oxygen-16 to determine the history of different parcels of ice. This ratio varies according to the season of the year, and also the altitude of the place in which the snow fell, and they quoted several examples where it had been of value in confirming whether ice samples found to be close to each other in the lower reaches of a glacier in fact came from the same region.

One of the most interesting developments in more orthodox methods of glacier study is the increasing use of photogrammetry, both terrestrial and aerial, to determine not only the map of a glacier, but also the velocity of flow and the variation in surface height of glaciers. For flow measurements, the photographs are usually taken with an interval of several days, and preferably from an identical position, but it was shown that even aerial photographs (which are necessarily not taken from exactly the same position on two different flights) could be used, if necessary, to determine glacier flow. There was some discussion of the best method of analysing such photographs, M. M. Baussart (Paris) favouring the plotting of two maps, one for each date, and deducing the velocity either from these or from the data from which they are constructed, whereas Dr. W. Hofmann (Munich) preferred to use two photographs taken at different times to give the velocity directly. However, it seems clear that both techniques give accurate results, and can even do so when no ground control at all is available. There were also many reports of measurements of glacier flow and variations of the more conventional kind, and perhaps the most interesting of these were some of the first results of International Geophysical Year expeditions to Antarctica given by Dr. L. D. Dolgushin (Moscow) and Dr. J. H. Zumberge (Ann Arbor, Michigan). The former described the features developed by flow in the large outflow glaciers of Queen Mary Land, while the latter reported on the deformation features on the Ross Ice Shelf.

J. W. Glen

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[1] Nye, J. F., *Nature*, 181, 1450 (1958).

THE HUMAN OPERATOR AND HIGH-SPEED FLIGHT

The first International Congress of Aeronautical Sciences was held in Madrid, during September 8–13, when representatives from twenty countries met to discuss forty-five papers delivered under the presidency of Dr. Theodore von Kármán.

The subjects included theoretical and applied science dealing with structures, aerodynamics, speed, height, range, propulsion, the handling of supersonic aircraft, navigation, aircraft taking-off and landing vertically, engine noise, and also the important subject of human engineering.

The human element is the limiting factor which faces the designer and operator of the new generation of high-speed aircraft. But considerable information has been accumulated over the past fifteen years about the physical and mental strains on a pilot subjected to violent manœuvres, and also about the psychological factors causing fatigue and thus an involuntary falling-off in efficiency. This experience has come from branches of science outside the general field of aeronautical engineering, namely, in the aero-medical field including physiology, neurophysiology and psychology.

From the early stages of design study for a new aeroplane the problem of the human operator is studied by scientists working with the design team to ensure that human limitations do not prevent the machine being flown to the best advantage.

Military and civil aircraft present some common problems, but naturally those of the combat aeroplane are particularly difficult; pioneering work on military aircraft is frequently useful for the later generations of civil machines, including the now familiar pressure suits worn by air-crews for the protection of the body against physical damage, and radar devices for navigation.

An invariable problem posed by the human operator and his working space in the cockpit lies in variations in size and shape of body, and arm- and leg-reach, all in some way affecting operating comfort and efficiency and involving, for example, the clearance between apparatus, controls, and the canopy. More intangible problems are those concerned with muscle, nerve and brain, underlying the senses and reactions, and much has yet to be discovered.

Laboratories exist in many countries for practical work as well as for theoretical analyses in the study of human engineering, which applies to any task in which physical and mental co-ordination is required of the operator. Too many tasks in the past have been carried out by the human operator adapting himself to the machine, whether it be aeroplane, machine tool, forging machine, or instrument observation.

The aircraft designer is thus increasingly required to range over a varied scientific field, and to consult other specialists on the human operator aspect. The following topics were discussed at the Congress:

(1) Simplification of the work of the air-crew, both physical and mental.

(2) The study of all aspects of visual observation both inside and outside the cockpit, including the design and arrangement of the instruments. Outside the cockpit the angle of view from a pressurized aircraft is limited, and with increase in performance a television display, reliable under all weather conditions, is desirable.

(3) Location, design and shape of controls, levers, and knobs, for instant recognition by sight or touch, day or night.

(4) Reliable information about what fuel remains at any given time, and what aerodromes are available within the remaining range.

(5) Warning lights that are insistent, but not too violent, for vital emergencies, and illuminated descriptive panels for secondary troubles.

(6) Air conditioning and temperature control.

(7) Methods of escape to safety in case of an emergency; the self-contained detachable cockpit dropping by a parachute, after clearing the air wreck, to a suitable altitude from which the crew can escape on their own parachutes.

(8) Disorientation in flight.

(9) Protection against cosmic radiation during space flight.

(10) The problem of weightlessness in space.

Observing, thinking and making a movement takes time whether it concerns operating an aeroplane, a machine tool or playing the piano, but smooth and apparently effortless action by an operator having a mastery of his task shows a high degree of combined skill.

The hazards and increasing complication of flying have encouraged great efforts to be made to reduce the reaction-time of air-crew, between hearing or seeing some signal and acting on it. One action may have to be followed by a second or a third, all taking time depending on how much mental interpretation is required after observing the dials and lights. A good deal of work can be performed quickly by robot-type apparatus ; but it can carry out only what it has been programmed to do, and cannot readily be adapted to differentiate between courses and evaluate alternative action. Robot apparatus, moreover, frequently occupies much space and is weighty, and it needs skilled attention to keep it serviceable.

Extending the pilot's senses without increase in fatigue is an important factor in getting the best out of an aeroplane. Vision is most important : many miles will have been travelled in the few seconds required to stop observing an instrument a few feet away on the cockpit panel, and to sight and recognize a distant aeroplane.

Quick-acting robot apparatus is best used in relieving the pilot of physical tasks ; for presenting the assorted instrument readings as integrated results ; and for displaying a flat television picture of the view around the aeroplane.

While aircraft design and construction has to conform to accepted standards and official specifications, no such definite direction is possible on the more intangible aspects relating to the human operator and so every new experience reported by air-crews is carefully studied, and may be the starting-point for further aero-medical research.

The many instruments on cockpit panels are arranged in groups or in horizontal and vertical rows so that the readings relating to a particular operational function may be viewed together. This helps in the rapid assimilation of facts from which the pilot mentally assesses the conditions. There remain the possible chance of error in observation, and the time-lag before any action follows : to improve matters, apparatus is being developed which will receive the instrumental readings and give the pilot a combined result from which he can take immediate action.

Thus the process of adapting the aeroplane to the pilot continues and reduces the chances of accidents due to so-called 'pilot error'. It has been a convention to attribute many crashes to "an error in judgment on the part of the pilot" when, in fact, the cause has been due to confusing or difficult operating conditions, which become more hazardous when the pilot is fatigued and flying conditions are bad.

The experience of the past ten years is now being used in the design study of new manned aircraft, and tasks apparently impossible for the pilot are now being assigned to apparatus with the pilot as the master mind. For example, an apparatus designed to relieve the pilot during combat at high speeds is the Ferranti 'Airpass' system (airborne interception radar and pilot's attack sight system). After several years development it is now fitted in the English Electric *P. 1B* high-speed fighter. 'Airpass' starts to operate when the fighter is beamed in the direction of a target, it scans ahead and when the target is located the radar locks on and a computer finds the best course for the aeroplane. The pilot observes the essential facts in his sights and acts at the right time. He has been relieved of the visual strain and the anxiety of determining the correct course and can concentrate on the proper time to fire.

Progress has been helped greatly by the aero-medical pilots who understand test flying and take part in it, co-operating with other specialist scientists in the design team in the study of the operational requirements of a new aircraft, and how these can best be met. A full-scale cockpit model is tested under varying climatic conditions for maximum operational periods. These tests disclose discomforts due to pressure suits, difficulties in making movements to operate controls and switches, and escape facilities. In adapting the future aircraft to the pilot it must be emphasized that operation at supersonic speeds presents conditions of control quite different from those in sub-sonic flight, while kinetic heating demands a cooling system to prevent excessive rises in temperature.

Present-day control columns and rudder pedals will probably give way to a set of small hand levers on the pilot's desk console, which will also have communication aids and signals, the television picture of the outside view being at eye-level beyond the console, and visible to any other members of the air-crew.

The new self-contained type of control cabin can more readily be accommodated within the best aerodynamic shape, avoiding the usual sharp hump in the top curve of the fuselage due to the cabin windscreen and roof. The windscreen spoils good performance at supersonic speeds, and it should not be permitted in the new aircraft using television display. Operation would be entirely by remote control using television and other instruments, but a retractable periscope would be useful for ground manœuvring.

Other fields of human engineering include the operation of cars and lorries, fast Diesel trains, automatic manufacturing plant, and many others co-ordinated by the Ergonomics Research Society and covering international interests.

It would not be realistic to suppose that manned combat aircraft will become obsolete in the near future, and it may be assumed that air-crew will be needed for many military operations, but their task must be made simpler. Unmanned robot aircraft and missiles have a future. But it is unwise to think that these could replace certain attack and defence duties.

The important development of VTOL aircraft (vertical take-off and landing) and STOL aircraft (short take-off and landing) were discussed at the Congress, and it was emphasized that failure-proof apparatus for autostabilization and landing are essential if these types of aircraft are to be successful.

Human engineering applied to helicopters is concerned with control factors quite different from those of the fixed-wing aircraft, but some basic problems are similar. When controlling a helicopter, the pilot is continually using his hands and feet to maintain stability, and at present it is necessary to keep the ground in view, until a reliable automatic-pilot system is available to permit safe flying in all weathers.

The special senses reacting to linear and angular movement often prove misleading to a pilot when he is not engaged in steady straight flight, yet these are two of the three main sources of information about orientation which emphasizes the supreme importance of the eyes. Under some conditions of prolonged manœuvre even the eyes may prove misleading for a time during the manœuvre, or immediately after it has been completed. Facts on the limits of human tolerance in aviation and on the question of reaction-times are being accumulated in the leading national institutions, so that more data are available to designers.

Crew for manned space-flights will have to be selected from test pilots trained to retain normal physiological and psychological functions under severe conditions.

Two problems which are particularly difficult to study on the Earth are those of weightlessness, and the effects of cosmic radiation. Weightlessness, which can be studied for short periods under certain conditions of parabolic flight, causes disturbances of muscular co-ordination and the nervous system, leading to awkward functions of certain reflexes. There may also be long-term effects on respiration and disturbance of the alimentary canal. Generally, there is likely to be a reduction of the input of information to the sensory pathways of the brain, and thus some effect on the mental processes. Recent data from *Explorer* satellites and the *Sputnik* 3 reveal a belt of intense radiation between latitude 30° N. and 30° S., at a height of about 6,000 miles and beyond. This may be a serious barrier to manned rockets in this region, but in the equatorial zone there seems to be relatively little radiation, according to the information at present available, so that it may be possible for future manned rockets to avoid this hazard to some extent.

A. CADMAN CLINTON

HYDROMEDUSAE NEW TO THE BRITISH LIST FROM THE FIRTH OF CLYDE

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IN the course of work on the plankton of the Firth of Clyde a survey of the Hydromedusae has been made from early 1956 to the present date, because of their value as hydrographic and biological 'indicators'[1,2] of conditions in the area. Further, it is thought that they are a valuable guide to the zoogeographical relationships of the Clyde fauna. Finally, this survey may prove of service in the future in the detection of any long-term changes in the fauna.

The Clyde fauna has proved to be rich in number of species of Hydromedusae, forty-seven species having been found during this work. A full report on them will be published on completion of the survey. As, however, the four undermentioned species, new to the British list, have been found, this preliminary note is of value at the present stage.

Plotocnide borealis Wagner. Twelve specimens have been taken in surface tow-nettings at Millport in April and May 1956 and during February-April 1957. None has been found in 1958. Routine daily surface-water temperatures on the dates of capture ranged from 6·1° to 9·0° C. The earlier occurrence of the species in 1957, compared with 1956, reflected the much milder winter and earlier spring of 1957 compared with the previous year. Its apparent absence in 1958 may have been due to the fact that cold winter conditions were unusually prolonged and were followed by an exceptional period of persistent east winds, which delayed the onset of spring conditions and appeared to disfavour certain forms normally occurring in late winter and early spring.

This species has been considered to be an arctic one of circumpolar distribution[3,4], having been reported from western Greenland, the White, Barents and Chuckchee Seas and the Sea of Okhotsk. However, Beyer[5] recorded its occurrence in the Oslofjord between 1946 and 1953, although he suggested the possibility that it may there be an arctic survivor from some cold period, capable of living at the temperature (about 6° C.) of the deeper layers of the Oslofjord.

The survival of *Plotocnide borealis* in the Clyde area as an arctic relict is extremely unlikely. While its accidental introduction into the area in the hydroid stage is possible, it is considered unnecessary to attribute its presence here to that cause. It is a very small medusa, easily overlooked and nowhere reported as abundant, and its apparently disjunct distribution may be due to limitations of collecting. Its occurrence in the Clyde area over at least two years suggests that conditions here are suited to the species. The medusa faunas of the regions from which *Plotocnide borealis* has been reported include a number of other species the ranges of which extend from arctic to boreal regions, such as *Hybocodon prolifer*, *Rathkea octopunctata*, *Staurophora mertensi*, *Tiaropsis multicirrata* and *Aglantha digitale*, all of which occur in the Clyde area. The presence of northern boreal and boreal-arctic forms in arctic seas is well known. For example, Gurjanova[6] has shown, in the case of amphipods, that many Atlantic northern boreal species have penetrated into the deeper parts of the Russian arctic seas because of relatively warm water in the deeper layers of the Arctic basin. It is significant that Jaschnov[4] reports that, in the Barents Sea, *Plotocnide borealis* occurs in the deep layers. The appearance of many boreal species in the waters off western Greenland during recent decades, because of climatic change, is well known[7]. The presence of deep, cool water in the Firth of Clyde may favour the establishment of any cold-water forms entering the area. It is considered that *Plotocnide borealis* can no longer be regarded as a purely arctic species, but its true distribution must await further discovery. The hydroid stage is unknown.

Bougainvillia muscoides (M. Sars) [*B. nordgaardi* (Browne)]. This medusa has hitherto been reported only from fjords on the west coast of Norway between Bergen and Molde, a single offshore locality north-east of the Shetlands, and one station over the Wyville Thomson Ridge[8]. In addition, the hydroid has been recorded from the west coasts of Sweden and Norway[9]. In Norway the medusae have usually been found from August to November, and exceptionally in April and May.