSTRALIA,
424 St. Kilda Road, Melbourne, 3004.
CONFERENCE ON “IONIC SOLIDS”

Longer title: “Physical Properties of Alkali and Silver Halides, Simple Oxides and Closely Related Crystals”.

This Conference is being organized by N.S.W. Branch of the Australian Institute of Physics and will take place from 29 to 31 May 1968, at the Newport Inn, Newport, N.S.W. The Conference will assemble from 4 p.m. on Wednesday, 29 May, the first papers being presented after dinner on Wednesday evening. There will be further sessions on Thursday morning and evening and on Friday morning. Thursday afternoon has been left free for informal discussions.

It is proposed that only a limited number of papers be presented to the Conference to allow ample time for discussion. The scope of the Conference is indicated by the following tentative list of papers: “Diffusion of Divalent Cations in Magnesium Oxide”, “Thermal Properties of Silver Iodide”, “Lattice Dynamics of Ionic Solids”, “Clustering of Impurity Ions in Alkali Halides”, “Mechanism of Production of Colour Centres in Alkali Halides”, “Radiation and Ultrasonic Absorption in Alkali Halides”, “Creep Rates in Magnesium Oxide”, “Expansion of Ionic Solids at Low Temperatures”, “Dielectric Breakdown in Alkali Halides”.

The Conference is to be fully residential and limited to a maximum of eighty participants.

The cost inclusive of all meals from dinner on Wednesday evening to lunch on Friday is—

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<th>Members A.I.P.</th>
<th>Non-Members</th>
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<td>Single Accom.</td>
<td>$25</td>
<td>$30</td>
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<tr>
<td>Double Accom.</td>
<td>$20</td>
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It is hoped to assist postgraduate students who may wish to attend the Conference, but are unable to obtain financial support from their Universities.

Those wishing to attend the Conference are asked to return the form below by 15 December.

J. S. Dryden,
(Convenor)

Conference on Ionic Solids
Newport Inn — 29-31 May, 1968

Registration
I wish to attend the Conference

Full Name (Prof, Dr, Mr, Mrs, Miss)

Full Professional Address

I am a member of the A.I.P. □
I am a postgraduate student □

Accommodation
I would prefer
Type of room: □ single □ double □ share double with (as double accommodation is limited, preference will be given to postgraduate students).

Contributors
I would be able to give a paper on

Signature

Date

Completed form should be returned by 15 December to the Conference Secretary—

Mr J. Birch,
National Standards Laboratory,
University Grounds, City Road,
CHIPPENDALE, N.S.W. 2008.

THE AUSTRALIAN PHYSICIST, NOVEMBER, 1967 197
AUSTRALIAN ATOMIC ENERGY COMMISSION
Research Establishment, Lucas Heights, near Sydney

—Physicists and Mathematicians—

Research Scientist  Senior Research Scientist
Principal Research Scientist

Vacancies exist at the Commission's Research Establishment for physicists and mathematicians to undertake research work on various aspects of the physics of reactors.

Position R15:
The appointee will undertake research in the general field of neutron transport theory. Typical topics would be:

- Techniques for numerical solution of equations for transport phenomena.
- Nature of eigenvalue spectra of transport operators.
- Angular dependence of neutron distributions emerging from diffusive media (energy or time-dependent Milne problem).

Experience in the field or in allied fields such as astrophysics will be an advantage.

Position R134:
Applicants should have a background in one or more of the following areas:

- Nuclear reaction theory.
- Optical model theory.
- Statistical fluctuations.
- Theory of fission.

The appointee will be concerned with assessing the validity of experimental nuclear data and with the interpretation of models to give data for reactor calculations. Access to an IBM 360/50 digital computer is available on site.

Applicants must possess a Ph.D. or qualifications and scientific research experience which, taken together, are equivalent thereto, have demonstrated a capacity for independent research and have a breadth of scientific interest which extends beyond their original specialised training. — The publication of the results of research will be encouraged. — Salary, depending upon qualifications and experience, will be within the following ranges:

RESEARCH SCIENTIST ......................... $5250-$6622
SENIOR RESEARCH SCIENTIST ............... $6892-$7974
PRINCIPAL RESEARCH SCIENTIST .......... $8242-$9490

Application forms and further information may be obtained by 'phoning the Recruitment Officer on 531-0111 or writing to the Director, A.A.E.C., Research Establishment, Private Mail Bag, Sutherland, N.S.W. 2232.
THIRD A.I.P. SUMMER SCHOOL—ADELAIDE: FEBRUARY 1968
PLASMA PHYSICS AND LASERS

The Third Summer School of the Australian Institute of Physics will be held at the Flinders University of South Australia, Adelaide, from 5 to 9 February 1968. The School will consist of lectures and discussions on two topics:

(a) Plasma Physics;
(b) Lasers.

The lectures will be at a postgraduate level but will be easily understood by non-specialists in these fields. The topics covered will include (a) the fundamental processes and physical properties as understood at present, (b) the nature of the present work and main lines of investigation and (c) basic physics for engineering and other applications. Visits to appropriate laboratories will also be arranged.

The purpose of the Summer School is to bring together (a) people interested in either fields of study, (b) graduates who have started or are commencing postgraduate research work in these fields in tertiary institutions, industrial or government research laboratories, and (c) provide information for physicists in other fields, in which the applications of lasers and plasma physics are useful, e.g. uses in other fields of physics, engineering, medicine, etc.

Readers are invited to give a contribution in the form of a review paper or a shorter paper covering one of the topics outlined above. Intending contributors are requested to write to Mr E. R. Sandercock, Honorary Secretary, S.A. Branch—A.I.P., School of Physics, S.A. Institute of Technology, North Terrace, Adelaide 5000, before 11 December, and to include the following information:

(a) name
(b) address
(c) proposed paper(s)
(d) indication of the range covered and the level at which the paper is directed.

It is hoped to arrange a School Dinner, the approximate cost of tickets being $4. Accommodation can be reserved in one of the University Colleges in Adelaide at an approximate cost of $5 per day.

Full time research students unable to obtain financial assistance elsewhere may apply to the organizing committee for a grant.

Prospective attendees are asked to complete an enrolment form as well as the attendance form below and return it to Mr E. R. Sandercock, before 11 December 1967.

3RD A.I.P. SUMMER SCHOOL — ADELAIDE: FEBRUARY 1968

Attendance Form

Mr E. R. Sandercock
School of Physics
S.A. Institute of Technology
North Terrace
ADELAIDE, S.A. 5000

It is likely that I shall attend the 3rd A.I.P. Summer School. Please send me an enrolment form and future notices.

I shall/shall not require a reservation in one of the University Colleges.

I shall/shall not contribute a paper. The probable title will be

Name (Mr, Mrs, Miss)..............................................................................................................

SURNAME (in capitals).................................................. First names

Postal Address.........................................................................................................................

(Signature)

THE AUSTRALIAN PHYSICIST, NOVEMBER, 1967 199
Vacancies exist at the Commission’s Research Establishment for physicists and mathematicians to undertake research work on various aspects of the physics of reactors.

**Position E22:**

The appointee will assist with the theoretical analysis of reactor physics experiments. The research programme aims at providing reliable data and methods for reactor physics calculations. It involves application of numerical methods to a variety of problems involving transport of neutrons and their interaction with matter. A sound training in applied mathematics is desirable and some experience with the use of digital computers would be an advantage.

**Position E106:**

In addition to assisting in the general reactor physics research programme (as in E22) studying neutron interaction processes, the appointee will be responsible for supervision of a small group of people who maintain a library of physics computer codes and carry out routine services of desk machine calculations, card punching, etc.

Applicants for these positions preferably should possess a first or second class honours degree in mathematics and/or physics. After some years’ experience in independent research and with proven research results, consideration may be given to transfer to higher status.

Salary, depending upon qualifications and experience, will be within the ranges of—

- **EXPERIMENTAL OFFICER CLASS I**…………….. $3194-$5047
- **EXPERIMENTAL OFFICER CLASS II**…………….. $5261-$5918

(Female salaries are $428 p.a. less than male rates quoted.)

Application forms and further information may be obtained by phoning the Recruitment Officer on 531-0111 or writing to the Director, A.A.E.C., Research Establishment, Private Mail Bag, SUTHERLAND, N.S.W. 2232.
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All AMPEX “VR-7000 Series” recorders are guaranteed to be mechanically and electronically compatible . . . program tapes may be duplicated and sent interstate or overseas and replayed on any other “VR-7000 Series” recorder. This vital feature is an AMPEX exclusive!

Applications for the “VR-7000 Series” are limitless in education and industry; lectures, demonstrations and delicate experimental procedures may be displayed to a mass audience. Things that are too hard to see (too small, too fast or too far away) may be taped in the “Stop Motion” position — thereby providing specific advantages over live instruction.

Picture definition is excellent and audio quality is first class. One spool of AMPEX “Series 147” Videotape provides one hour of continuous television recording. AMPEX cameras available include the Model CC-324 vidicon TV camera, equipped with a 25 mm, 1:4 standard lens, a 12.4 mm, 1:4 wide angle lens and a 50 mm, 1:4 telephoto lens.

For the technically minded the high efficiency video head of the “VR-7000 Series” is guaranteed for 500 hours use. Rotary transformer signal coupling to the video head assures long term reliability . . . and sophisticated all solid state electronics with phase linear replay equalization provides additional specific advantages.

Although the AMPEX “VR-7000 Series” is a professional recorder in every sense of the word, price is attractively low and it is easily operated.

When you invest in portable video recording equipment select the fully compatible AMPEX “VR-7000 Series” . . . the most reliable and technically advanced recorder from the world’s foremost manufacturer. Prompt and efficient service is available in all States from the Australian National Distributors, Simon Gray Pty. Ltd.