ASSOCIATION OF RESPIRATORY TECHNICIANS AND PHYSIOLOGISTS

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BREATH

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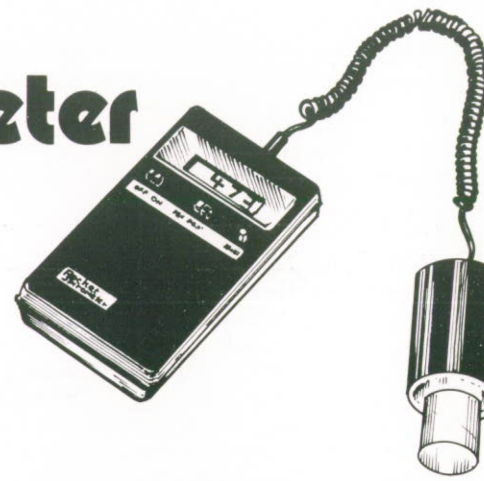

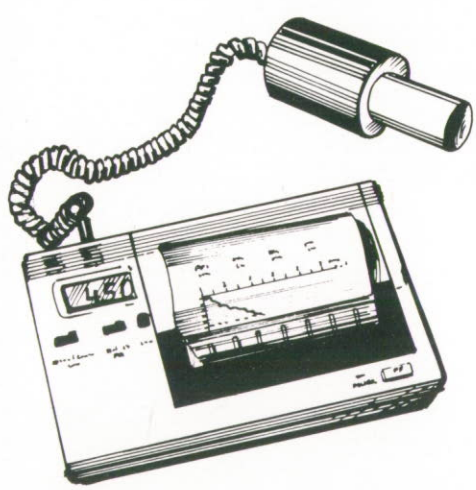

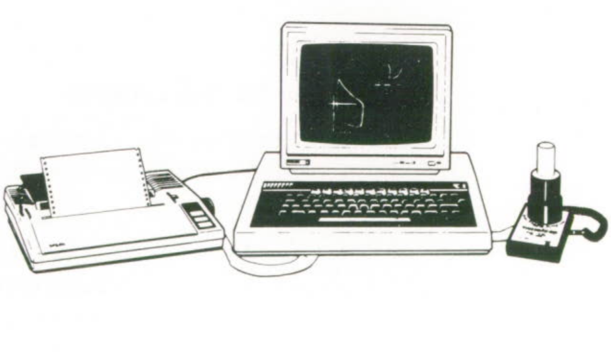

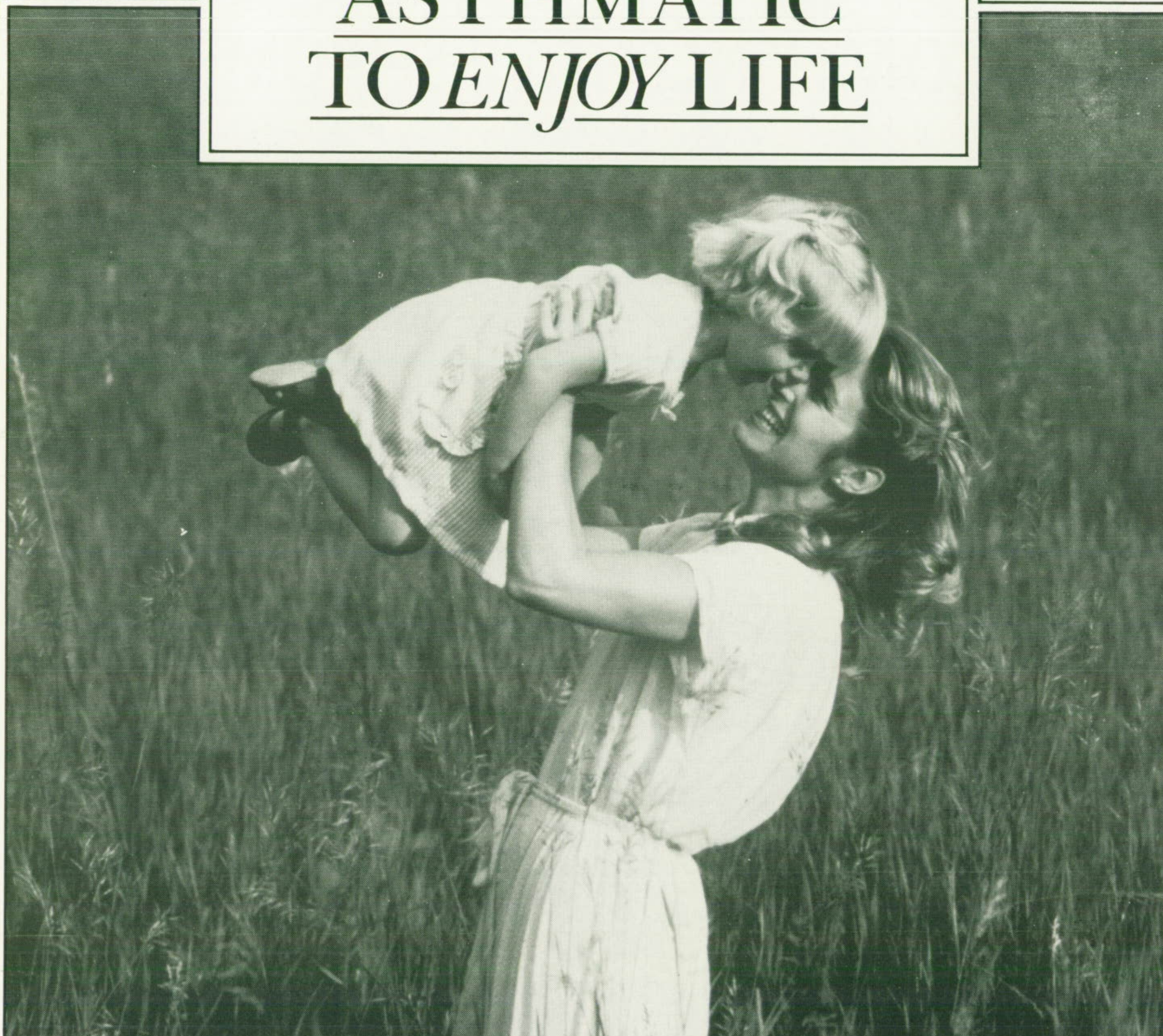

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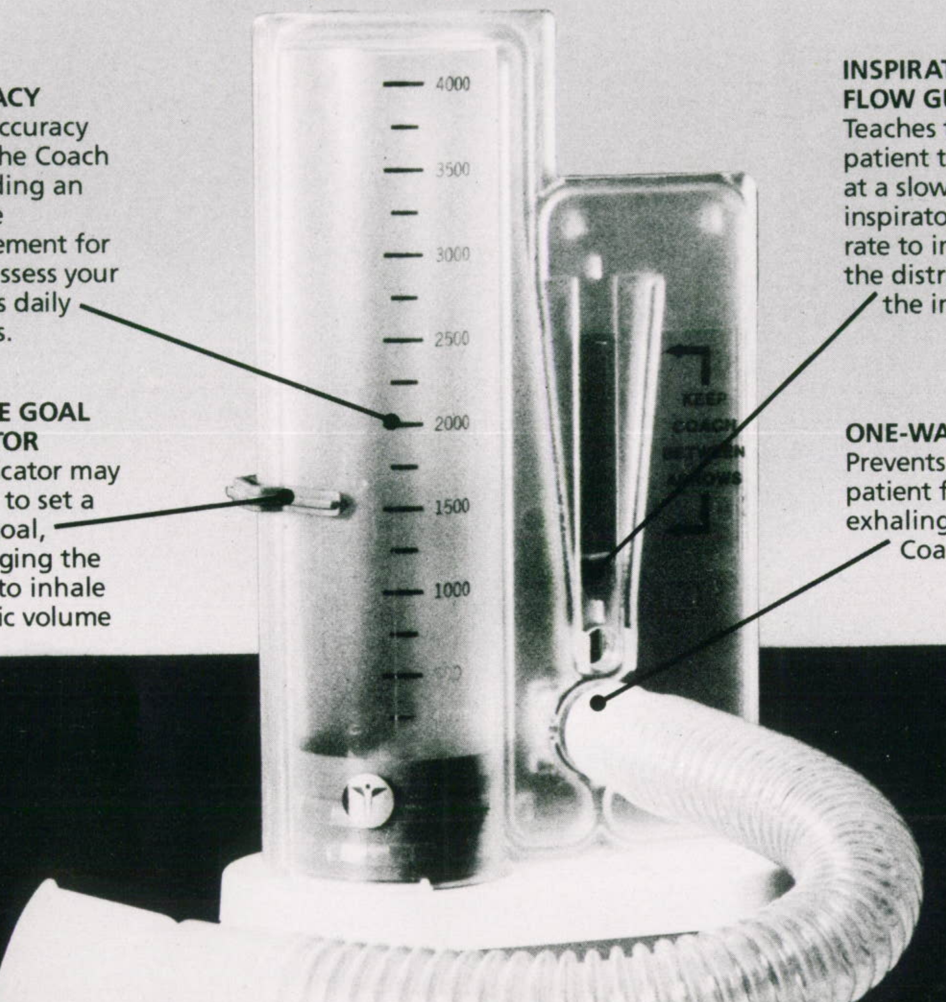

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EDITORIAL

The National Health

The recent General Election obliged many of us to focus our attention again upon that hard-pressed body, our National Health Service, which came into being nearly forty years ago. Just a few of the Election slogans and headlines remain in the memory: 'The pride of the nation' occasionally — more often 'financial disaster', 'brain drain' or 'lost morale' and of course 'it's safe with us'. Not all the debate was trivial and as the manifestoes are tidied away for another five years, this may be an opportune moment to reappraise this Service and to dwell briefly on its background and history.

The National Health Service was established in the year 1948 and now, with over one million on its payroll, has become the largest employer in the country. It was at that time a wholly new concept and Britain was the first country in the world to offer free medical care to the whole of its population. Aneurin Bevan, Minister of Health in the Labour Government, is often credited with its foundation; he was indeed responsible for steering the Act through Parliament though he had to build on much previous legislation and committed endeavour by others.

State involvement in public health really began in the 19th century. The Public Health Act of 1848 was mainly concerned with the provision of clean water supplies and drainage and it comes as a slight shock to realise that even these benign schemes which did so much to improve the nation's health, were vigorously opposed by pressure groups such as the rate-payers on whom the financial burden had to fall. The services provided for patients, on the other hand were niggardly to say the least. Those without financial resources were entitled to receive free medical care through the 'Poor Law' Institutions but only after a means test which many refused to undergo.

A great step forward was achieved in the year 1911, when Lloyd George who was Chancellor of the Exchequer at that time, with great energy obtained the passage of the National Health Insurance Act. This gave certain patients the right to free treatment from a general practitioner, though this right did not extend to their children or to non-working wives. There was much opposition from the upper ranks of the medical profession though support did come from doctors in industrial and inner city areas. The debate was bitter at times with reports of intimidation and even of being 'terrorized', but eventually the scheme was accepted mainly due to a favourable system of remuneration based on the number of patients on the doctor's list.

The hospitals however remained outside this scheme. At that time there were two main types, the 'Voluntary' Hospitals, which depended on charity and the Workhouses administered under the Poor Law. The Voluntary Hospitals even though they had a much higher standard, varied considerably in quality over the country, depending on the generosity of local benefactors. The consultants had 'honorary' appointments, that is to say they worked without direct payment from the hospital and earned their living from private practice. This system was of course much more effective in London and other large cities with a plentiful supply of wealthy patients but in poorer parts of the country the voluntary hospitals had to be staffed by the local general practitioners. The workhouses were of a very poor standard, it seems as a deliberate policy to discourage people from attending!

The National Insurance Act, admirable in many ways, nevertheless left many needy patients outside its net. By the 1940's this had become all too obvious, though opinions differed on what ought to be done. The British Medical Association favoured an extension of the National Insurance principle but the Government was strongly influenced by the Beveridge Report of 1942 which proposed that the Health Service should be funded out of general taxation. Bevan overcame the objections of the medical profession in a now famous phrase:- he 'stuffed their mouths with gold.' In fact with some finesse he divided the profession down the middle; the hospital consultants (or rather, a minority of them) were the only ones to see real gold, by a generous scheme of 'distinction awards', which still exists in much the same form. The general practitioners did rather less well; they had originally been obliged to buy their way into practice and they never managed to get this refunded. Nevertheless, a salaried service was in the end to be a considerable advantage to both staff and patients, and both general practice and the hospital services were finally incorporated into a health service for the whole nation, the great ideal envisaged in the Beveridge Report.

It should not come as much as a surprise to find that this service costs an ever increasing amount of money. The original planners have been accused, unlikely as it may seem, of having considered there to have been a fixed quantity of illness in the community which the free NHS would gradually erode, after which the expenditure would level off. Whether they really thought this or not, the opposite occurred and we have seen ever since its foundation a relentless expansion in the costs of the NHS.

The reasons are not hard to find. In the first place, there have been important and enormously expensive advances in techniques of investigation of which the CT scan is perhaps one of the most spectacular of the new imaging techniques. The same escalation of cost has occurred in treatment methods, including cardiopulmonary bypass and transplant surgery, intensive care and drug prescriptions. In fact all pathological and physiological measurement services have undergone the same expansion. In Respiratory Physiology departments (which barely existed in the 1940's), the FEV_1 and VC were once the only tests required but now CO transfer tests and blood gases and much else besides are mandatory. Computers, unheard of in medicine at that date are now essential to many techniques and their rate of obsolescence is legendary. Departmental and personal prestige likewise depends much on the quantity of staff and equipment and stimulates further financial excesses.

The second main cause of the unexpected, rapid rise in the costs of the NHS was the great expansion of ill-health itself. While the early planners may have been falsely reassured by the apparently falling incidence of problems such as tuberculosis and the promise held out by the immunisation programmes, they did not forecast the subsequent rise in the proportion of the elderly, nor did they and perhaps they could not, anticipate the alarming increase in the so-called 'self-induced' disorders associated with tobacco, alcohol and drug abuse. Like it or not, the NHS cannot walk away from these problems and must not only supply whatever investigative and therapeutic services are required, but put a major effort into preventive medicine, with a special emphasis on Health Education which as yet touches only a minority of the population. The Government's lack of commitment to this aspect of the problem is exemplified by the abolition of the Health Education Council grants and its continuing dependence on the tobacco and alcohol revenues to balance the books.

Any Health Service worth the name should be able to improve the health and well-being of every section of the community but we now have powerful evidence that this is not the case. The evidence is marshalled in the 'Black Report' drawn up by the Royal College of Physicians under the leadership of Sir Douglas Black. Their investigations have brought to light serious inequalities of health in this country. While there are significant regional and sex variations the most striking differences are those that are based on social class, that is, the occupation-based classification used by the Registrar-General. The problem is particularly obvious in the field of respiratory medicine where there are highly significant gradients across the social classes. To put it bluntly, the mortality ratio for respiratory disease is far higher among unskilled manual workers than among the professional classes. What is more, these trends, instead of improving with the passage of time as one would be entitled to expect, are growing steadily worse.

How do we account for this grave state of affairs? A possible reason is that those in manual trades are more likely to be exposed to toxic dusts and fumes, but unfortunately for this theory only a minority are in occupations associated with such hazards. Another reason put forward is ineffective use of the health services; again there may be an element of truth in this though it does not explain why the patients need to consult the health service in the first place. It seems only too likely that this is largely due to the old enemy, tobacco smoking. Tobacco consumption has for many years been higher among these occupational groups and the increasing trend can be accounted for very neatly by the fact that over the last twenty years the swing away from tobacco has been greatest among the professional classes. This answer merely points yet again to the failure of the Health Education programmes to alleviate the problem.

The overall cost of the NHS in the year 1984 was over £16,000 million, a sum that has been calculated as 6.2% of the gross national product; this is a lower percentage than in any other Western developed nation. Debate still continues on where the money should come from. Some still consider that it should be found through an extension of the principle of private insurance; this is no doubt possible but would leave out the high-risk groups such as the poor and the elderly who will still need to be cared for out of general taxation. Private profit-making hospitals have over the last ten years expanded at twice the rate of the NHS and have attracted staff away from the NHS by their favourable rates of pay. From time to time we hear the call for 'privatization' but to take this road holds a serious danger of a return to the pre-1948 two-tiered system where those most in need get least.

In the final analysis, we will have to recognize the fact that the NHS has a task which can never be fulfilled. This was recognised years ago by the more perspicacious and has now been stated more formally by Sir Bryan Thwaites, Chairman of the Wessex Regional Health Authority and a noted mathematician. He has calculated that 'expectations' (roughly speaking, what the public wants) always rise at an annual rate which is about twice what can be supplied. QED, the NHS can never fulfil the demands made upon it. It follows therefore that hard choices have to be made and someone, somewhere has to take the onerous decisions on how to divide limited funds between a multitude of worthy causes. Some of these causes have been spelt out in the Black Report with health education, early detection of disease and the care of children and the disabled being high on the list. It is time this crucial document was taken more seriously.

Further Reading:

Ham C. Health Policy in Britain 2nd Ed. (1985). MacMillan, Basingstoke.

Townsend P, Davidson N (Eds) (1982) Inequalities in Health — The Black Report. Penguin Books.

Abel-Smith B. National Health Service — The first thirty years (1978). HMSO, London.

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COMPUTER INTERFACING: an example using the BBC microcomputer

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Summary

The BBC microcomputer is easily interfaced to lung function equipment; it has four types of interface (not counting a printer interface and a second processor connection) as standard, a fast BASIC which is easily mixed with machine code for greater speed, and an operating system designed to simplify the use of interfaces. In this paper, an exercise test system is described to illustrate ways in which two of the interfaces may be used.

Ventilation is measured by an optically coded disc on a gas meter, the data being read through the user port, which contains a simple serial input. The heart rate is also read by the user port, this time using the integral counter to count pulses derived from the ECG. Two more lines from the user port, control sampling of expired gas. Expired gas concentrations are read directly from electronic analysers by two of the four analogue inputs.

Two BBC micro facilities, the simple interrupt handling and the paged ROM system, are used in the sampling program. This is a multi-tasking machine code program held in a ROM which is called from the main program, which is written in BASIC for easy modification. A glossary and further technical details are given as appendices.

Introduction

The BBC micro is probably the easiest microcomputer to use for physiological measurement in that it has a wide range of sockets which may be connected to measuring equipment. In Southampton we use two of these standard interfaces to collect data from exercise tests. The following description of our system is intended to suggest ways of interfacing the BBC micro. Many of the techniques are also applicable to other microcomputers, but in most cases additional electronics would be required.

Space does not allow full explanations of all the technical terms used here, but Appendix 1 contains definitions of those which students starting BTEC level III would not be expected to know.

The BBC micro connections most used for physiological measurements are:

1. The analogue port, which can measure up to four analogue signals.
2. The user port, a multi-purpose interface containing ten digital signal lines, which is described more fully below.
3. The RS423 port, which can send to, or receive information from a wide range of standard equipment such as printers, ear oximeters and other computers.
4. The 1 MHz bus, to which many more specialised devices such as fast analogue to digital converters and EPROM programmers may be attached.

Our exercise test system only uses the first two (Fig. 1)

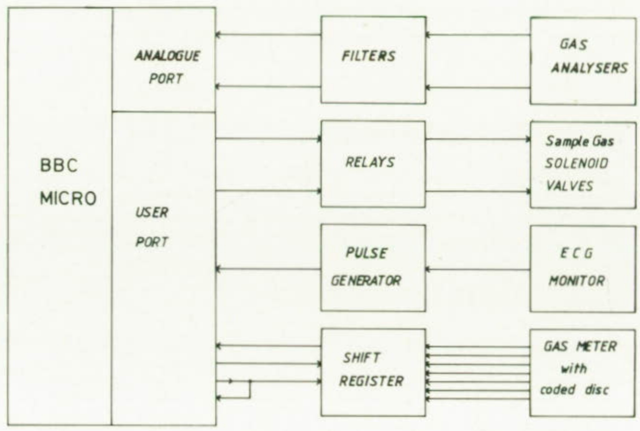

Fig. 1. Block diagram of the exercise test system showing the interconnections.

Methods and Results

Our system measures each breath and calculates mean tidal volume and minute ventilation and also counts the heart rate. In order to measure oxygen uptake and CO_2 production the expired gas is mixed and then sampled over each minute into a sample bag while the previous sample, in another sample bag, is analysed. At the end of each minute the bags are switched by a solenoid valve.

All these various operations have to be carried out together. The program has to measure the composition of expired gases, interchange the gas sampling bags once a minute, count the pulse, measure each tidal volume, display the time and the curent work load on the screen and store all the data. The easiest way to do this is by multi-tasking, that is, by using a system which allocates time to a number of programs which appear to run simultaneously.
While BBC BASIC is not itself multi-tasking, its operating system provides 'events', (such as the 'vertical sync event', which occurs every 20 msec) which are designed to help programmers to synchronise machine-code routines or even to write simple multi -tasking programs without using timers or special interrupt routines. For instance, if the BBC is used to measure flow-volume curves then the vertical sync event can be used to trigger each volume measurement. This program contains about 100 bytes of machine code which use the vertical sync event to run each of the various tasks at predetermined times.

Another clever BBC micro idea is that machine code programs may be held in plug-in chips (ROM's) and called by name from within BASIC programs. This is particularly useful in that the collection of data can be done by standard programs in ROM, while the analysis and presentation of the data may be performed by easily written and easily altered BASIC programs. It also saves memory, a scarce commodity in the BBC model B.

Our ROM program, called *EXTEST, first allows the volume measuring system and gas analyser calibrations to be checked. It then makes minute by minute measurements until the end of the test, calibrates the gas analysers, carries out corrections for temperature and pressure and calculates O_2 uptake and CO_2 production. It then returns to BASIC with the data stored in an array at a predetermined location.

The BASIC program normally used, first runs the *EXTEST program. It then displays the collected data and allows the user to alter values (for instance, to insert interpolated data for heart rate for a minute in which an electrode came loose). The patient's personal data are then entered and a report form generated (Fig. 2).

SOUTHAMPTON UNIVERSITY HOSPITALS — Name
RESPIRATORY UNIT — No 4054
Age 23

EXERCISE TEST
Female — Physician

Reason for test — Date 5th May 1984

Height — Weight

MIN	LOAD	PULSE	VE	VT	VO_2	VCO_2
1	0	104	12.20	0.610	0.360	0.315
2	0	115	11.56	0.608	0.336	0.297
3	15	124	18.72	0.624	0.591	0.504
4	30	140	23.86	0.745	0.869	0.656
5	45	145	27.72	0.792	0.977	0.788
6	60	149	31.21	1.040	1.198	0.938
7	75	152	34.51	1.190	1.336	1.083
8	90	162	43.41	1.113	1.619	1.360
9	105	163	44.24	1.264	1.691	1.471
10	120	175	55.35	1.495	1.994	1.775

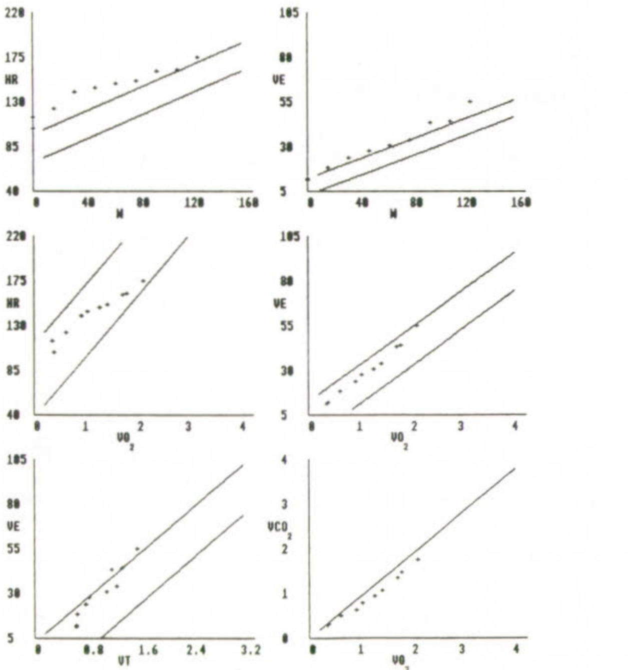

Fig. 2. A typical report form generated from the patient's data.

Valve outputs

Our system uses two solenoid valves. One interchanges the two sample bags as described above, while the other switches the analysers either to the sample bags or to the calibration gases. Both valves are controlled by lines from the user port. A simplified version of the circuit used is shown in Fig. 3. This circuit will operate relays in the voltage range 5-15 volts, but an external power supply should be used to avoid overloading the BBC.

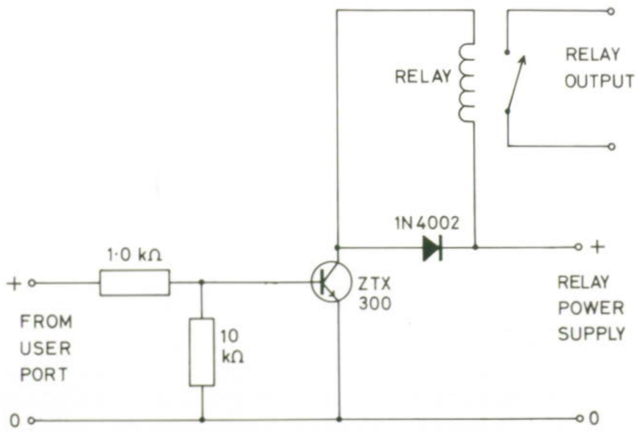

Fig. 3. Simplified diagram of the relay driving circuit.

The BBC user port has eight data lines, PBO to PB7. Each of these may be defined as an input or an output by writing a 0 or 1 to the appropriate bit of the user port control register, either directly or, preferably, by using the operating system call (*FX97) provided. Further details may be found on p.467 of the user guide (1).

Gas concentrations

Mixed expired gas concentrations, measured with commonly used gas analysers, are measured by the BBC analogue port (Fig. 4). Up to four separate analogue inputs may be read by the BASIC command ADVAL, but our program is in machine code and therefore calls an OSBYTE routine (BBC user guide p.429 (Reference 1)). Details of the interface circuitry are given in Appendix 2.

Pulse counting

The chip (6522 VIA; see reference 2) which provides the user port has a number of useful facilities. One of these is the ability to automatically count pulses sent to it on one of the user port lines (line PB6). Briefly, this is done by loading one of the chip's counters (timer T2) with a number. Each input pulse will decrement this number, which may be read at any time. Unfortunately the BBC micro has no inbuilt software to use the manifold possibilities offered by the user port VIA, so users must write their own programs. The following program will count pulses over a minute:

```
10  ?&FE6B = &20 :REM set up Auxiliary Control Register
20  maxcount% = 400 :REM number larger than the expected
    maximum count
30  ?&FE68 = (maxcount% MOD &100) :REM load low byte
    T2
40  TIME = 0
50  ?&FE69 = (maxcount% DIV &100) :REM load high byte
    T2
60  REPEAT
70  REM do what you like while pulses come in
80  UNTIL TIME> = 6000
90  highcount% = ?&FE69
100 lowcount% = ?&FE68
110 IF lowcount% = 0 THEN highcount% = ?&FE69
120 REM read high byte again in case there's an error
130 count% = maxcount%-lowcount%-highcount%*&100
140 PRINT "COUNT = ";count%
```

Heart rate is counted by this method. The isolated output from an ECG monitor must first be converted from an analogue ECG signal to a pulse train. An outline of the circuitry which we use for this is given in Appendix 3.

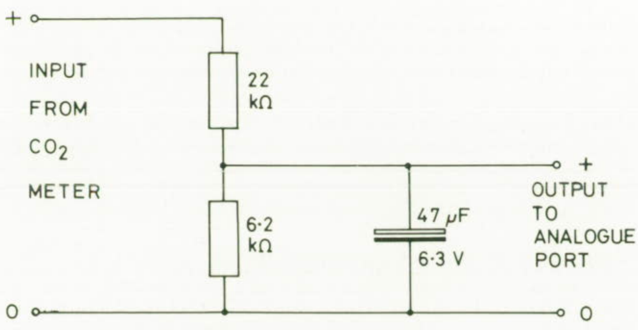

Fig. 4. Filter for analogue port.

Volume

A dry gas meter is used to measure volume. Gas meters may be read by counting the pulses produced by a coded disc, but with this method it is difficult to sense the position of rotation reliably and small errors tend to creep in with pulsatile flow. Our system measures actual disc position by means of a home-made optical disc (which costs £3, far less than a ready-made version). The disc is coded, not in pure binary, but in the Gray code (see Appendix 4) to avoid errors as numbers change. The disc is read by seven pairs of infra-red emitters and receivers. The resulting seven bit number is converted from parallel to serial form by a shift register and sent to the BBC micro. There is also a decoding circuit connected to a cheap digital to analogue converter so that the gas meter may also be connected to a chart recorder.

The BBC micro comes with a serial (RS423) port and the software to run it, but fairly complex circuitry is needed to send data to this port. Fortunately, among the facilities offered by the user port VIA is a simple serial register. This reads data on user port line CB2, using a data clock which it reads from user port line CB1. This data clock may be sent out on any other user port line (we use PB7). The procedure is this: A program sends a load pulse out on user port line PB5, which has previously been defined as an output. This loads the gas meter's shift register. In the same way the program then sends 8 clock pulses out on line PB7 in order to clock the data out of the sending shift register along line CB2. Line PB7 is connected to CB1, so that these pulses also shift the data into the VIA, where they are stored in the VIA's shift register. The program then reads this shift register, which lives at address &FE6A. Finally, a short program converts the volume from Gray code to binary.

Discussion

While it is particularly easy to connect measuring instruments to the BBC micro, other computers may also be used, provided that access is provided for the interface; some machines only provide RS232 or IEEE488 connections, which are relatively expensive and inflexible compared with a simple parallel port such as that provided by the BBC's user port 6522 VIA.

A 6522 VIA may be added to many other 6502, 6809 or 68008 based micros, including the QL and the Dragon, the latter even providing a chip select line so that an interface can be built with a single chip, a circuit board and a capacitor to smooth the power supply. Analogue to digital converters such as the Ferranti ZN433 may easily be connected to such an interface.

When choosing a computer for a measuring task it should be borne in mind that although the BBC micro is relatively expensive, adding interfaces to other computers is often more expensive. This is particularly so where standard industrial interface boards are fitted to machines primarily designed for business use. Such machines may also have a BASIC much slower than the BBC micro, so that other languages or machine code may be necessary even for quite simple tasks like measuring tidal volume. Furthermore, writing programs for machines without interfaces as standard is often more difficult and time consuming.

Although *EXTEST was written in machine code it is possible to write multi-tasking applications or carry out timed sampling using high-level languages. For instance, this application was originally written using Skywave Software's MultiFORTH—83. Other machines, such as the QL and those using BASIC09, will allow multitasking in BASIC. In machines where machine code has to be used it is often possible to intercept a regular interrupt, such as the 50 Hz interrupt in the Dragon.

The *EXTEST ROM also contains a 'screen dump' program which enables the writers of programs in BASIC to draw their graphs on paper using a printer. Such software is commercially available for most computers using graphics; a screen dump ROM makes a BBC micro and a cheap printer into a combined data logger and four-channel X/Y, Y/T chart recorder, though in many cases it will be necessary to build an amplifier or a gain control similar to that in Fig. 4 to adjust the input signal levels.

References

1. Coll J, Allen D (1982). The BBC Microcomputer user guide. British Broadcasting Corporation, London.
2. Commodore Semiconductor Group (1979). NMOS data sheets: 6522 Versatile Interface Adapter (VIA), 2-35 to 2-47
3. Bray A C, Dickens A C, Holmes M A (1983). The advanced user guide for the BBC microcomputer. The Cambridge Microcomputer centre, Cambridge.

Appendix 1: Glossary

Array: a block of numbers. Arrays usually have a predetermined size and structure.

BASIC: the main high-level language used by the BBC micro.

Bit: One binary digit, with a value of either 0 or 1. A bit may represent a logical state (e.g. solenoid valve open or closed) or carry the weight of some power of 2 within a binary number, e.g. the '1' in the binary number 0100 has the weighting 4, so the value of the complete 4 bit number is 4. See also Appendix 3 (Gray Code).

Byte: A binary number, usually of 8 bits, or space for such a number.

High-level language: a computer language in which programs may be written in more or less intelligible text which is ultimately translated into machine code. High level languages are easier to use and less error-prone than direct machine code but are less flexible and the resulting programs usually run slower.

Interrupt: A signal within a computer to inform it of an event (e.g. a key-press) which requires attention. The internal timers of most microcomputers generate regular interrupts. Many commonly-used interrupts in the BBC micro may be intercepted easily using 'event handling'.

Machine code (language): The numeric instructions required by a computer's processor. Machine code may be written as a list of numbers, but more usually a translating program known as an Assembler is used. The BBC micro is unusual in having an assembler built into BASIC, so that machine code may be used within BASIC.

Operating system: The program which manages a computer's operation and provides facilities (such as reading lines of text from the keyboard) for other programs, including the languages used by the computer.

Parallel (data): Digital data presented simultaneously over several wires, c.f. 'serial'. Data transfer within a computer is usually in parallel.

Register: a store, often within a complex chip like a microprocessor, where one or more (often 8) bits of data are held or processed.

ROM: Read-Only-Memory. Contains data or programs which cannot be altered either during normal operation or when power is turned off. Quarter of the BBC memory map is allotted to any one of up to 15 ROM's (including the BASIC language ROM), which may be interchanged as the operator requires.

Serial (data): Digital data sent, one bit at a time, down a single wire.

Shift register: A device to convert serial to parallel data, or vice-versa.

Appendix 2: Analogue Measurements

The BBC analogue port is notorious for giving noisy, drifting readings. Noise may be reduced by taking a series of readings over a period of time and then averaging. Our program averages 32 samples over about 7 seconds. The input signal may also be filtered to remove high-frequency noise such as mains hum. We use the circuit shown in Fig. 4. The two resistors reduce the voltage provided by the gas analysers to the level required by the BBC, that is, from 0 to about 1.5 volts full scale. The values shown are for the CO_2 signal. Increasing the value of the 22 k resistor would decrease the sensitivity, and vice versa. The capacitor filters the signal, removing high frequency noise. The value shown gives a time constant of just under 0.25 sec, and is suitable for signals which take at least a second to change; for measuring end-tidal CO_2 the capacitor would have to be about one tenth of this value. The filters are built into the analogue port connecting plug to reduce noise still further.

Another source of noise is the analogue 0 volts (signal earth) line. When compared with mains earth it is noisy and can give rise to errors when voltages from other earthed equipment are measured. A simple op-amp circuit may be used to add the difference between BBC analogue 0 volts and signal 0 volts to the incoming signal.

Drift is almost eliminated (at the expense of a change in sensitivity) by replacing the diode chain used in the BBC as a voltage reference by a ZN423 band-gap reference. This may be done by cutting the wire on one of the diodes D6,7 or 9 and soldering the reference between the anode of D9 and cathode of D6. R71 must also be bridged, by a 2.2 k resistor, in order to provide sufficient current for the ZN423. The BBC Master has a space reserved for a voltage reference.

If the analogue port is used to read a potentiometer position (for reading a spirometer, for instance), then a much simpler way to eliminate drift is to power the potentiometer by the reference voltage signal, which is available on pin 11 of the analogue port. In this way any drift of the reference voltage will be mirrored in the signal voltage and thus cancelled out. It is possible to connect two potentiometers of 10 k or more in this way, but any greater load would require additional circuitry to buffer the reference voltage.

The BBC analogue port is also rather slow. For fast measurements or with other computers it may be necessary to use a separate A-D converter. The ZN427, giving 8 bit accuracy, is easy to use and very fast, while for the greater accuracy required to record flow-volume curves a ZN433 10-bit converter can be used. (The complete interface costs less than £100).

Appendix 3: Pulse Counting Circuit

The isolated output from an ECG monitor is first filtered by two second order filters which cut off low frequency drift below 12 Hz and high frequency noise above 22 Hz. The signal is then adjusted to a constant strength by a variable-gain amplifier. Small oscillations (such as those caused by prominent P waves) are then removed by a couple of back-to-back diodes in parallel. Lastly the signal is squared up by a trigger circuit with hysteresis which is high after a transition but which decreases with time; this helps prevent false triggering by noise pulses such as movement artefacts. The squared signal then triggers 0.15 sec pulses which are sent to the computer. These pulses are also displayed by a light so that the operator can check the system is working properly.

Appendix 4: Gray Code

On transitions between certain numbers (e.g. 3 to 4, 011 to 100) optical readers may give erroneous intermediate values. The Gray code is a binary code in which only one bit changes at a time, and so such uncertainties cannot occur. A comparison of Gray code and pure binary is given below for 3-bit numbers.

Decimal	Gray code	Pure binary	possible transitional errors
0	000	000	
1	001	001	
			000,011
2	011	010	
3	010	011	
			000,001,010,101,110,111
4	110	100	
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BIRD FANCIER'S LUNG

Roger White, Consultant Physician, Frenchay Hospital, BRISTOL.

Bird fancier's lung arises as a result of allergy to avian protein and is one of a number of types of extrinsic alveolitis where damage to the lung parenchyma arises as a result of inhalation of foreign protein. In this instance the protein is excreted from birds through their feathers and faeces. In response to inhalation of the protein a susceptible subject will develop precipitating antibodies which can be identified by examination of the serum. In the early stages of the condition, an alveolitis occurs which is completely reversible if the offending allergen is withdrawn but if the antigenic challenge continues over a period of months or years, the condition can progress to cause irreversible fibrosis of the alveoli. It is important to distinguish this condition from the other main disease resulting from bird contact, that is psittacosis. Psittacosis is an infection with a clinical picture of bronchitis or pneumonia lasting for two or three weeks, whereas bird fancier's lung is an allergic condition and unrelated to infection.

Clinical Features

The main symptoms of the disease are cough and breathlessness of gradual onset. In younger patients weight loss may also occur. In some of the other causes of extrinsic alveolitis such as farmer's lung, where symptoms arise from contact with mouldy hay there is a more acute illness with the onset of dyspnoea several hours after contact with the allergen. In bird fancier's lung, it is unusual for there to be such acute symptoms and most patients report very little variation in their breathlessness from day to day.

Physical examination reveals fine inspiratory crackles at the lung bases in the early stages and as the disease progresses these crackles become more widespread. Where the disease has been unrecognised and presents at a very late stage there may be signs of respiratory failure with cyanosis and perhaps cor pulmonale. Diagnosis is not usually too difficult as long as the crucial question about contact with birds has been asked. The disease is most frequent in people keeping budgerigars or pigeons, but in recent years I have seen several patients developing the disease from parakeets.

Investigations

The chest x-ray in the early stages shows a rather vague 'ground glass' appearance in the lung fields. The changes can be very subtle and on occasions the x-ray may be reported as normal, particularly in rather obese patients where some haziness of the lung fields is not uncommon.

In more advanced disease, the lung changes are obvious with nodular and linear shadowing resulting from more extensive alveolitis and from developing fibrosis (Fig.1). The diagnosis is confirmed by finding precipitating antibodies to the bird protein in the patient's serum. The presence of this antibody in a person with a budgerigar, breathlessness and an abnormal radiograph is diagnostic of the disease. Pigeon fanciers, however, can develop antibodies in the blood without clinical evidence of the disease. As with budgerigar fanciers however, the presence of antibody in a patient with alveolitis is very suggestive of this disease.

In difficult cases a challenge test can be arranged. The patient sweeps some of the contents of the floor of the pigeon loft into a plastic bag and brings this to the hospital. After baseline lung function tests the patient is confined to a single room for about twenty minutes and with a small shovel transfers this material from one tray to another, thus creating a dust which is inhaled. Ventilatory tests are performed every half-hour for the next eight hours and the full tests are repeated on the following day. In the event of a positive test with a fall of FEV_1 peak flow and gas transfer, five or six hours after exposure, a control test is set up on another day with a different kind of dust, such as the contents of a vacuum cleaner bag.

Lung function tests There is usually a restrictive ventilatory defect with reduction in gas transfer. These changes are completely reversible if the disease is recognised at an early stage, but in some cases the disease is so far advanced and there is so much pulmonary fibrosis that no improvement can be achieved.

Treatment

Where the disease is caused by budgerigars, parakeets, or other house birds, there is really no alternative to removal of the bird. This may be all that is required to achieve complete clearing of the active alveolitis and certainly there is usually improvement in the lung function tests and in the chest x-ray within a few weeks. I do, however, usually give a course of corticosteroids in the form of Prednisolone for two to three weeks in order to ensure complete suppression of any residual alveolitis and to achieve maximum reversibility. In pigeon fanciers the situation is slightly different, because exposure is less constant. Most of the inhalation of offending allergen probably occurs when the loft is being cleared out and this can sometimes be done by a friend or relative. Many pigeon fanciers are completely engrossed in their hobby and have no intention of disposing of their birds. There is some evidence that the wearing of a mask whilst in contact with the pigeons can give protection against the disease, but in these circumstances I impress upon the patients the importance of regular review with serial measurements of lung function so that detection of recurrence or of progression of the disease can be made at an early stage.

Case History

A 48 year old woman was referred by her General Practitioner because of breathlessness. She found it difficult to date the onset of her symptoms but she had reported these to her doctor following a holiday in Guernsey where she found some difficulty in negotiating the hills of St Peter Port. She was a short, stout lady and it had not been unreasonable to attribute her symptoms to her obesity. She had, however, been successful in reducing her weight by almost a stone without any improvement in her dyspnoea. A recent chest x-ray had been reported as normal.

Examination showed her to be a healthy but overweight lady with a normal blood pressure and no signs of heart failure. There were, however, some fine inspiratory crackles at both lung bases.

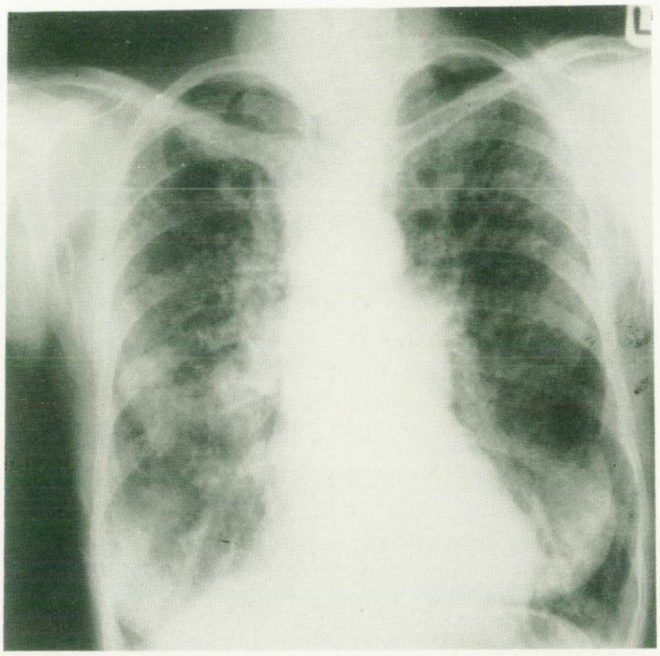

Fig 1. *Chest x-ray from a 69 year old patient with severe pulmonary fibrosis; she had kept budgerigars in her lounge intermittently for 20 years.*

Tests of ventilatory function showed a moderate restrictive defect with a vital capacity of 2.3 litres (predicted 3.0) and an FEV_1 of 1.9 litres (predicted 2.2). This clinical picture with just a few lung crackles, a normal x-ray and a restrictive defect that could have been due to obesity all suggested that her problems could still be due to her excessive weight.

Arrangements were made for her to have measurement of her gas transfer and the chest x-ray was repeated. The gas transfer was markedly reduced at 4.5 mmol/min/kPa (predicted 7.9). Examination of the chest x-ray showed a haziness throughout both lung fields; this had previously been considered to be due to the increased soft tissue around the chest wall from obesity, but it was now clear that this was the 'ground glass' appearance characteristic of alveolitis. It was only at this stage that she was asked about her contact with birds and it was revealed that she had acquired a parakeet just over a year previously and this resided in a cage in her living room. Her blood was positive for avian antigens and the diagnosis thus confirmed. She sold the bird to a neighbour and in subsequent weeks there was some improvement in her breathlessness and some increase in vital capacity but since the improvement seemed to be slow she was given a course of Prednisolone which resulted in marked improvement in symptoms, disappearance of lung crackles and increase in the tests of ventilatory function and gas transfer. Because of the very vague changes on her chest x-ray it was difficult to determine the stage at which the lung fields had returned to normal. This case illustrates the difficulties of making the diagnosis in relatively mild cases of the condition and underlines the importance of routine inquiry about birds.

Summary

This is a disease where early recognition is crucial and this depends on the right questions being asked. Doctors are not always the best people to elicit the relevant history and there have been occasions where the lung function technician has been able to draw attention to the presence of the disease by obtaining the information about the birds. Treatment is very effective as long as the condition is not too far advanced and it is curable in the early stages.

SPRING SCIENTIFIC MEETING

The Spring Meeting of the Association took place on 3rd and 4th April, 1987 at the City Hospital, Edinburgh. We are grateful to Dr. Patricia Tweeddale for organising a most enjoyable meeting, and to the many speakers for their interesting papers.

We are extremely grateful to the following firms who sponsored the meeting and put on an exhibition of their products.

Collingwood Measurement
Erich Jaeger
Mercury
PK Morgan
Spectramed
Surgical Services Scotland.

Computer Seminar

Benchmark Tests for Choosing Your Next Computer Based System. Mr J Griffiths, Clinical Measurement Dept., Kidderminster General Hospital.
Computerisation of Lung Function Equipment — CAUTION! Mr A Kendrick, Respiratory Dept., Bristol Royal Infirmary.
Application of Data-Bases to the Pulmonary Function Laboratory — Including What, When, Why and How, and an opportunity to try out! Dr P Altounyan & Mr M Williams, Collingwood Measurement Ltd.

General Scientific Session

Airway Resistance by the Forced Oscillation Method Using the BBC Micro. J R Heath, Pulmonary Function Dept., General Hospital Southampton.
An analysis and Comparison of Two Exercise Tolerance Test Protocols. D Harrison, Cardiothoracic Measurement Dept., Derbyshire Royal Infirmary, Derby.
The 6 Minute Walking Test in the Assessment of Cardiac breathlessness. M Papouchado, MA James, A Rozkovec, Dept. of Cardiology, Bristol Royal Infirmary, Bristol.
Sleep Studies; Indicators, Methods and Problems. Dr M Allen, Dept of Respiratory Medicine, City General Hospital, Stoke on Trent. (Now at Chest Unit, City Hospital, Edinburgh)
Assessment of Emphysema by Analysis of Lung CT Density Histograms. GA Gould, W MacNee, PM Warren, A McLean, D Lamb & DC Flenley, University Dept of Respiratory Medicine and Pathology, Edinburgh.
Repeatability of Pulmonary Function Tests in Doncaster — a First Step Towards Quality Control. HC Smyllie, MA Smyllie & J Foster, Doncaster Royal Infirmary.

Symposium on Standardization and Quality Control

Quality Control: The International Scene. Dr J E Cotes, Dept of Occupational Health, Medical School, Newcastle upon Tyne.
Quality Control of Dynamic Spirometry. Dr D Chinn, Dept of Occupational Health, Medical School, Newcastle upon Tyne.
Quality Control in TLCO Measurements. Mr A Kendrick, Respiratory Dept., Bristol Royal Infirmary.
Standardization in Respiratory Laboratories: a Multi-Centred Study. R Gooch Birmingham Chest Clinic and DCS Hutchison, Kings College Hospital, London.
Quality Control in Blood Gas Analysis. D Cramer, Lung Function Unit, Brompton Hospital, London.

Benchmark tests for choosing your next computer based system.

John Griffiths, Clinical Measurement Department, Kidderminster General Hospital, Worcs.

Benchmark tests are simple tasks set by prospective users for computer systems to perform. Each system performs the same task and their relative performances are compared. The performance criteria within a specific field (e.g. respiratory) depend on the user requirements and the application and any test for suitability should be designed by the eventual user team. This may cause some difficulty if there is no computer expertise within the group, but the following procedures may be helpful in obtaining the best results:

1. Establish a user group.
2. Decide on your requirements. Do you really need a computer system?
3. Formulate the benchmark tests.
4. If you need computer expertise ask advice.
5. Have demonstrations (ideally more than one), and ensure that all potential users have a chance to operate the system personally.
6. Perform all the tests and document the performance of the system.

Examples of benchmark tests

PRICE-	What can you afford? Don't forget the running costs and the costs of installation and security.
USAGE-	Can you justify the purchase?
SAVINGS-	These can help to justify buying the system.
SECURITY-	Tempest. DP registration.
INSTALLATION-	Soundproofing, networking, desks, storage space.
RUNNING COSTS-	Disposables (paper, ribbons and discs), software updates, and maintenance.
EASE OF USE-	The best looking or fastest may not be the ideal system.
SPEED-	Saves patient, technician and physician time.

Specific computer questions

DATA SAFETY-	Ensure there are good backup procedures in case of failure.
STORAGE CAPACITY-	Choose the largest you can afford. This is critical for data bases.
MICROPROCESSOR-	8, 16, 32 bit —?parallel processing? — speed of processor?
STATE OF THE ART-	Is the system going to be obsolete next year?
LANGUAGE-	Avoid "BASIC" for databases.
FLEXIBILITY-	Can you use the system for anything else?
OTHER OPINIONS-	Contact other users, ask to visit their system, and obtain their opinions.

Computerisation of lung function equipment — caution!

A H Kendrick, Respiratory Department, Bristol Royal Infirmary, Bristol

Computers have decreased in size and cost, and increased in their speed and reliability. The advantages of their use far outweigh the disadvantages, and therefore more and more equipment is now sold with a computer attached. This either controls the procedure and performs the calculations, or simply performs the calculations, leaving the instrument under manual control. The result is a more costly and more complex piece of equipment, which in turn necessitates a greater need for comprehensive quality assurance.

The American Thoracic Society has recently produced guidelines for the use of computers in lung function laboratories (Amer Rev Resp Dis 1986; 143; 628-629). These guidelines state the need for 1) comprehensive performance testing and validation of systems by the manufacturer; 2) extensive documentation of all procedures within the software; 3) documentation of all formulae and calculations; 4) the evaluation of all software updates and changes by the user prior to implementation; 5) duplication of all stored data; 6) procedures for computer malfunction; 7) data protection and 8) continuous evaluation of the system using physiological controls. The implications of these guidelines for users and manufacturers will be discussed.

Airway resistance by the Forced Oscillation Method using the BBC Micro

J. R. Heath, Pulmonary Function Department, General Hospital, Southampton.

Airways resistance may be measured by directing low frequency sound waves into the mouth and measuring the pressure and flow produced. While this method is very easy for the patient, it has the disadvantage that airway resistance changes with lung volume, which is not usually measured during the forced oscillation method. However, Lehane et al* have shown that by continuously measuring airway resistance during a slow expiration it is possible to analyse the relationship between resistance and lung volume so as to obtain a value for resistance which is independent of lung volume.

I have recently been developing the forced oscillation method with Roussel Pharmaceuticals, who wanted a technique simple enough for use in the field, quick enough to measure the relatively rapid changes which may take place after the administration of aerosol drugs and also relatively cheap.

We use a BBC microcomputer to generate a driving sine wave of known frequency and phase. This is passed to a power amplifier and loudspeaker. The flow and pressure signals from the pressure transducers are fed to the analogue input of the BBC micro. A sine wave is fitted to both pressure and flow data for each single oscillation cycle and the magnitude and phase of resistance is calculated. The average flow during each cycle is used to calculate the change in lung volume. The data are then plotted, curves

fitted, and specific conductance calculated. The whole procedure, including a secondary calibration and iterative curve fitting, usually takes just over a minute. The final graph may be printed out on paper if desired.
*Lehane J.R. et al. Thorax 1981: 36: 221.

An analysis and comparison of two exercise tolerance test protocols

D. D. Harrison, Cardiothoracic Measurement Department, Derbyshire Royal Infirmary

History:- For some time now exercise tolerance tests have been used by both chest physicians and cardiologists, to observe cardio-pulmonary responses for various reasons.

Up to now there have been three main methods widely used to provide the exercise, two step, bicycle ergometer and treadmill. Having adopted the apparatus to be used a suitable protocol must be selected.

Discussion:- Having decided to use a treadmill in combination with the modified Bruce protocol, we began stress testing in earnest. After a short while it became apparent to us that many of the subjects undergoing the test were stopping before their cardio-pulmonary systems were being stressed. We therefore set out to analyse and compare the modified Bruce protocol with another, to determine if we were using a suitable protocol for the typical subjects that were presented to us.

Method:- A sample set of ten "normal" subjects underwent two exercise tests on separate occasions. During exercise the following parameters were measured: expired oxygen, expired carbon dioxide, minute volume, heart rate and systolic blood pressure. Having measured these we then plotted the Means against time and compared the two protocols, Modified Bruce against Modified Balke.

Conclusion:- Both protocols save maximal Cardio-Pulmonary responses, with the Modified Balke obtaining these in a more linear way.

The 6-minute walking test in the assessment of "cardiac" breathlessness.

M Papouchado, MA James, A Rozkovec, Department of Cardiology, Bristol Royal Infirmary, Bristol, Avon.

In the absence of lung disease, anaemia or locomotor disability, exercise capacity is limited by the ability to increase cardiac output when stressed. Many patients referred to a cardiac unit are limited by chest pain and undergo exercise testing on a treadmill or bicycle ergometer, with full electrocardiographic monitoring.

There are, however, many patients with ischaemic or other forms of heart disease whose exercise capacity is limited by breathlessness and tiredness ("Cardiac" breathlessness). A number of these patients are elderly or are so disabled that testing on a treadmill or bicycle ergometer would be inappropriate. The 6-minute walking test (McGavin et al, Br Med J 1976;1:822-823), originally introduced for the assessment of exercise capacity in patients with chronic airways disease, may be more appropriate in such cases but has not been widely used for the assessment of breathlessness in cardiac disorders.

We have used the 6-minute walking test in three studies;

1) 18 patients with chronic heart block and breathlessness, without syncope, were assessed before and after ventricular pacing at 70/minute (study group). 8 patients admitted for elective replacement of a previously implanted pacemaker were assessed in the same way (control group). There was no significant training effect in 10 patients walked twice before pacing, or in the control patients. There was, however, a significant increase in walking distance, and a reduction in symptoms, in the 18 patients following pacing. This improvement has been maintained.

2) The effect of ventricular pacing at three heart rates (50, 70 and 90/min) on exercise capacity was studied in 18 patients with programmable pacemakers. Walking distance was least and symptoms greatest at 50/min. There were no differences between 70 and 90/min.

3) 14 patients with poorly controlled artrial fibrillation and breathlessness on exertion and/or palpitations were studied in an attempt to reduce symptoms by improving heart rate control. All were on a maintenance dose of digoxin. Two one month treatment periods consisted of 1) double the maintenance dose of digoxin and 2) the addition of verapamil, 40 mg tds, to maintenance digoxin. Patients were assessed on maintenance digoxin and at the end of each treatment period. There were no differences in walking distance and symptom scores between the maintenance and the two treatment periods, though the best heart rate control was achieved with combination digoxin-verapamil therapy.

Our general impression is that the 6-minute walking test is useful in the assessment of breathlessness in certain groups of patients with heart disease who might find a standard exercise test difficult. The test may be insufficiently stressful in patients with mild or moderate symptoms and is of greatest descriminatory value in those with severe symptoms.

Sleep Studies. Indications, Methods and Problems.

*Dr. M. Allen, * Dept of Respiratory Medicine, City General Hospital, Stoke-on-Trent.*

Following the description of periodic breathing in overweight sleepy patients with heart failure (Pickwickian Syndrome) in 1965 there has been a marked increase in the number of centres in North America performing sleep studies, spurred on by the apparently high incidence of sleep apnoea.

With increasing public awareness of medical problems during sleep the demand for sleep studies in the UK has escalated. Unfortunately governmental funding is restricted and few centres have been able, except for research programs, to acquire the 'hardware', knowledge and staff to undertake a full assessment of respiration during sleep.

Because of the limited facilities selection of patients for investigation and treatment of sleep apnoea is important. Although a history from the bedpartner of loud snoring, excessive movements during sleep and episodes of not breathing is suggestive, a screening procedure would further help reduce the workload of sleep laboratories.

The paper presented briefly examines indications, methods and problems which are associated with performing full sleep studies. Several forms of screening, along with their relative merits and disadvantages will be discussed.

***now at: Chest Unit, City Hospital, Edinburgh.**

Assessment of emphysema by analysis of lung CT density histograms

G. A. Gould, W. MacNee, P. M. Warren, A. McLean, D. Lamb, D. C. Flenley. University Departments of Respiratory Medicine and Pathology, Edinburgh.

Currently available methods for assessing the severity of emphysema are inaccurate, though a combination of Kco and compliance measurements may provide optimal sensitivity and specificity, particularly for early disease. We have made objective measurements of lung physical density (from analysis of lung CT density histograms) and correlated this with precise morphometric measurements of distal air space size in a group of patients undergoing surgical resection for small peripheral lung tumors (32M,13F; 46-74 years, FEV_1 47-123% predicted). In this surgical group, most of whom had very early emphysema, the severity of microscopic emphysema correlated with impairment of gas transfer (Kco n = 34, r = 0.84) and with lung CT density (n = 28, r = −0.77) but not with other physiological measurements, such as spirometry or lung volumes. In a larger group of non-surgical cases (53M,17F; 23-82 years; FEV_1 15-125% predicted) lung CT density correlated strongly with physiological measurements thought to reflect the severity of emphysema, in particular gas transfer (Kco n = 58, r = −0.77) and air flow limitation (FEV_1/FVC% n = 70, r = −0.72).

In patients with bullous desease CT scanning can accurately localise bullae, but in addition, the analysis of CT density histograms provides an objective measurement of the severity of emphysema in the non-bullous areas of lung, which is an important factor when these patients are considered for surgery.

We conclude that the analysis of lung CT density histograms provides an accurate measurement of emphysema severity, and in combination with measurement of gas transfer may offer the greatest sensitivity and specificity for detecting early disease.

Repeatability of pulmonary function tests (PFT's) in Doncaster: a first step towards quality control

H. C. Smyllie, M. A. Smyllie, J. Foster, Doncaster Royal Infirmary

Recent publications on standardisation of PFT's reveal almost as many controversies as agreements. Very few publications deal with investigations into the accuracy and repeatability of equipment and procedures currently in use in our laboratories. Unfortunately, without exception, these few papers spell out a gloomy message (Saunders K. B. 1977, Chinn, Naruse and Cotes 1986, Personal Communication 1986).

At Doncaster we have studied one aspect of quality control: repeatability of duplicated routine tests. We were helped by 2 publications a) "Medical Laboratory Statistics" by Paul Strike b) "The Analysis of Method of Comparison Studies" by Altman and Bland. Neither was written with pulmonary function in mind and we have had to adapt their advice to our needs. We were concerned to find a simple practical approach to quality control which could be applied to routine PFT's with the minimum of additional effort or expense.

Initially we looked back through our day book and took the duplicate results of the last 100 patients tested for FEV_1, FRC (helium dilution) and TLCO (sb). From these duplicates we calculated, for FEV_1, the mean difference and the "within batch standard deviation." For FRC and TLCO (sb) we calculated the Mean % Difference and the Standard Deviation of % Difference.

Subsequently we have recorded duplicate results on all patients having tests and have progressively updated the statistics by plotting moving averages.

The Mean % Difference between FRC's in Doncaster is 3.5% and for TLCO (sb) it is 4.5%. The mean difference between duplicate FEV_1's (non-asthma) is 30 to 40 ml, with 95% confidence limits of ± 70 ml. For asthmatics it is 70 ml with 95% limits of ± 170 ml.

We discuss the possible benefits to technicians and clinicians of these repeatability studies.

Quality Control: The International Scene

J. E. Cotes, Respiration & Exercise Laboratory, Department of Occupational Health, Medical School, Newcastle upon Tyne

The recent report of the European Coal and Steel Community "Standardised Lung Function Testing" (Quanjer PhH ed, Bull Europ Physiopath Resp 1983: Suppl 5) sets a target for quality control in lung function laboratories and a standard for instrument manufacturers. It also facilitates dialogue with the American Thoracic Society which, as a result of experience, now places great reliance on standardised methodology. However, the criteria for standardisation often include an element of expediency and this is storing up difficulties for the future. The way ahead is through codes of practice which can be amended and which take into account both local conditions and experience in other countries.

Quality Control of Dynamic Spirometry

D. J. Chinn, Respiration and Exercise Laboratory, Department of Occupational Health, Medical School, Newcastle upon Tyne.

In hospital laboratories dynamic spirometry provides the first, and sometimes only investigation of lung function. With a few exceptions the procedure is well tolerated by patients and the indices obtained are both reproducible and informative. However, our reliance on the procedure has encouraged many manufacturers to develop their own equipment; some are simple devices, others less so, but all are required to meet minimal standards as laid down by internationally agreed criteria. Calibration for flow, volume and time is essential but difficult using commercially available equipment. However, salvation is at hand with the recent development of a simulator which reflects the relationship between flow, volume and time during forced expiration. Will our problems soon be over or are they just beginning?

Quality Control and standardization of single breath carbon monoxide transfer factor

A. H. Kendrick, Respiratory Department, Bristol Royal Infirmary, Bristol.

Measurement of single-breath carbon monoxide transfer factor is used to assess the gas exchange function of the lung parenchyma. To ensure comparability of measurements between laboratories, there is a need for standardization of the method and calculations, and quality control procedures of instrument performance and methodology.

Instrument performance must be assessed regularly and should include verification of 1) the volume accuracy and kymograph paper speed of the spirometer, 2) the absence of leaks from the system, and 3) the performance of the gas analysers. Whole system performance can be assessed by a simulated volume dilution test. Methodological quality control should ensure the procedure is performed within accepted standards- volume inspired of at least 90% of vital capacity, correct performance of the manoeuvre and the removal of gases which interfere with CO and He analysis. A minimum of two acceptable attempts should be made, the results agreeing within 10%.

The computation is of equal importance and should be the same in all laboratories. Significant changes in calculated transfer factor occur by correcting for haemoglobin concentration, deadspace, carboxyhaemoglobin and alveolar carbon dioxide fraction. If these and other corrections are not applied, differences of up to 41% can occur in calculating the same test results (Morris and Crapo, Bull Eur Physiopathol Respir 1985;21:183-9). The corrections will be described, and a standardized equation presented.

The measurement of FEV_1 and VC in Respiratory Laboratories: a multicentred survey.

R. Gooch, Birmingham Chest Clinic and D. C. S. Hutchison, King's College Hospital, London.

A questionnaire on respiratory methods was devised by the ARTP Education Committee and circulated to all known Respiratory Laboratories in the UK undertaking service commitments. The questionnaire covered a wide range of lung function tests; in this paper, only data relating to FEV_1 and VC are reported.

Forty-nine questionnaires were returned relating to a total of 52 laboratories. Five modes of measurement were in use: plastic bellows spirometer 61%, rolling seal spirometer 26%, water sealed spirometer 9%, pneumotachograph 4% and turbine 2%. Some laboratories used more than one mode.

The year of equipment manufacture was 1980-1985 in 52% of instances, 1971-1979 in 38% and pre-1971 in 7%. Forty-four percent of laboratories used an on-line computer to obtain results.

Patients were routinely tested in the sitting position in 69% of laboratories and standing in 31%. A nose-clip was routinely used in 60% of laboratories but not in the remaining 40%. The number of blows normally ranged from two to six. The "best" result was reported in all laboratories and was converted to BTPS in 96%.

With regard to the calculation of reference values, six laboratories were routinely using the European Community for Coal and Steel regression equations for FEV_1 and VC. In other laboratories, regression equations from a total of twelve other sources were employed, their dates of publications ranging from 1959 to 1981. In five laboratories, computer held equations of undetermined sources were in use. An allowance for ethnic group was made in 56% of laboratories.

In 60% of the laboratory reports, no estimate of the expected range of normal values was given. In the remaining laboratories, the range was given variously as 1 SD, 1.65 SD, 2 SD or ± 15%.

A move towards the standardisation of these methods is recommended.

Acknowledgement; The authors owe grateful thanks to all those who returned the Questionnaires.

Quality Control in Blood Gas Analysis

Derek Cramer, Lung Function Unit, Brompton Hospital.

In common with many clinical investigations, in pH and blood gas analysis, accurate results are important for accurate diagnosis, and precise results are required since small changes in the measured variables can be significant. In addition it must be remembered that pH and blood gas results are most often needed to help in the management of acutely ill patients, including those on cardio-pulmonary bypass and those under intensive care.

The potential source of error is usually to be found in one of the following areas: calibration procedures, sample handling, instrument performance or handling results.

In an attempt to improve the quality control in blood gas analysis, this presentation outlines where specific improvements can be made using reference materials such as buffers, tonometered whole blood, gases and liquids. Also, reference is made to improving techniques where sample handling, maintaining/servicing analysers and transcription of results is involved.

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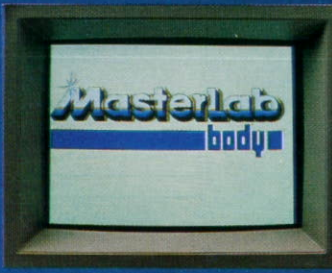

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