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NOTES AND NEWS

Physics and Music

A common observation is that there is an affinity between physics and music. This seems quite obvious to physicists who have musical interests, but there are plenty who do not. It may be a pity that the 'attitudes survey' conducted by the AIP employment survey sub-committee did not include a question which could have proved or disproved the existence of such an affinity once and for all.

Education to the ancient Greeks was Music (the culture of the mind) and Gymnastic (the culture of the body). In the twelfth century, the growth of Universities as centres of knowledge ignored the body and the useful arts (carpentry, woodwork, etc.) and emphasized the sphere of the spirit (grammar, rhetoric, dialectics - trivium) for a bachelor's degree and the physical sphere (arithmetic, geometry, music, astronomy - quadrivium) for a master's degree. Music — which was Pythagorean principles rather than practice — was thus a precursor of physics, or at least of that part which we now call acoustics.

Whatever their basis, physics and music activities continue and a number are evident in this issue. J. Shearer (formerly Reader in Physics, University of WA) has been spending some of his retirement writing about Wagner and Shakespeare (see notice, this page). N.H. Fletcher (Professor of Physics, University of NE) includes amongst his research interests, notable improvements to the theory of strings and pipes (see article on 'Some Problems of Musical Instruments').

H.F. Pollard (Associate Professor of Physics, UNSW) who is well-known as an organist, entertained a large audience at the July meeting of the NSW Branch. The recent installation of a new organ in the Great Hall of the University of Sydney provided the motivation for a lecture on the physics of organs (see article) followed by an informative and entertaining demonstration. In the atmosphere of one of Australia's oldest University buildings, this was undoubtedly physics at its most enjoyable.

NOTICES:

Music and Drama — A commentary on Wagner and Shakespeare (160 pp) by John Shearer (author and publisher). Available at University Bookshops in Australia @ $3.95, or direct from the author (89 Thomas Street, Nedlands, WA 6009).

Wall Chart — A coloured wall chart featuring the specifications of Belling-Lee fusesholders and connectors, Bourns potentiometers, Bussman fuses, Electrosl resistors, Prestinert bushes, RCL switches, Signetics integrated circuits, is available free. Apply (on business letterhead) to Tecnico Electronics, Box 12, Marrickville, NSW 2204 or Box 180, Northcote, VIC 3070.

Small Ads — Readers may have small advertisements placed in the Australian Physicist at a cost of 50 cents per line (maximum - 8 lines). Copy should reach the Editor before the 6th day of the month of issue.

Seismicity and Earthquake Risk

A one-day symposium on this topic will be held at the Bureau of Mineral Resources in Canberra on 5 December 1973. Organising Secretary — D. Derham, BMR, Box 378, Canberra 2601.
SOME PROBLEMS OF MUSICAL ACOUSTICS

N. H. Fletcher

Department of Physics, University of New England

Introduction

To many people the subject of musical acoustics has a peculiarly nineteenth century sound about it — surely Rayleigh and Helmholtz between them solved all the important problems! But physics and music seem to have had a particular affinity since the time of Archimedes and a surprisingly large number of physicists play musical instruments and are interested in the study of their acoustical properties.

For some the wave of the future lies with electronics and the synthesis of entirely new sounds, and I would not decry their enthusiasm, but my purpose here is to look briefly at the analytical approach to traditional musical instruments which has made such great progress in the past few decades. In this field at any rate we must recognise the human ear as superior to the wave analyser, the insight of the master craftsman as superior to the products of computer aided design. But we can use these modern tools to understand the acoustical bases for traditional design solutions and, in this way, both renew our respect for the subtlety of the intuitive approach and extend traditional designs for new purposes.

Strings and Pipes

From ancient times to the present day most musical instruments have been based on one or other of two basic resonant systems — the stretched string or the air column. How simple they seem and with what completeness we expound them to our classes! The transverse eigenfunctions of the string are sine functions and their frequencies are integral multiples \( n \) of the fundamental frequency \( f_0 \). The sound given out by the string when it is plucked is rich in harmonics, with the particular mixture being determined by the plucking point, and each overtone decays exponentially as it loses energy. The organ pipe is nearly as simple, with the open and closed varieties to add interest, and the sound spectrum is \( n f_0 \) or \( (2n - 1) f_0 \) for the two cases. The end correction seems a little mysterious, but it is just 0.6 times the radius so there is obviously some straightforward calculation somewhere. How simple it all is!

Actually, of course, we are deluding ourselves. The overtones of a real string are not harmonic — the stiffness of the string requires that the \( n \)th overtone has frequency

\[
\nu_n = n f_0 \left(1 + 4 \pi^2 n^2 \right),
\]

where the inharmonicity parameter \( \alpha \) increases as the square of the radius for a string of given length tuned to a given pitch. \( \alpha \) for a given string also varies inversely with the tension, which explains the miserable twang emitted by a lightly loaded sonometer in our first year laboratories! The eigenfunctions are not really quite sine functions either, since the stiffness makes the differential equation of fourth order, and they are all coupled together non-linearly through their effect on the tension, or more properly through the longitudinal modes of the string.

We could, perhaps, neglect all this as theoretical sophistry were it not for its practical implications. A piano is tuned by first setting a tempered scale over a central octave and then extending this to the full compass by tuning successive octaves above and below. But an octave is tuned by eliminating beats between the fundamental of the upper note and the first overtone of the lower note. If this first overtone is sharper than a true second harmonic, then the octave will be stretched.

Figure 1

Typical tuning curve for a small piano. Upper notes are tuned sharp and lower notes flat because of inharmonicity of the strings.

Figure 1 shows the cumulative effect of such stretching in ordinary piano tuning. For a harpsichord, which has very thin strings, the effect is scarcely measurable.

The non-linearity, too, shows up in the sound of both piano and harpsichord. Two overtones of frequencies \( v_1 \) and \( v_2 \) interact to pump energy into modes \( v_1 \pm v_2 \) but, due to inharmonicity, this is not exactly a normal mode for the string and slow beat phenomena are produced among the upper partials even for a single string. It is these variations which give "life" to the sound.

Having gone this far, however, we have barely started, for the string is attached to non-rigid supports which couple it to a more-or-less resonant soundboard structure loaded by its own internal damping and its radiation resistance to the air. It is hard to know where to begin an analysis, even if all we wish to do is to specify the wire gauges and overspinning of bass strings to be used to give even volume and properly graded decay time over the whole compass. A classical harpsichord and a modern
piano both behave superbly in their own fashion but it is not yet because physicists understand exactly what is going on!

The situation with a simple organ pipe is even more complex, since we must deal not only with the pipe but also with the air jet which excites it. Even the pipe is bad enough, for the simple end-correction turns out to decrease as the frequency increases so that all the higher resonances of a simple pipe are sharp of true harmonics of the fundamental. Of course we never really have a 'simple pipe' in an instrument, for it is always connected to the blowing mechanism, so that the individual resonances may be either sharp or flat in particular cases.

What happens, though, when we blow the pipe? Are the upper partials harmonics or do they coincide with the pipe resonances, and what determines their amplitudes?

The answer is that the blowing mechanism is generally strongly non-linear, whether it is an air jet or a vibrating reed, and this non-linearity couples together all the upper partials and forces them into harmonic relation to the fundamental. The amplitude of each harmonic then depends upon the characteristics of the non-linear excitation mechanism and the extent to which the harmonic frequency agrees with the frequency of one of the pipe resonances. For a narrow pipe the end correction is small and the resonances are nearly harmonic so that the sound is rich in overtones, while a wide pipe has a dull simple sound. Because there is no inharmonicity, the organ scale is true, rather than being stretched like the piano scale.

A major problem for an organ designer is to construct each rank of pipes so that it is tonally coherent and, somewhat surprisingly, this does not mean that each pipe has the same amount of harmonic development. Rather, the bass pipes must be relatively narrower in scale than the treble pipes so that their harmonic development is greater. Organ builders have good empirical rules to solve this problem, and physics is only now beginning to understand their basis.

For the designer of instruments like the flute, oboe or trombone the problem of balance is different, since the same pipe must serve as the resonator over the whole compass. Once again traditional designs are often excellent and theory is only now beginning to be able to understand their success and to suggest minor modifications.

The Violin Family

Instruments of the violin family have, for a long time, been the basis of orchestral music and to many musicians a fine violin represents the greatest achievement of all time in the field of instrument making. How strange then that the modern violin developed to its present stage during the lifetime of just one group of Italian craftsmen and that the instruments which they produced three hundred years ago are still regarded as the pinnacle of perfection.

In the past twenty years the reasons for the quality of these instruments have been painstakingly analysed and it is now possible to produce modern instruments which nearly equal them. More significantly, perhaps, a whole new string family has been developed based on the violin as prototype but replacing viola, cello and double-bass by more compatible designs and adding a further four instruments to the series to make eight in all. The importance of this development is hard to judge as yet, but may prove to be very great.

Performance Technique

There are, of course, many other instruments to which individualists have given attention but, instead of discussing these, let us look briefly at an entirely different aspect of musical acoustics. Given an instrument, how does one play it and, in particular, how do distinguished performers play it?

Some instruments, like the organ, are fairly easy to analyse since the action is largely mechanical and interest then focuses on the purely musical aspects of performance. Even the piano comes into this class, since the possible range of variation in touch is relatively small. At the other end of the scale, if we regard the human voice as an instrument, then performance is such an individual and physiological matter that most physicists would hesitate to undertake an investigation. Between these two extremes come the 'personal' instruments like the violin, flute and oboe which are readily accessible to physical measurement, and here modern studies are beginning to disclose information of considerable importance.

Generally speaking the studies follow two lines to analyse the sound produced and to relate it to actual performance techniques through measurement of parameters such as bow pressure and speed for violinists and blowing pressure and lip configuration for wind players. Once we are armed with a sufficient understanding of the acoustical principles underlying the sounding of the instrument itself, these observations can yield information which is both interesting for its own sake and important for those who wish to improve their performance technique of that of their students.

At this stage, of course, we begin to move away from the field of simple physics into neighbouring considerations of psychology, physiology and aesthetics. We must ask questions about the nature of human perception and attempt to make value judgments based on experience and intuition rather than following the established general principles which guide most physical research. It is something of a leap from the equation of motion of an open pipe to the niceties of vibrato in flute playing and our foothold on the other side is not yet secure, but physics has, I am sure, something to contribute.

References

For those who would like to read about some of these things in rather greater detail, the following are suggested as a suitable starting point:


PHYSICS AND THE ORGAN PIPE

Howard F. Pollard
School of Physics, UNSW

Introduction

The pipe organ has a complex character, not only because of the large number of individual pipes it contains, but also since its manufacture and installation involves architectural, mechanical, musical and acoustical elements. Architecturally, there is the need to integrate the instrument with the style of the building and its acoustical properties. On the mechanical side a knowledge of engineering skills is required as well as a knowledge of the properties of materials. Musically there is the need to acquire the art of registration (the selection of stops according to acoustical and musical principles) as well as the art of playing on more than one manual together with pedals.

There has always been a close connection between physics and the development of musical instruments. Superficially, an organ pipe is a musical instrument that can be studied independently of the characteristics of the performer. The apparent simplicity of an organ pipe is deceptive since it is only in the last few years that the underlying physical mechanisms involved have come clearly into focus.

Amongst early workers who contributed to the understanding of organ pipes was the French Franciscan friar, Marin Mersenne (1588–1648), who is credited with writing the first scientific text dealing with acoustics (L’Harmonie Universelle, Paris 1635). Hermann Helmholtz (1821–1894) who also made considerable advances in the theory of resonators, summation and difference tones detailed in his book ‘Sensations of Tone’ published in 1862; and Lord Rayleigh (1842–1919) who produced a theory for the end corrections applicable to an open organ pipe and many other contributions described in his ‘Theory of Sound’ published in 1877.

Amongst his many interests, James Clerk Maxwell (1831–1879) kept a skeptical interest in musical acoustics and on one occasion referred to “that untrodde wild between acoustics and music, that Serbonian bog where whole armies of scientific musicians and musical men of science have sunk without filling it up”.

Elements of a Pipe Organ

The earliest form of pipe organ was the hydraulis which dates back to the third century BC. The pipes were mounted on a wind chest and supplied with air under pressure from hand-operated cylindrical pumps. Up to four stops were common on these organs which also had a balanced keyboard and a stop system similar to that in the later slider chest. The pneumatic organ, using a bellows system, is also old, there being a record of one in Constantinople in 395 AD.

During the 12th century in England the portative organ was developed for use in processions. This consisted of a small instrument having only about two octaves which was carried by means of a strap round the shoulder, the performer playing the keys with his right hand and operating a bellows with his left hand. It is recorded that portatives were suitable for both “infernal” and “heavenly” music.

By the early 15th Century some large instruments had been developed consisting of one wind chest with many ranks of pipes sounding at octave and fifth pitches and called the Blockwerk. There were no separate stop controls so that for each note on the keyboard a large number of pipes played. During the 16th century a small positive organ was added, located behind the player, and containing separate ranks of pipes with a light playing action. At first it was necessary for the player to play on the Blockwerk and Positive by means of physically separated keyboards. However, the modern type of console soon appeared which contained more than one keyboard with frequently a third division, the Bruitwerk, located right in front of the player where quick adjustments to the tuning of unstable reed pipes could be made if an emergency arose.

As the size of organs increased and the effort to play them likewise, foot pedals became common in order to control the largest pipes. In a modern organ there are two or more manuals with pedals each of which controls a separate division of the organ. Each manual contains five octaves of keys (61 notes) and the pedals cover 2½ octaves (32 notes). The wind supply to each set of rank of pipes (a row of 61 pipes on the manuals) is controlled by a stop mechanism which is basically a simple mechanical gate which admits or closes off the air to a given rank of pipes.

As shown in figure 1, in the slider chest system all pipes controlled by the same key sit on a common wind channel and share the same pallet which is connected to the key. The arrangement of pipes on such a wind chest is therefore in the form of a matrix with the rows con-
trolled by the stop controls and the columns controlled by the keys (a 61 x n matrix, where n is the number of ranks). For instance, if all the stop controls are pulled on for an organ having 22 ranks of pipes and middle C is played, 22 pipes of different pitches will sound.

Types of pipes

Physically, there are two main types of pipes: the flue pipe and the reed pipe, as shown in figure 2. Flue pipes are usually classified as principal tone or flute tone depending on the type of sound produced. The Principals are the basis of organ tone and consist of sets of cylindrical metal pipes at different pitches usually sounding at octave or fifth intervals. Depending on the ratio of diameter to length, the tone ranges from keen to flutey. The diameter of the pipe determines its high frequency spectrum cutoff.

Flute pipes may be made of wood or metal and have a larger diameter than the principals. They may be open or closed or partly open and may have a tapered body. Flute ranks may be found at all harmonic pitches ranging from Pedal pipes of length 32' (frequency 16.4 Hz for an open pipe) up to the smallest practical size of 3/8" (16, 744 Hz).

The source of sound in a flue pipe is an edge-tone mechanism which is coupled to the resonant air column. The source of sound in reed pipes is a vibrating metal tongue which is also coupled to an air column. Transmission line theory has been applied with some success to the computation of the resonant modes of cylindrical and tapered air columns. One of the problems with real pipes is to make adequate correction for end effects which are usually frequency dependent.

Physics of the Organ Pipe

In order to explain the operation of a flue organ pipe, a satisfactory theory should be able to predict (a) the frequencies of each resonant mode, (b) the relative power radiated by each mode, and hence (c) the overall power radiated by the pipe. In addition, the theory should also be able to predict the scaling required for a rank of pipes, that is, for each pipe in the rank, the ratio of diameter to length is required together with the settings at the mouth of the pipe such as width of flue, height and width of mouth, etc. While the basic mechanisms involved in the operation of a flue pipe seem to be well understood now, there is so far only one theoretical paper which is capable of producing limited quantitative results.

Basic mechanisms in the flue organ pipe

The source of power in a flue organ pipe is a low pressure jet. Air emerges from a narrow rectangular flue and impinges on a sharp edge forming the upper lip of the pipe. Brown (1937) showed that the edge-tone frequency is proportional to the wind velocity and inversely proportional to the height of the mouth. When a resonator is added, a non-linear feedback mechanism comes into play. Under steady operating conditions this takes the form of an alternating pressure disturbance at the point of emergence of the jet which has the effect of modulating the jet. The modulation travels with a velocity approximately 0.4 times the wind velocity and causes vortices to form in the windstream alternately on either side of the upper edge. As shown by Powell (1961), with the right phase and loop-gain conditions, self-sustained oscillations will occur. In the organ pipe the situation is

Figure 1:
Schematic cross-section of a slider chest. The key chambers, one for each key, are divided by partitions.

Figure 2:
Essential features of (a) a flue pipe, and (b) a reed pipe.

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made very complicated since the feedback from the pipe has a complex waveform and the jet system itself has several modes of operation.

It is of interest to note that when an open tube of air is excited externally, for example by a loudspeaker, it does not produce a harmonic series of partial tones. It is found that the simple classical theory does not apply to a radiating column. However, when tightly coupled to a jet source with the right non-linear feedback mechanism, the partial tones radiated by the system are harmonic within 1 part in 1000.

In a new theory proposed by Fletcher (1973) both the air pressure and the pipe modes are written in terms of Fourier series. Both series are coupled by a non-linear acoustic velocity function which provides the necessary feedback at the flue. So far solutions have been found only for a two-mode resonant system so that there is scope for further development along these lines.

Physical Characteristics of the Playing Action

The connections between the player's fingers and the pipes may be made entirely by mechanical means, by a pneumatic system or by some form of electromechanical system. In the mechanical system the keys are connected by a series of levers and roller-boards (which allow for change of direction) to the pallet which admits air into the pipe channel. In this system the player has initial control over the rate of opening of the pallet. The main time delays in operating a mechanical system are (a) the opening time of the pallet, and (b) the speech rates of the pipes. The time to reach steady speech depends on the length of the pipe. Measurements show (Pollard, 1968) that, in normal pipe speech, between 10 and 20 cycles are required in order to achieve a steady state. The initial time delay (the time interval between touching the key and the first onset of sound) for a mechanical organ is usually in the range 30-50 milliseconds.

In the electromechanical system of control the main time delays are (a) the energizing time of the electromagnets which control various pneumatic devices, (b) the operating time of any pneumatic motors and valves, (c) the opening time of the pallet (now no longer under the control of the player), and (d) the speech rates of the pipes. Measurements show that the initial delays for an electromechanical system are commonly in the range 70-80 ms. There is an increasing trend amongst organ builders to revert to the mechanical system of control because of its greater touch sensitivity, the possibility of control over the initial transient sounds, its faster response times and the lower costs of maintenance.

Tone Quality

The old system for specifying steady sounds relied on three parameters: (a) pitch, (b) loudness, and (c) timbre or tone quality. The pitch of a sound is usually closely related to its fundamental frequency, the loudness is the intensity of the sound weighed according to the ear's characteristics. Tone quality has always been assumed to be related to the spectrum of the sound. According to Schouten (1968), the use of an overall term such as tone quality includes too many identifiable parameters. As a result of his researches he suggests the following subdivision for tone quality:

(1) the location of the sound in a range between tonal and noise-like character
(2) specification of the spectral envelope
(3) specification of the time envelope including rise time, duration and decay time
(4) some measures of change — such as (a) formant glide (change in spectral envelope)
(b) micro-intonation (small changes in fundamental frequency)

(5) specification of any acoustic prefix — which may consist of a burst of noise or of more easily excited higher partials of the eventual steady sound.

At present it is not possible to measure all these parameters in a reliable, objective manner. With short-duration transient sounds a major problem is to know the function performed by the ear and brain in assessing the sound. The resolving time of the ear with respect to steady tones is usually assumed to be about 50 ms. With the type of transients which occur in organ pipes there does not appear to be sufficient time for the ear to indulge in any form of Fourier analysis. It is probable that some more subtle system of comparison is involved.

Appendix

The Great Hall organ, University of Sydney

As an illustration of the tonal design of a modern organ, a brief description is given of the new organ in the Great Hall which was designed by Rudolf von Beckerath of Hamburg and built in association with Ronald W. Sharp of Sydney. The organ has three manuals and pedals, 53 speaking stops, 78 ranks and 3947 pipes and was designed with many musical functions in mind, including ceremonial use, solo recitals and the accompaniment of choral and instrumental works. In the abbreviated specification below, the main numbers indicate the basic pipe length for each rank (numbers in a bracket indicate more than one rank of that length), and the Roman symbols, such as IV, indicate a mixture stop containing more than one rank of high-pitched pipes.

GREAT

Principals: 16, 8, 4, 2, IV, IV
Flutes: 8, 4, 2 2/3
Reeds: 16, 8, 4

POSITIVE

Principals: 8, 4, 2, IV-VI
Flutes: 8 (2), 4, 2 2/3, 1 3/5, 1 1/3, 1
Reeds: 16, 8

SWELL

Principals: 4, V-VIII
Flutes: 16, 8 (3), 4, 2 2/3, 2, 1 3/5, 1 1/7
Reeds: 16, 8 (2), 4

PEDAL:

Principals: 16, 8, V
Flutes: 16, 8, 4, 2, III
Reeds: 16 (2), 8, 4

Accessories include manual and pedal couplers, swell pedal, tremolo on positive and swell, 14 adjustable pistons, 1 setter piston and 1 general cancel. The playing action is mechanical and the stop controls are electrically operated.

References


THE SEARCH FOR AND BETTER SUPERCONDUCTORS

T.F. Smith

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Introduction

Since the first discovery of superconductivity in mercury at 4.15 K in 1911 by H. Kammerlingh Onnes, the number of known superconductors has grown to several hundred and includes the majority of the elements either in their equilibrium state, or in a meta-stable state, as induced, for example, by high pressure. With the advent of the now famous theory by J. Bardeen, L.N. Cooper,
and J.R. Schrieffer (the BCS theory) in 1957, the fundamental understanding of the microscopic nature of the superconducting state was formulated in terms of an attractive interaction between the electrons situated in a relatively narrow energy range about the Fermi energy. The BCS theory has provided the explanation of many of the fascinating properties of the superconducting state, and subsequent refinements have brought it to the point where realistic values for the superconducting transition temperature $T_c$ of a number of 'simple' elements (those with nearly free electron-like Fermi surfaces) can be calculated.

Compact superconducting solenoids readily capable of providing fields up to 100 kilogauss (10T) have had a revolutionary impact on magnetic-field studies in the research laboratory and are now finding their way into a diversity of technological applications in fields ranging from transportation to communications. The present development of electrical generators and large d.c. motors incorporating superconducting materials promises an ever increasing industrial application for superconductivity. Given already existing materials, the transmission of the vast quantities of electrical power required by the ever-expanding, densely populated urban areas, particularly in the USA, will very likely depend heavily upon superconducting transmission lines by the end of the century. The full appreciation of the macroscopic quantum nature of the superconducting state, first proposed by F. London in 1935, which came with the brilliant work of B.D. Josephson in 1962, provided the basis for the development of sophisticated electronic devices enabling such sensitive measurements as changes in magnetic flux of order $10^{-10}$ gauss cm$^2$ ($\sim 10^{-18}$ Wb) and a high precision determination of the fundamental constant $e/h$, now employed as a voltage standard.

From even this brief, and by no means exhaustive survey, it is evident that superconductivity has "come of age" and is past the stage of being an esoteric laboratory curiosity. One may be prompted to ask then whether the need remains for the expenditure of further effort towards finding new superconductors, traditionally a significant aspect of research in superconductivity. The answer, I feel, is a very definite yes. Areas of ignorance in our understanding of the occurrence of superconductivity still remain, particularly in the transition metals where their complex Fermi surfaces defy rigorous theoretical treatment. Even a modest increase of the maximum superconducting transition temperature from its present value of 21 K would greatly speed the large scale industrial utilisation of superconductivity. An evaluation of possible inherent limitations upon the establishment of the superconducting state, both at high and low temperatures, calls for as comprehensive a picture of the existence of superconductivity as experiment can provide. The following gives a brief review of some of the current efforts in the quest for further superconducting elements and new materials with higher transition temperatures, which have led the search into the millidegree temperature range and to pressures in excess of 100 kbar.

Search at zero pressure

The magnitude of $T_c$ varies exponentially with the strength of the attractive interaction $V$ between the electrons, i.e. $T_c \propto e^{-1/V}$. It has been said that it is this exponential dependence of $T_c$ upon $V$, the quantity which emerges from theoretical calculation, which has kept the theorist and the experimentalist apart. Certainly, it is this exponential dependence which has necessitated millidegree temperatures and continues to thwart attempts to raise $T_c$. As may be seen from figure 1, in the low temperature regime $T_c$ may easily vary by an order of magnitude for only a small change in $V$, whereas to increase $T_c$ beyond its present maximum value calls for a relatively substantial increase of $V$.

The development of the He$^3$-He$^4$ dilution refrigerator has greatly facilitated the investigation of superconductivity in the millidegree temperature range and led to the discovery of superconductivity in tungsten at 12 mK, thereby filling what, up until then, had been a gap in the overall occurrence of superconductivity amongst the transition metals (see figure 2). However, further endeavours down to 3 mK have failed to uncover any additional superconducting elements. In an attempt to resolve the question of whether superconductivity may occur at yet lower temperatures for Rh and Mg, Mota and co-workers (1971, 1972) have studied the compositional dependence of $T_c$ above 6 mK for a number of alloys in the extensive range of solid solutions which these elements form with Ir and Os, and Cd, respectively. From a reason-

Figure 1:
The variation of $T_c$ with $V$ for a typical Debye temperature of 300 K.
able extrapolation of their data, they arrive at convincing estimates of 0.2 and 0.5 mK respectively for the transition temperatures of the pure elements. It is interesting to note that theoretical prediction put the $T_c$ of Mg in the range 9 - 80 mK (Allan & Cohen 1969). With the extension of this extrapolation procedure to other elements, which have suitable solid solutions, further estimates of $T_c$ values below 3 mK may be anticipated.

Search at High Pressure

The impact of high pressure upon the search for new superconducting elements has been considerable and largely due to the efforts of J. Wittig (1970). Almost one quarter of the present elemental superconductors only become so at high pressure (see figure 2), and fall into two groups, the larger of which is composed of elements which are semi-metals or semi-conductors under ambient conditions, but transform to the metallic state at pressures typically around 100 kbar. All these elements effectively comprise an extension to the occurrence of superconductivity in the 'simple' elements on the right hand side of the periodic system and, viewed as such, it does not seem unreasonable to suppose that the remainder of the members in this section of the table will become superconductors in their metallic forms. Unfortunately, the required pressures are still in excess of those available at low temperature.

Wittig's discovery of pressure induced superconductivity in Ca, Ba and Y presents a particularly interesting situation as these elements are already metallic and located in an area of the periodic system where superconductivity is rare. Furthermore, the superconductivity of Ba and Y has the intriguing aspect of transition temperatures which increase with pressure. Such a pressure enhancement of $T_c$, which has emerged as being a property of a number of the early transition metals, is not found elsewhere amongst the elements. It is tempting to link the appearance of superconductivity and the positive pressure dependence of $T_c$ to a common origin, with a change in the band structure due to a relative displacement of the unoccupied d states and the s band being a likely candidate. Should this be the case it is to be expected that other members of groups I and II will also become superconducting at high pressure.

Cerium represents the unique case of pressure induced superconductivity in an element which possesses strong magnetic character at zero pressure. The possibility that the suppression of the magnetic state in Fe and Cr under pressure might also lead to superconductivity has also been investigated, so far without success. Indeed, on the contrary, P. Schmidt (1973) has found that Cr films which are deposited at room temperature by ion beam sputtering in a noble gas stream and which are crystalline, but have an expanded lattice relative to normal (presumably due to the presence of gas atoms) are superconducting at close to 1 K.

A recent and exciting development in the search for new superconductors amongst the elements has stemmed from the discovery by Skoskiewicz (1972) that hydrogenation of palladium produces superconductivity at close to 4 K for a H/Pd ratio of 0.87. By ion implantation at low temperature Stritzker and Buckel (1972) were able to significantly increase the hydrogen content and in doing so raise $T_c$ to just over 9 K. Deuteration achieved a $T_c$ of 11 K. These are truly remarkable results for a material which is generally regarded as being on the threshold of magnetic order. A yet more dramatic behaviour was found upon deuteration of solid solutions of silver in palladium with a maximum $T_c$ close to 16 K being attained for an alloy containing 20 atomic percent Ag.

Towards Higher $T_c$

Clearly, the study of superconductivity in the elements has enjoyed a considerable success. Unfortunately, the efforts to improve upon the maximum value for $T_c$ have not been so encouraging. The first of the high $T_c$ materials, NbN, was discovered by Justi in 1941. More than a decade lapsed before superconductivity close to 18 K was found in the A15 structure compounds V$_2$3Si and Nb$_3$Sn by Hardy and Hulm (1954) and by Matthiessen (1954). The following 15 years saw a tremendous amount of effort involving a wide variety of preparation techniques and sample treatments before $T_c$ was eventually raised by Matthiessen and his co-workers (Andreev et al. 1968) to its present maximum of 21 K for the compound Nb$_3$ (Al$_{0.75}$Ge$_{0.25}$). The theoretical understanding of superconductivity in the transition metals and their alloys benefitted considerably from the wealth of information which this period of intense experimental activity produced, but throughout, the approach to uncovering new superconducting systems and raising $T_c$ was strictly empirical, relying upon inspired intuition and physical insight based upon the steady accumulation of data. This situation is still true today and the empirically derived "Matthiessen Rules", which relate high $T_c$ values to optimum valence electron per atom ratios close to 5 and 7, continue to be the single successful guideline.

This seeming inability to raise $T_c$ further naturally raises the question of whether there is some inherent limit which has been reached, or at least closely approached. Theoretical arguments would suggest that this may well be the case, though there is sufficient latitude in these to allow for a significant increase in the maximum
value of $T_C$. Experimentally, it has now emerged that high $T_C$ values are only achieved at the expense of structural stability which ultimately leads to a distortion of the crystal lattice and a lowering of $T_C$. This realisation offers what is possibly the most promising direction to be taken in the further search for high $T_C$ materials; namely the investigation of compounds which may be prepared in a metastable state. The value of this approach is demonstrated by the recent discovery by Krupka and co-workers (1973) of superconductivity at 17 K in body-centred cubic Y$_2$C$_3$-Th$_2$C$_3$ mixed compounds which are unstable under ambient conditions and can only be formed at a pressure of 20 - 30 kbar.

Conceptually, there is no reason to consider the origin of the electron pairing interaction to be constrained to the lattice vibrations and recent years have shown what may be described as a theoretical search for superconductors embodying a variety of new interactions. Such model systems, which have included organic salts, thin films, semi-conductors, plasmas and metallic hydrogen, have offered promises of $T_C$ values as high as room temperature. However, as yet, these remain but promises and it is the least glamorous chemical approach which continues to produce the new superconductors.

References

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**BOOK REVIEWS**


Reviewed by R.G. Hewitt, School of Physics, University of Sydney.

This book was written for students without a grounding in calculus and not majoring in physics. It is at an appropriate level for the New South Wales Higher School Certificate and covers a large portion of the 2F and level 1 science syllabi. The first part of the book deals with classical mechanics and includes a chapter on the four basic forces. This is followed by a chapter giving an integrated account of the various forms of energy, and by chapters on fields, magnetism and induction, and oscillations and waves. The latter part of the book treats relativity, quantum mechanics, atomic physics, nuclear physics, and astrophysics and cosmology.

Although the book as a whole is well written, it is the latter chapters on modern physics which provide the main justification for yet another book of this type. The main results of special relativity are derived in a lucid fashion. Reasonably full accounts are given of the hydrogen atom, of the role of the exclusion principle in determining the electronic structures of atoms, molecules and solids, and of radioactivity, nuclear reactions and elementary particles. In addition, the author has managed to unobtrusively include discussions of the ruby laser, superconductivity and of the biological effects of radiation. The final chapter gives details of nuclear reactions in stellar interiors and discusses stellar evolution, pulsars, quasars, black holes and cosmology. Each chapter finishes with a half page summary of the important ideas, a set of questions and a set of simple numerical problems. The author has attempted to weed students from British to MKS units; unfortunately some of the abbreviations for units are not standard SI usage. In view of the positive features of the book, this is a minor point and I recommend the book to high school teachers and local libraries.


Reviewed by L.G. Parry, School of Physics University of New South Wales.

This is part b of a two volume attempt to list the properties of magnetic oxides. Part a was reviewed on p.46 of the March 1971 issue of "The Australian Physicist". Part b comprises the sections on the non-iron garnets, the spinels and the hexagonal ferrites with an index of some 3000 compounds covering both parts. The format is the same as for part a and a number of authors have taken part in the compilation.

The introductory remarks for each section are given in English and German and the technical data are presented in tables and/or graphs with descriptions and captions in either English or German.

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The two parts of volume 4 provide a compact and comprehensive reference to the properties of a wide range of scientifically and technically interesting magnetic oxides which had been published up to the end of 1968. There is some cover, too, of publications in 1969 but this is not complete. This rather seriously limits the use of the volume, as a considerable amount of work has appeared since the last cited references.

The electromagnetic and qgs systems of units have been used in this publication and so conversion to S.I. units requires considerable effort. The descriptive name magnetic moment per unit volume has been used for magnetization \( M \) but generally the various properties have been clearly stated on the inside front cover.

**TOPICS IN SOLID STATE AND QUANTUM ELECTRONICS, W.D. Herschberger (Editor), John Wiley & Sons Inc. 1972, xiii + 506 pp., $23.50**

Reviewed by J.C. Macfarlane, National Standards Laboratory, Chippendale.

The book is the result of efforts by the School of Engineering and Applied Science of the University of California, Los Angeles, to serve engineers, scientists, and recent graduates whose courses of study did not cover a number of currently important topics in solid-state technology. A list of chapter headings will adequately convey the range of subject dealt with:

- Solid State Physics — an Overview; Gunn Effect — Bulk Instabilities; Avalanche Diode Oscillators; High-frequency Ultrasonic Devices; Superconductivity; Lasers; Optical Second Harmonic Generation and Parametric Oscillation; Laser Systems; Image Pick-up and Display Devices; Advances in L.S.I. Technology; Microwave Integrated Circuits; Magnetic Materials.

The reviewer cannot hope to do justice to such a range of fields, but would note that the chapter on superconductivity, by a well-known authority J.E. Mercereau, is a useful introduction for non-specialists, though necessarily rather condensed. The emphasis throughout the book is on device applications, and topics such as ultrasonic amplifiers, impact oscillators and semiconductor lasers are treated at some length. A major aim of this type of book must be to present material which, by its nature, becomes dated over a short time scale. The material here was presented in a course of lectures in 1970, at which time it presumably represented the latest state of the art. The book is generally well written with good illustrations, there is a fairly complete index of subjects and authors, and there are several tables containing useful numerical data on devices and materials.

In summary, the book should find a place in many technical libraries, and will be of assistance to industrial or academic personnel wishing to keep abreast of a number of rapidly-growing technologies.

**THE JAHN-TELLER EFFECT IN MOLECULES AND CRYSTALS, R. Englman, Wiley Interscience 1972, xx + 350 pp. $19.50**

Reviewed by J.R. Pillbrow, Physics Department, Monash University, Clayton, Victoria.

This book provides a thorough and comprehensive account of the Jahn Teller effect by one of the better known workers in the field. The author aimed to describe how the Jahn Teller effect operates rather than to describe the systems in which it operates. This aim has been achieved rather well through concentration upon the physics of the phenomenon and on details of particular physical systems and measurement techniques which were of secondary importance throughout.

The book begins with a useful clarification of what the Jahn-Teller effect is and what it is not. Then follows a discussion of the Born-Oppenheimer and adiabatic approximations and the reasons why corrections to the former are used in theoretical calculations. In the later chapters, the effect is discussed in terms of ideal vibronic systems, the role of strains and other distortions, extended systems and dynamic and relaxation effects.

In the final chapter, results from a surprisingly large range of physical systems are discussed in some detail. About sixty pages of appendices provide a good deal of useful information and, in particular, there is a catalogue of more than 200 systems in which the Jahn-Teller effect occurs.

The major strength of the book lies in the many illuminating insights but its weakness lies in that all but the informed specialist will find the going tough. This is undoubtedly a book for the specialist, but most needs will be met through access to a library copy.

**THE CALENDAR**

**NOVEMBER**

1-2 23rd Council Meeting, Melbourne (AIP).
12-16 A course on Liquid Crystals, Macquarie University.
13 Liquid Crystals, Glenn H. Brown (AIP – NSW)

**JANUARY, 1974.**

21-25 AIP Summer School, Perth, 'Physical Techniques for Mineral Search' (AIP-WA)

**FEBRUARY**

11-13 5th AINSE Nuclear Physics Conference, ANU, Canberra (AINSE)

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STEEL AND RESEARCH

The NSW Branch had a day out on 14 August, 1973 — at Newcastle. Except for the early starters who saw the BHP steelworks in the morning, the visit started at Lysaght's Research Laboratory, continued at the University (with dinner at the Staff House), and finished with a talk by Professor H.C. Webster.

Lysaght's Research Laboratory

Profits and steel strip are the joint themes in research serving a production company. Nevertheless, the enthusiasm for solving problems and doing it in an intellectually pleasing way were quite apparent. Errors in pyrometry for a reflective surface, reduction of the reflectance of a surface with exposure to the atmosphere, and the development of materials with improved properties; these lose none of their challenge just because they apply to a mundane material such as steel strip.

The use of atomic structure models to explain internal friction and the derivation of chemical and structure information from curves for internal friction as a function of temperature; the development of on-line methods for measuring the shape of steel strip; methods for rapid testing of electrical steels; these were some of the other projects shown to visitors. It is nice to be a visitor and not have to worry whether the money that could be saved as a result of any of these developments can exceed the costs of their implementation.

Whatever their philosophical musings, the visitors enjoyed a pleasant and informative hour or so and our thanks must go to the staff for the time and effort spent in making this visit a success.

University of Newcastle

The city of Newcastle is dominated by its industrial foreground, but not so the University. This is dominated by the new Great Hall — a massive brown brick edifice with an air-conditioning chimney picked out in striking blue. Other buildings are low and horizontal, set amongst tall trees.

Research at the Physics Department includes spectroscopy, x-ray emission, geomagnetic micropulsations and airborne infrared studies. A network of micropulsation stations at Hobart, Woomera, Auckland and Newcastle exchange data to study the way in which the sun's radiant energy feeds into the magnetosphere and the ionosphere. Other projects study the emission of radiation from laboratory specimens (such as a scratched metal surface in an ultra-high vacuum) or in field studies of earth resources by plane and satellite.

Research and teaching merge in the development of new ways to give students a feel for physics. At least the demonstrators get a lot of enjoyment out of developing a square aluminium tube as an air table, or microwave emitters and sensors for use in demonstrating the properties of electromagnetic radiation on a size scale much easier to appreciate than for optical wavelengths.

Current research at the Department of Metallurgy includes interactions between solute atoms in x-iron, ordering phenomena in intermetallic compounds such as in x-brasses, and structure sensitive parameters affecting the superconducting transitions in non-stoichimetric niobium alloys.

Once again, the hospitality of the University staff was much appreciated.

The Science Scene in Washington

In a repeat of a lecture given to the Queensland Branch, Professor H.C. Webster described his role as a scientist attached to the Australian Embassy in Washington, and gave thumbnail sketches of many of the problems and plans for physics in the USA.
The effects of the reduction in support for science are well-known in terms of statistics, and the spectacular stories of PhDs doing deliveries. However, much of the personal upset does not reach the outside observer. Although some projects are still supported quite well, University research is very depressed. Perhaps the hardest hit have been the self-employed scientists who had found that they could make more money by starting their own small firms to do development work under contract to NASA, USAEC, etc. These small firms have just folded up.

The initial high level of interest in the possibility of finding employment in Australia has subsided — partly from a realisation that there aren’t many jobs available and partly because the unemployed scientists have found a job or left their profession.

In Government positions, salaries are mostly safe and it has been equipment money that has been pruned. Many scientists have therefore turned from experimental work to theoretical work. A lot of expensive equipment (from particle accelerators to a new ship for marine research) is lying idle while scientists work on the interpretation of earlier work or devise schemes for new projects.

Even although money for pure science has been seriously depleted, much worthwhile research is being done. New accelerators such as the National Accelerator at Batavia, and LAMPF at Los Alamos are to be used for a wide range of projects, while the development of superconducting linacs continues. A 150 inch telescope was recently completed and a very large aerial array for radioastronomy has recently been funded.

Amongst the priority problems listed in the President’s Science and Technology message are Transportation, Clean Energy, and the Anti-Cancer Campaign. The need for work on these topics is well established but the best directions and the prospects for success are not yet so obvious. Electricity or hydrogen to propel vehicles, magnetic levitation, and solar energy conversion are some of the interesting research challenges and there are many stimulating ideas to be tried in these and other fields.

Prof. Webster concluded with the optimistic assessment that, although the USA is facing many very difficult problems, it has the capacity — particularly in young minds — to face up to them and to find solutions.

R. Bird

NOTES AND NEWS

New Senior Science Courses in N.S.W.

Following three years of trials, and a comprehensive evaluation study, new science courses will be generally introduced in 1974-1975 in all N.S.W. schools. The trials covered Project Physics, Chemical Studies, Web of Life, and Geology. There will be two 12-period courses, multistrand (physics, chemistry and biology or geology), and double strand (probably physics and chemistry). There will also be a 6-period multistrand course, and an integrating terminating course.

IAU Conference Held

Over 800 astronomers from 46 countries attended the Fifteenth General Assembly of the IAU in Sydney on 21-30 August. Among other recommendations was one from the working group on lunar nomenclature, honouring a distinguished Australian amateur astronomer, John T. Bell (1834-1916), by naming a crater after him. Also announced was the decision for a collaboration between the Schmidt telescope at Sidings Spring and the ESO 1 m Schmidt in Chile to make a survey of the southern sky similar to the famous Palomar Sky Survey.

Use of Solar Energy

The National Capital Development Commission is studying the possibility of installing solar hot water systems in Canberra. These are already standard equipment for Government houses built in the Northern Territory. The economics of operation is the main consideration, since heaters in Canberra would almost certainly need an electrical booster.

History of Physics in Australia

The following items have been contributed to the AIP Archive by J.F. Richardson (Commonwealth Radiation Laboratory):

Conference of Australian Physicists, 1929; Proceedings and Abstracts of Papers;
Conference of Physicists and Astronomers, 1933; Proceedings and Abstracts of Papers;
Fifth Conference of Physicists and Astronomers, 1936; Proceedings and Abstracts of Papers.

Original copies of the Proceedings and Abstracts for the third (1931) conference are needed to complete this set as the first contributions to the AIP Archive.

Communications relating to the AIP Archive should be addressed to:

Mrs S.W. Hogg, Physics Dept., NSWIT, Thomas St., Broadway, NSW 2007

On Walkabout

Professor K.D. Cole, La Trobe University, is attending the Second General Scientific Assembly of the International Association of Geomagnetism and Aeronomy in Kyoto, Japan, to deliver two invited papers on the subjects of interaction of the solar wind with the geomagnetic field and dissipation of electric fields in the ionosphere.

Physics at the University of Queensland

Research in Physics at the University of Queensland is the title of a booklet describing current activities at
the Physics Department (copies may be obtained from the department, Brisbane 4067). The range of topics covered is indicated by the contents list of the Booklet:

*The Development of Research in Physics at the University of Queensland* — an Introduction.

*The Ionosphere* — Aerial Array Experiments; Satellite Observations; Signals from Distant Transmitters; Automation and Precision (a digital phase ionosonde); The Nature of Ionospheric Irregularities; Processes in the Upper Atmosphere.

*The Magnetosphere.*

*Astrophysics and Atomic Physics.*

*Microwave Spectroscopy.*

*Solid Earth Geophysics* — The Piezomagnetic Effect in Geophysics; Earth Strain and Anelastic Effects; Electric and Magnetic Properties of Rocks; Magnetoelluric Sounding and Heat Flow; The Deep Interior of the Earth.

*Physical Problems of the Local Environment.*

*Nuclear Physics.*

*Crystallography.*

*Radiation Damage.*

**Helium in Bulk**

A special dewar containing 23 800 m$^3$ of liquid helium arrived in Sydney on 25 August 1973 for the Gases Division of CIG and thence for helium users throughout Australia. Replacing the shipment of thousands of compressed gas cylinders, this new method of shipment will improve efficiency with resulting economies which will be passed on to helium consumers.

This story is the theme of issue number 8 of 'Gases in Research and Industry' published by CIG. Helium was first observed as a bright yellow line in the spectrum of the sun and later isolated from uranium-bearing minerals. Nowadays it is extracted from natural gas sources and Australian supplies come from Kansas, USA.

The need for the new bulk helium facility arises from expanding uses in industry, laboratory and even entertainment. Helium has superior properties for some arc-welding applications and as a carrier gas for chromatography (a vital part of oil-refinery operations). Helium-oxygen mixtures are used for deep-diving (beyond 60 m) to avoid nitrogen narcosis.

Vacuum leak-detecting, low temperature instrumentation and applications, and the growth in the interest in superconducting magnets are expanding fields of laboratory use of helium. The first helium liqueifier in Australia was constructed at NSL shortly after World War II and uses of liquid helium at NSL are still expanding.

Helium filled balloons are finding continuing uses in research. The Mildura Balloon Launching Station regularly operates scientific flights for the USAEC, (monitoring atmospheric radiation levels), and for research projects for CSIRO, Melbourne and Adelaide Universities. Some 587 balloons with volumes from 2000 m$^3$ to 1.29 x 10$^6$ m$^3$ have been launched since 1960.

Recovered helium, returned to CIG, is resold as ‘Balloon Gas’. This is popular for use in lighter-than-air balloons sold at fêtes and store promotions. Balloons are also receiving renewed attention for use in advertising and other communications applications. Can man continue in this way — releasing the stocks of helium which have been locked up within the earth’s crust for millenia?

**Nuclear Structure Facility, ANU**

This facility was opened officially on 1 September, 1973, by the Prime Minister, the Hon. E.G. Whitlam. Whilst claiming the credit for a Labour Government in 1947, for establishing the Research School of Physical Sciences and permitting it to conduct research in nuclear physics, the Prime Minister was careful to restrict his approval of nuclear physics “as a discipline, as an exercise in the pursuit of pure knowledge”. “There is room for dispute, passionate dispute, about the practical value of nuclear physics and the technological uses to which it has been put”.

After emphasizing the importance that the Australian Government places on efforts to check the spread of nuclear weapons, the Prime Minister went on to discuss the Labour Party Conference resolution calling on the Australian Government “to stimulate the growth of nuclear technology”. Whereas there is little prospect that the construction of a nuclear power station at Jervis Bay would be revived in the foreseeable future, there may be great opportunities for Australia, as a member of the Association for Centrifuge Enrichment, to develop centrifuge technology, augment mineral earnings and contribute to world-wide nuclear research.

Professor Sir Ernest Titterton in his opening remarks said: “In 1950 when I was appointed to the foundation Chair of Nuclear Physics in this University, there were no..."
buildings, no equipment and no staff. My task was obvious and challenging, it was, simply to build as good a Department of Nuclear Physics as I could with the funds available.” The first accelerator installed in pursuit of this aim was a 1 MeV Cockcroft-Walton. This has since been donated to the University of NSW. A 33 MeV electron synchrotron was installed in 1955 as a gift from Harwell. This accelerator is still in operation at the University of WA. Next there was a 12 MeV EN Tandem accelerator which has now been expanded into a Cyclo-Graff by the addition of a 26 MeV Cyclotron as an injector. The 2 MeV injector no longer required has recently been sold to the University of Queensland.

The final stage in an up-grading expenditure of $2.2 million, has been the installation of a 14UD Pelletron intended for the acceleration of many kinds of ions with a central terminal potential of up to 14 MV. This vertical tandem accelerator is installed in a 22 m long by 5½ m diameter steel pressure vessel which is housed in an ‘ivory tower’ which is now one of the outstanding buildings on the ANU campus.

PHYSICS AND EDUCATION

Committee on Arrangements For Secondary Courses and Assessment

The Victoria Universities Committee has recently set up a Committee on Arrangements for Secondary Courses and Assessments (CASCA). The task of CASCA is a structural one. It is asked to suggest the form of a new statutory body which it is hoped will interest itself in curriculum development, in encouraging teachers in their curriculum development work, and in assessment for entrance to tertiary courses, other training courses, or for employment. It is not CASCA’s task to suggest how questions in these fields should be answered but rather to suggest by what kind of body they should be answered.

The AIP was asked if it has any views it would like to put forward on the nature of the new statutory body of the kind mentioned — its membership, its structures, the powers which should be given to it and the relationship it should have with other bodies. The request was sent to the Victorian Branch Committee of the AIP and the following report is based on a discussion by this Committee. In view of the interest which many members of the AIP have in teaching and in professional standards, it was thought that they might like to see this report.

— H.C. Bolton

The Committee of the Victorian Branch took the view that it could comment only on the likely effects that various methods of assessment and different types of curricula could have on the profession of physics. Because of this, they did not see the need to emphasize the vocational courses at the tertiary level.

It was felt that as an educated scientific profession is vital for the community, the best means of assessment for entry into the professions (via tertiary institutions) are essential. The HSC has many virtues and it would be regrettable if these were abandoned. Whatever type of assessment is finally used, it should, at least, be conducted by an independent body in order that uniformity of standard can be achieved.

The Committee also felt that an early and sequential development of interest in science is necessary. This can, in part, be achieved if the correct type of curriculum is chosen for the secondary schools. It is desirable that this curriculum, at least in its essentials, be standardized. The Committee sees the task of standardization of curricula as a responsibility for the new body.

It seems appropriate to quote from an article on Novosibirsk University in the New Scientist, 3 May, 1973. “Another principle we think important is to hunt out and select young people with an aptitude for science. This has to be done with school children some two or three years before they finish secondary school — using meetings, talks, radio television, scientific circles and so on. The most effective means has been correspondence and direct competitions in mathematics, physics, chemistry and biology — the traditional all-Siberian school olympiads.” The Committee wishes to draw attention to the need, expressed in this quotation, to have objective assessment in science. As professional scientists we live with this daily and recognize its power; we wish to see it continued, especially in the progression from school to University.

The Victorian Branch of the Australian Institute of Physics, in its own way, offers its own contribution to this relationship between secondary and tertiary studies. Each year it holds a Youth Lecture in Melbourne and in selected State centres at which a practising physicist talks to secondary students. It is gratifying to say that the response is measured always in terms of hundreds of enthusiastic students.

Summarizing this part of our report, the Committee saw every need for the presence of tertiary teachers of science on the new body which CASCA had to discuss. The Committee also felt that the new body should cater for physics as VUSEB has done so admirably in the past.

— H.C. Bolton

LETTERS

Typist’s Howlers

Sir;— The transcript of a recent Physics meeting held at Swinburne College of Technology included the following:

Electricity and magnitude
Obes and Optics
motostat (thermostat)

The Australian Physicist, October 1973

171
week stone ridge
forsy-electro (force on an electron).
and the following which has so far defied translation —
resistive afacid discharge.

Physical Science in Australian Hospitals

Sir:— The recent Supply and Demand Report on
Employment of Physicists (Table 5, AP November 1972)
shows a sharp contrast between Commonwealth and
State agencies. Of 1914 physicists employed in 1972 in
the public sector, 69 were in state employment, half of
these being in hospitals. (I hope readers will allow me to
regard Universities and CAE's as "Commonwealth" for
the purpose of this letter.) Although the projected growth
rate in hospital work is a respectable six per cent per
annum, in absolute terms it is miniscule and gives no
early prospect for tackling the physical science and
technology requirements of Australian hospitals on a
worthwhile scale.

My contention that these needs are not being attacked
on a worthwhile scale rests on personal observations in
my own hospital and elsewhere in Australia and comparison
with the conditions in the United Kingdom. In this
country there is no physics establishment with as many
as ten graduates; there is no Professor of Medical Physics
and no department with worthwhile academic standing.
Many of my colleagues are under the direction of a
radiotherapist or other medical chief with no prospect
for grasping the many opportunities for work in electronics,
computing or instrumentation which abound in the
modern hospital. Few of them have an effective voice in
the selection of equipment or a chance to influence equip-
ment purchases on technical grounds. Very few, if any,
are members of the committees which count in the
direction of hospital policy or in settling management
priorities.

In the UK there were six years ago (the latest accessible
figures) 11 departments with more than 10 graduates;
the mean number being 17.7. The largest department
was (and is) in Glasgow with 51 graduates (about 70 now).
This department serves an area and population not
greatly different from that of the Wollongong — Sydney
— Newcastle conurbation, yet the latter has no worth-
while centre for the Physical Sciences in Medicine!

It is not clear to me why the Australian health services
should not require a broadly similar scientific and tech-
nical effort to that of the UK. What can be done here to
establish the kind of growth rate that would put the
Australian endeavour on its feet in a few years? How
can physicists interested in medical work carve out a
bigger piece of the action for themselves? Has the AIP a
role to play?

— D. Puix
Prince of Wales Hospital,
Sydney, NSW.

THE REGISTER

Changes in Membership from 16 July 1973 to

Fellowship

Transfers
Segall, R.L.
Thyer, J.R.W.
University of Melbourne, Vic.
Ballarat Institute of Advanced
Education, Vic.

Associateship

(a) New Elections
Dracoulis, G.D.
Rawlinson, W.R.
Australian National University, ACT.
Kodak (Australasia) Pty. Ltd., Vic.

(b) Transfers
Peter, T.R.
South Australian Institute of
Technology.

Stewart, P.K.
Tytler, R.W.
Education Department of Victoria.
Melbourne College of Education,
Vic.

Graduateship

New Election
Suliman, Y.G.
University of New South Wales.

STUDENTS

New Elections
Elijah, J.S. (NSW)
Mather, P.K. (Vic.)
Winkler, D.A. (Vic.)
Yates, C.J. (Vic.)
MACQUARIE UNIVERSITY
THE CLEAN AIR SOCIETY OF AUSTRALIA AND NEW ZEALAND SCHOLARSHIP IN AIR POLLUTION METEOROLOGY

Applications are invited from suitably qualified candidates for this Scholarship, tenable in 1974. The Scholarship, valued at $600, will assist the successful applicant to undertake a programme of study and research in the field of air pollution meteorology, in the School of Earth Sciences, for any of the following degrees: B.A.(Hons), M.A. or M.A.(Hons), M.Sc. or M.Sc.(Hons), Ph.D. It will be tenable for one year and may be held in conjunction with other awards.

Applicants should arrange for two referees to forward supporting references to the Registrar, Macquarie University.

Applications, including the applicant's name, experience, referees' names, and a certified academic record, should reach the Registrar, Macquarie University, North Ryde, N.S.W., 2113, by 26th November, 1973.

October, 1973
A. J. T. FORD,
Registrar

FOR THE PHYSICIST

Octal ADC 9040
- Eight channel 8 bit ADC's in single width module
- Dual register, giving fast readout times
- Accepts "fast" pulse inputs
- Charge sensitive inputs
- Built in test facility
- No special components; top-leading IC's providing ease of servicing

100 MHz Scaler
- 003 quad 16 bit
- 002 dual 16 bit, with indication of overflow and least significant bits
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