'constructed response mode' where the student first makes his own answer and compares it with the answer which is then supplied by the machine, or, on an alternative procedure, where the machine first supplies a multi-choice solution and the student has to select the correct response. The advantages of these procedures are being investigated.

Mr. Leslie Reid, lecturer in psychology in the University of Aberdeen, discussed and actually produced the simpler forms of teaching machines which he has developed and is using at present in his research work in Scottish schools. His programmes have followed Skinner's principles with an accent on eliminating frustration and difficulties. From this point of view, teaching machines preserve the teacher–pupil relationship by ensuring that pupils are consistently rewarded, and not punished, for their responses. This is achieved primarily by the ordering of items in a suitable sequence, such that the transition from ignorance to knowledge is not a bumpy and apparently unmapped journey, but a smooth and logical progression in which a pupil can be expected to achieve success. Mr. Reid explained how a pupil working through a programme achieves insight through a gradual understanding of his subject; by contrast, that insight which a pupil achieves by a sudden flash of comprehension—the so-called 'eureka' phenomenon—is mainly a product of bad teaching.

Mr. Gordon Pask, of System Research, explained the principles of an adaptive teaching machine. Unlike a programmed machine the adaptive device itself 'learns' about the student's behaviour and modifies the training routine to suit each individual throughout the learning process. In teaching a manual skill the designer has to select certain parameters. These refer both (1) to the students' behaviour, such as the response latency, and (2) to the instructor's behaviour, such as the amount of 'cue' information with each category of problem. It will be observed that the parameters in (1) define measures of the student's behaviour which an instructor might make, and those in (2) consider the ways in which the instructor might manipulate a training routine. Thus the designer is constructing a computing device which measures the performance and then by an adaptive servo-mechanism adjusts the parameters of (2) in order to increase to a maximum the performance measure. Well-designed machines adopt a competitive strategy when the student is doing well and a co-operative strategy when he is making no improvement. Mr. Pask went on to describe how adaptive teaching machines might be used for group or classroom instruction. Here students are carrying out exercises in scientific inference and act either as a problem poser or a problem solver. The student coming quickest to the right conclusion using the minimum of evidence is most successful. A miniature economy is imposed on the group, and the machine controls the group's behaviour by modifying the parameters of the game. The most useful parameters seem to be 'cost' of communication, 'cost' of evidence, 'gain' for successful solution, and a bias on the process of role assignment.

Mr. K. Austwick, of the University of Sheffield, presented "An Educational Viewpoint" on the subject. Mr. Austwick has conducted preliminary experiments at schools on the teaching of mathematics with a simple linear programmed procedure. Preliminary results are encouraging and suggest that work learned by this method is well retained over a period of time. Programming of school and university courses is now under way. If such procedures were widely adopted they could lead to modifications in school design since they do not require the formal arrangement of a classroom. The possibilities of such machines to handicapped children, isolated children, personnel in the Services, and adults keeping up to date in a subject were brought out. On the other hand, the machines could not take over the 'human' role of the teacher, though they might give the teacher more time and opportunity to show his humanity.

The discussion was brisk enough and ranged from the university teacher anxious to discover how far machines could take over the part of tutor to a self-styled 'plain local family doctor' who knew they could not. These are early days for the teaching-machine movement, but it was apparent that we have here an educational development which is already arousing considerable interest and some opposition—both happy indexes. In a remarkably short time this type of instruction has now used 'hardware' ranging from simple pencil and paper booklets to electronic gadgets controlled by a full-scale computor. Systems are already being produced for public sale by both the publisher and the electronics industry. It is clear that the results of research are needed to give some guidance to this diversity, but research efforts in Britain are, as usual, on a small scale. To the academic psychologist this subject represents a further development in the field of communication systems, and it now offers another opportunity for studying how man can most efficiently receive and store information. But the pace and detachment of academic research are confronted by the urgency of the demand for instruction. The need in Britain for scientific and technical teaching is obvious enough, but is trivial in comparison with other areas of the world. Part of the impetus behind automated teaching is that universally, in so many subjects, there is so much demand for knowledge. There is every indication that this demand will continue to increase, and that it cannot be fulfilled by conventional methods.

H. KAY

BREATHING

UNDER the chairmanship of the Section's president, Sir Bryan Matthews, a symposium on "Breathing (External Respiration)" was held on September 4 by Section I (Physiology and Biochemistry) during the recent British Association meeting in Norwich. Four papers were presented, covering varied topics connected with respiratory physiology. Two of these had a clinical bias, and concerned the distribution of ventilation and flow of blood in the lungs, and the effects of oxygen on breathlessness. The other two demonstrated the application of respiratory physiology to aviation, one concerning the design of an aircraft breathing system, and the other describing the results of research into the effects of positive acceleration on the mechanics of respiration.

The symposium was opened with the paper "Variation of Ventilation and Blood-Flow in Different Parts of the Lungs in Health and Disease", presented by Dr. P. Hugh-Jones, physician at the Hammersmith and King's College Hospitals. Starting by showing a model of the air passages in the lungs, and demonstrating how a two-lumen tube could be used to collect expired air from the two lungs separately, Dr. Hugh-Jones went on to describe the limitations of X-rays as aids to studying lung function. Chest radiographs were shown to illustrate this, where there was a complete dissociation between the X-ray appearance and the subject's exercise tolerance. Two new techniques were then described which could give details of local lung ventilation and blood supply, full tribute being paid to the advances of the physicists which had made them possible. In the first, the subject is merely required to take in a quick breath of air containing a minute trace of radioactive oxygen (oxygen-15), and then to hold his breath for about 30 sec. Counters arranged to look at different areas of lung tissue through the chest wall sense the arrival of the oxygen-15 in their fields and then follow its disappearance as it is washed away in the pulmonary circulation. The rate of rise of the counting-rate is a measure of ventilation, and the rate of the ensuing fall in counting-rate is a measure of the local blood-flow. The 2-min. half-life of oxygen-15 is a disadvantage of the technique, but was immaterial at Hammersmith, where it is prepared on the spot in the Medical Research Council's cyclotron. Other gases with longer half-lives might be used elsewhere where such facilities did not exist, for example, radioactive isotopes of argon or krypton. Carbon dioxide made from oxygen-15 had been found to give better results when the technique was used for studying pulmonary blood-flow.

The second technique described by Dr. Hugh-Jones was that of regional gas analysis, using a mass spectrometer which could provide almost continuous analysis of up to four gases simultaneously. Samples were taken through a 0·5-mm. diameter tube which could be inserted into any chosen part of the lung during bronchoscopy. This allowed a study to be made of ventilation and blood-flow in any small area of the lungs, and information obtained in this way would be of value not only to the experimental physiologist but also to the physician and surgeon.

The second paper, "Physiological Requirements in the Design of Aircraft Breathing Systems", was presented by Squadron-Leader J. Ernsting of the Royal Air Force Institute of Aviation Medicine. The variation in properties of the atmosphere with increasing altitude was described, and it was shown that the two main problems to be overcome at a flight-level of 40,000 ft. were an air temperature of − 55° C., and an air pressure of 1/5 of an atmosphere. Ideally, aircrew and passengers should be provided with sea-level cabin conditions at any aircraft altitude, but the weight penalty of the structure needed to withstand the required pressure differential is too great, so that the physiologists reach a compromise with the engineers, and a cabin pressure equivalent to an altitude of 8,000 ft. is chosen. Though this is acceptable, the possibility of a failure in the pressurization system must be allowed for, and with this in view the physiological effects of decompression had been studied. In a civil air-liner, window or valve failure will result in slow loss of pressure over several seconds. In military aircraft, on the other hand, a smaller cabin, together with the necessary provision of aircrew escape systems, makes an explosive decompression, where ambient pressure is reached in 1/10 sec. or less, a real possibility. Dr. Ernsting went on to describe the effects of explosive decompression, first, those due to the low final pressure, anoxia and decompression sickness, and secondly, those due to the rapid change in pressure. Protection against anoxia could be provided by the breathing of oxygen between 10,000 ft. and 40,000 ft., and the breathing of oxygen under pressure at higher altitudes. Above 50,000 ft., the pressure required is so great that counter pressure has to be applied to the rest of the body to make breathing possible, and since at 63,000 ft., the vapour pressure of water at body temperature is equal to the barometric pressure, some form of pressure suit is required to prevent vaporization of body fluids. Experiments on aircrew were described with a short film in which explosive decompression from 8,000 to 38,000 ft. was followed by short periods of impaired function, even when the decompression was followed by breathing 100 per cent oxygen within 5 sec. It had been found that the subject must already be breathing at least 40 per cent oxygen at the time of decompression if impairment of function were to be avoided.

Dr. Ernsting concluded by discussing the serious consequences of explosive decompression on enclosed volumes of gas in the body. If the lungs were shut off from the outside air, serious or even fatal lung damage might occur. Masks had to be designed which would allow free escape of air when decompression took place but which would immediately allow oxygen to be breathed under pressure. The sudden expansion of 200 ml. of gas in the gut to 1 litre was less serious but still very uncomfortable.

The third paper, "Breathlessness: its Alleviation by Oxygen in Health and Disease", was presented by Dr. J. E. Cotes of the Medical Research Council Pneumoconiosis Research Unit at Llandough Hospital. Pointing out how appropriately this subject followed the centenary of the birth of J. S. Haldane, he went on to discuss the 12-month mortality figures of a group of 67 men severely disabled with breathlessness, and the curious finding that those whose symptoms were improved on breathing oxygen fared far worse than those on whom oxygen had no effect. If the reason for this were known, then more might possibly be done for these patients.

Dr. Cotes then discussed the development of our knowledge of the effects of oxygen, and showed that as a respiratory stimulant, while lack of oxygen was of less importance than excess of carbon dioxide, it did play a small part at rest, and with increasing exercise it played an increasingly important part. The administration of oxygen improved tolerance of exercise, and prolonged the time for which heavy exercise could be carried out. Oddly enough, 50 per cent oxygen was better than 100 per cent oxygen in this respect, due possibly to the adverse local effects of too high oxygen tensions on the brain, and it was suggested that 50 per cent oxygen might be the better gas for respirators when work has to be carried out in unfavourable environments. A small cylinder of 50 per cent oxygen should allow the wearer to run a mile in 3½ min. A portable respirator was demonstrated, and sets like this were of great value in improving the tolerance of exercise by disabled men, not only subjectively, but also objectively in treadmill tests. The increased work which could be carried out was associated with a reduction in pulmonary ventilation, the limit to capability of work being reached when the resulting ventilation reached the subject's voluntary maximum.

Dr. Cotes was unable to say why the breathing of extra oxygen should produce these effects, but many possibilities had been excluded, such as secondary changes in the pulmonary circulation, blood lactate-levels, or in the stiffness of the lungs. This was the limit of present knowledge on the subject, but it was hoped that the mechanisms operating would soon be elucidated.

The fourth and final paper in the symposium was given by Flight-Lieutenant D. H. Glaister, also of the Royal Air Force Institute of Aviation Medicine, under the title "Some Effects of Positive Acceleration on Respiratory Mechanics". Describing the interest physiologists have had in the effects of posture on breathing, Dr. Glaister went on to show how the human centrifuge could be used to extend data beyond the $1g$ which normally limited laboratory experiments. Positive acceleration was described as that acting in the same sense as gravity on a man standing on Earth's surface, and is measured in terms of this being $1g$. The postural change from lying to standing was thus equivalent to a change from $1g$ transverse acceleration to $1g$ positive acceleration.

Circulatory effects prevented many experiments being carried out above 4 or $5g$, since the degree of relaxation required to produce accurate respiratory measurements resulted in blackout or even unconsciousness. Most comparisons were therefore made between 1 and $3g$. As positive acceleration was applied the diaphragm was pulled down by the weight of the abdominal contents, and at $3g$, about 500 ml. of air were drawn into the lungs. Despite this, the vital capacity of the lungs fell by 300 ml., due partly to an increase in stiffness of the chest wall, and partly to a rise in intra-abdominal pressure which limited the full descent of the diaphragm. The basic mechanics of respiration were then described, and it was shown how the various properties of lung and chest wall could be isolated and measured. Results of experiments using these techniques had shown that no change occurred in the stiffness of the lung, nor in the air resistance of the passages leading to it, at least when the subjects were submitted to positive accelerations of $3g$.

The work done on the lungs had been measured by recording continuously the changes in their volume and the pressure gradient across them during quiet breathing. This was shown to be unchanged at least up to $3g$. The total work done by the muscles of respiration, however, had to rise under the effects of increased positive acceleration, due to the stiffening of the chest wall and to the raised intra-abdominal pressure. The overall efficiency of the respiratory process thus fell during positive acceleration. Dr. Glaister concluded by pointing out that while this lowered efficiency was probably of little moment at the lower g-levels, and with a subject at rest, it would impose a marked limitation to tolerance of exercise during prolonged positive acceleration.

The symposium concluded with a brief discussion on the four papers. D. H. GLAISTER

THE NORMAN LOCKYER OBSERVATORY

By PROF. G. K. T. CONN
Department of Physics, University of Exeter

SIR NORMAN LOCKYER founded and endowed the Hill Observatory at Salcombe Regis, Sidmouth. He was its first director. It is now the Norman Lockyer Observatory and has been, since 1948, intimately associated with the University of Exeter. Lockyer was a remarkable man. His discovery of helium in the Sun's spectrum in 1868 was made as a "private citizen", for he was not appointed to the Science and Art Department at South Kensington by Disraeli until 1875. On the formation of the Royal College of Science he became director of the Solar Physics Laboratory and professor of astrophysics. When the Solar Physics Laboratory at South Kensington was transferred to Cambridge in 1913 he set about building a new observatory on the superb site at Sidmouth, at the age of seventy-seven. Lockyer was the founder editor of *Nature* in 1869 and remained responsible for fifty years. He was succeeded as chairman of the Observatory Council by Sir Richard Gregory, his successor as editor of *Nature*. Indeed, both Lockyer and Gregory took great interest in the affairs of the old University College of the South West, now the University of Exeter, and it was Gregory's initiative that led to the intimate association of the Observatory with the University, "a possession which is unequalled in any but the older universities".

The peninsula Salcombe Regis is relatively free from industrial haze and Lockyer chose a site with a superb horizon and a very low noise-level; it is now of some 44 acres. The buildings consist of offices and laboratories with a well-equipped library, a store room, a cottage and three domes. The McLean dome houses a 12-in. refracting telescope with an objective prism of 20°, mounted with a 10-in. visual refractor on a Grubb equatorial mounting with electric control. (The donor, Sir Francis McLean, was the co-founder of the Observatory and became known to the public as the first airman to fly under the Thames bridges, in 1912.) The Kensington telescope is a 9-in. refractor with an objective prism of 45°, made by Henri Frères, and giving great transparency in the near ultra-violet, on a Cooke equatorial with Russell control; a 10-in. Cooke visual telescope is mounted alongside. The Mond photographic telescope consists of a four-camera, astrographic equatorial by Cooke with three Zeiss triplet lenses of apertures 17, 14 and 10 cm. and one Zeiss anastigmat, aperture 7 cm. The mounting is designed to allow an uninterrupted circumpolar motion at all declinations; the clock drive is fitted with electric control. There are various pieces of equipment which have not hitherto been set up, for example, a 30-in. reflecting telescope and a 21-in. siderostat.

Work began in 1919, the first paper, published in the *Monthly Notices of the Royal Astronomical Society* in 1920, being "Spectroscopic and Magnitude Observations of Nova Cygni III, 1920". Some 90 research papers have been published, about 40 in the period 1920–36 and 45 during 1936–56, when D. L. Edwards