his special field he should give a third of his time and energy to the continued study of the use of English and to the discussion of general problems, cultural, religious and social. Discussion really came to mean something if each boy could contribute to it on the basis of his own expertise and hear his friends do the same. Ideally, sixth-form work, outside the subjects of special choice, should not be subject to external examinations. It was necessary here to exploit idiosyncrasies in the teachers, not to steam-roller them. The most important single thing was a real understanding between teachers and schools, and this would now be perfectly practicable if it were set about in the right way.

In the course of an interesting discussion, Mr. Clegg made the point that local education authorities had in effect asked the universities to organise through the joint matriculation boards the selection of students for financial grants, and the universities were now criticizing the students selected. The remedy, he thought, lay in the hands of the universities themselves.

The president of the British Association, Sir Henry Tizard, said that in his view university teachers should recognize that they were not experts in the education of schoolboys and schoolgirls, and should leave this to the schools. University students must be in the upper range of intelligence and must *want to do something*. Intelligence and zeal—provided students had these virtues on entering the university, it did not matter what subjects they had been taught at school.

A number of speakers emphasized that public opinion did not sufficiently appreciate the part that ought to be played in the higher education of the nation by technical colleges. It was most short-sighted to allow these to continue to fall so far short of the universities in prestige.

MORPHOLOGICAL ASTRONOMY

THE Halley Lecture for 1948, with the above title, was delivered at Oxford on May 12 by Dr. F. Zwicky, of the California Institute of Technology, Pasadena. The lecture covers such a wide range in astronomy that only the more important points can be referred to in this short summary; fuller information can be obtained from *The Observatory* (**68**, 845, August 1948), where it is printed in full.

The morphological method is merely an orderly way of looking at things, and its essence is direct thinking and direct action—a combination which is a great asset of free men and of the democratic way of life. A complete morphological analysis of astronomy is a very comprehensive undertaking, and Dr. Zwicky discusses only some of the basic elements of such an analysis, among which he includes the following: observation of celestial phenomena; experimentation with celestial phenomena; theoretical integration; use of the knowledge gained in construction; dissemination of the knowledge and its bearing on all activities of man.

Under the first of these headings, Dr. Zwicky deals with the instruments to be used for observation and gives a very brief description of the photo-electronic telescope, which has introduced a number of new features. Even with such telescopes of relatively limited definition and light power, the search for novæ, supernovæ, variable stars, comets, meteors, etc., can be put on a 'mass-production' scale because images from photo-electronic telescopes can be televised. Another of the different advantages of this telescope is the ability to steady moving or scintillating images resulting from unsteadiness of the atmosphere or motions in the telescope, and automatic guiding of the telescope can be accomplished through devices similar to those used for steadying the refocused image on the recording surface.

Reference is made to the devices for observing phenomena from points above the main portion of the earth's atmosphere, by the use of rockets carrying scientific instruments. V2 rockets have already carried various instruments to heights exceeding 200 km., and it is proposed increasing this range to 1,000 km. to eliminate the greater portion of the atmospheric absorption. There are visions of vehicles carrying observers to great heights, and even the high-flying conventional aircraft have possibilities in this direction which may some day be exploited.

The accomplishments of the 18-in. Schmidt telescope on Palomar Mountain during the last ten years are dealt with, and important results mentioned refer to work on clusters of nebulæ, nebulæ, stars, supernovæ of various types, common novæ, very blue faint stars, and the general theory of relativity and the theory of the expanding universe. In connexion with this last subject, it was proposed that compact nebulæ acting as gravitational lenses could be used as a check for the deflexion of light, and the idea of nuclear matter of a density of the order 10^{14} gm./c.c. was also suggested. Such matter, which should exist in neutron stars—perhaps ancient remnants of supernovæ—would act as gravitational stars *par excellence*, and it is intended to make a determined search with the 18-in. Schmidt. Bright supernovæ supply data for some interesting conclusions on nuclear chain reactions, knowing that such bodies emit during the first 200 days about 5×10^{48} ergs in the form of visible light. For a star of mass 100 times that of the sun and containing about 10^{59} protons, the energy liberated per proton is, therefore, much greater than the maximum energy liberated per proton in the most energetic chemical reaction. There is, therefore, some justification for the conclusion that in a supernova outburst there is a nuclear chain reaction attended probably with a gravitational collapse to nuclear matter. Some supernovæ, notably the object NGC 4636, have been caught on the rise, and in such cases the speed is in accord with the assumption of nuclear chain reactions. As Zwicky remarks, "We here therefore have one more example how apparently academic astronomical observations led the way to the discovery of phenomena of the greatest import". A short investigation suggests that there is the possibility that cosmic rays are generated in supernovæ.

Astronomical knowledge has been used in the past for the conduct of human affairs, and an extrapolation of these applications, which lies in the line of morphological thinking, is a reconstruction of the universe, in which that of the earth comes first. This is of fundamental importance as there is the danger that the whole earth might be exploded by large-scale nuclear chain reaction, and schemes for stabilizing the earth against such an eventuality are part of morphological astronomy. Possibly there will also be plans for making some of the planets habitable by changing them intrinsically and by altering their positions relative to the sun; and however fantastic such schemes may seem, Zwicky suggests that these

thoughts are nearer to scientific analysis and mastery than were Jules Verne's dreams in his time.

The aim of the universities is to produce astronomers, chemists and so on; but this approach has failed us, especially if it is admitted that the purpose of education is the creation of realities that are in agreement with the avowed purpose of man. The purposes have frequently been stated, but the actualities present a state of affairs in which it is often difficult to recognize them. In the morphological reconstruction of human society and the material universe, astronomy and astronomers may be destined to play an important part.

SOCIAL SCIENCES AND INDUSTRIAL PRODUCTIVITY

BESIDES discussing the place of science in government and scientific man-power (see *Nature* of August 7, p. 199), the first annual report of the Advisory Council on Scientific Policy gives some account of the work of the committee set up to report to the Advisory Council regarding the directions in which a scientific approach is most likely to promote an increase in the national productivity. In an interim report submitted in September 1947, the committee concluded that current fundamental research in the physical and biological sciences was unlikely to have any material short-term effect in increasing productivity, whatever might emerge from its results in future. For short-term results the more effective application of scientific knowledge already available was likely to prove much more fruitful; but for this an adequate supply of qualified technologists and engineers is essential. The committee recommended that steps should be taken immediately to ensure that this demand is met. It was also suggested that the type of approach used so successfully by the Services during the War and commonly described as 'operational research' might also be very fruitful in yielding rapid results. Publication of a book on operational research was recommended and its preparation is in hand. The committee also suggested that it is important to try to establish scientifically whether the quantity and quality of the existing rations are likely to diminish the worker's potential outlook. Later, it strongly recommended the energetic pursuit of research on the nutritional consumption and physiological requirements of the main occupational classes in the United Kingdom, as well as obtaining relevant data from abroad, particularly from the United States and from the British Zone of Germany.

The Committee on Research and Productivity also appointed a special sub-committee to review existing technical information services and to consider their improvement. The work of this sub-committee was afterwards transferred to a Panel of the Committee on Industrial Productivity. It has been decided that the Information Unit in the Intelligence Division of the Department of Scientific and Industrial Research should be expanded to provide a national service for putting inquirers into touch with sources of specialist information. The possibility of achieving rapid results by the application of sociological principles was likewise explored. A memorandum issued on the human factor in production recommended a review of existing knowledge in this field, more effective co-ordination of the work being carried out by different bodies and further research into the basic conditions of good morale and efficient organisation, the characteristics of successful joint production committees, the status and position of the foreman, the differences of response as between male and female operatives, and the selection and training of managerial staff. It emerged in this general inquiry that the concrete objective of raising the level of the least efficient firms nearer to the level of the most efficient would go a long way towards effecting the general rise of ten per cent in overall output by British industry for which the Government had asked. The functions of this Committee have now, as announced last December, been transferred to the new Committee on Industrial Productivity, which, with its four subsidiary panels, is continuing and extending the work initiated under the Advisory Council.

This new Committee is quite independent of the Advisory Council on Scientific Policy, but Sir Henry Tizard is chairman of this Committee also, and three other members of the Advisory Council are also serving on it. Two of the panels under this Committee are continuing the earlier investigations into the potentialities of operational and sociological research, and a statement has recently been issued from the Economic Information Unit of the Treasury on the work of the Panel on Human Factors, of which Sir George Schuster is chairman. The Panel was constituted "to advise the Committee concerning the directions in which productivity could be increased by the application of research into the human factors in industry and to make recommendations for further researches into this field where called for". At its first meeting on February 2, 1948, the Panel decided to establish a research advisory group of representatives of the Medical Research Council, independent institutions engaged in research in the social sciences and departments of applied psychology in certain universities to advise the Panel on matters of research and on the availability of research workers.

The Panel was impressed at an early stage by the lack of workers with practical experience in the field of the social sciences, and has considered the means by which the number of workers could be increased and their training undertaken. In the meantime, it was decided to arrange for existing research institutions to undertake a series of investigations selected so as to cover points where it is important to acquire more scientific knowledge and so as to provide opportunities to train additional field-workers. The statement lists a number of projects which have thus been inaugurated, and the responsibility for supervising their completion and for making grants towards their costs has been undertaken by the Medical Research Council. In addition to these projects, certain activities of the British Institute of Management have been co-ordinated with the programme of the Panel, and a number of further projects from university departments are being considered.

The projects approved include studies of productivity in the Royal Ordnance Factories by the Industrial Health Research Board, and of work, design and the measurement of human performance by the Cambridge Applied Psychology Unit. The Tavistock Institute of Human Relations is investigating within an engineering firm the effect of different methods of payment, joint consultation procedures, methods of communication within the firm and inter-management relations, and is also examining methods of disseminating knowledge by group discussion, films, radio, etc. The Nuffield Research Unit, Cambridge,