plete, it will be possible to design alloys on a more rational basis and possibly with greater economy of alloys.

After reviewing some of the characteristics of "Brittle Fracture in Mild Steel", which has become so important since the introduction of welding on a large scale into shipbuilding, Mr. T. S. Robertson went on to describe a new form of test for the assessment of brittleness. In this test a shock crack propagated at low temperature passes through material stressed to a value comparable with that carried by the structure in practice. A temperature gradient is maintained along the direction followed by the crack, and this enables the temperature at which the material arrests propagation of the crack to be determined. As the transverse stress is reduced there is a sudden drop in the temperature at which the propagating crack is arrested, and Mr. Robertson suggested that this stress could be regarded as a safe design stress below which there is no chance of brittle fracture at ordinary working temperatures. Mr. Robertson illustrated his remarks with an excellent colour film of a test in progress. This showed that the speed of crack propagation is such that for the usual travel of about six inches, photography at 4,000 frames per second is too slow to record it, since no film so far taken has shown the crack in process of development. The speed of propagation must therefore exceed 2,000 feet per second.

In discussion Prof. J. A. Pope reminded the meeting that engineers are specially interested in the dynamic properties of metals. Under fatigue conditions the nature of the surface is most important: for example, light alloys tested with the as-extruded surface show much poorer properties than when the surface is carefully polished. Again, engineers are interested in machinability. If easily machined alloys are used, it might be possible to use water-cooled gas-turbine blades and to maintain a lower metal temperature by taking advantage of the stationary 'air' layer adjacent to the blade surface.

GENETICS AND EMBRYOLOGY

A DISCUSSION on the relations between genetics and embryology was held by Section D (Zoology) of the British Association on August 9. In introducing the topic, Prof. C. H. Waddington pointed out that when Bateson invented the word 'genetics' he defined it as the science which dealt with the physiology of descent, a phrase which could be held also to cover the subject which is usually known as experimental embryology. In spite of this, these two branches of biology, both of which have grown extremely rapidly in the past few decades, have developed almost in isolation from one another. After the disproof of at least the simple forms of the theory that differentiation is due to differential nuclear divisions, the concepts commonly used in them gradually diverged. Genetics came to envisage development in terms of the control of single chemical substances or enzymes by nuclear genes; while experimental embryology operated with the notions of gradients, on one hand, and active substances or regions, such as specific plasms or organizers on the other, neither of these types of agent being essentially connected with the nuclei. In quite recent years, these two categories of thought have begun to come together again. Thus, experimental embryology has been driven to recognize the fundamental importance of developmental competence, and to realize that this property is controlled, at least in the main, by genetical factors; while genetics has discovered that the connexion between gene and final product is not simple, but involves a balance between interacting forces which issues in a condition similar to the competence postulated by the embryologists. It may be hoped therefore that the natural unity between genetics and embryology will come to full expression in the near future.

Dr. R. A. Beatty then discussed some aspects of the importance of chromosomes in development, particularly in mammals. He described the occurrence of polyploids in mice. Triploid embryos are found to occur naturally in certain strains, and both triploids and tetraploids can be induced by hot shocks applied to the early stages of the eggs in the Fallopian tubes. So far no polyploids have been observed after birth; but the embryos appear to develop normally to mid-term, and it is hoped that polyploid young will shortly be identified. Turning to a rather different subject, he pointed out that evidence has been gradually accumulating that the cells of differentiated mammalian tissues may contain very different numbers of chromosomes. It does not seem plausible to attribute this to the technical difficulties of counting the chromosomes. There is no evidence that the type of differentiation is correlated with chromosome number; it seems more probable that neighbouring cells can co-operate, so that the important matter is the chromosome balance in the whole tissue rather than in the individual cells composing it.

Dr. D. S. Falconer pointed out that one approach to developmental genetics is to regard a mutation as causing a 'natural experiment'. It may be possible to show that the mutant gene produces some rather simple effect early in development and to trace a whole series of later modifications back to this original cause. As an example of such an approach, he described the analysis of a recent mutation in the mouse known as 'Crinkled'. The main initial effect seems to be the prevention of the formation of hair follicles except during a short period just before birth. This has a direct effect on the coat as a whole, which lacks the long guard hairs, normally initiated at an early period, as well as the short 'zig-zags', which are normally initiated after birth. It also explains the existence of certain localized bald patches, the absence of certain vibrissæ, and, by its effect on the growth of the skin, the distortion of the vertebræ of the tail from which the gene gets its name, as well as a number of other minor effects.

After the discussion, a series of cinema films were shown, one of which demonstrated the technique used for inducing polyploidy in mouse eggs.

SHIPBUILDING

AN international conference of naval architects and marine engineers was held during June 25–30, with proceedings in London, Glasgow and Newcastle upon Tyne.

The first paper read in London, "Ships Structures —A Century of Progress", by Mr. R. B. Shepheard, of Lloyd's Register of Shipping, traced the development of ships' structures from the wooden ships in general use one hundred years ago, through the stages of iron and riveted mild steel to the modern welded steel ship. With certain noteworthy exceptions, progress following the introduction of new methods of shipbuilding has been delayed by persistent attempts to reproduce the traditions of the earlier methods in the new material.

The application of scientific principles to the structural design of ships developed from the earlier work of Grantham and Fairbairn about ninety years ago, until some forty years later rational methods of obtaining the distribution of material in the section of a ship were developed, largely due to the work of Foster-King, Bruhn and Isherwood. Since that time, research on the behaviour of ships' structures and component structural members has continued in order that further economies might be effected in the light of increased knowledge. The recent introduction of welding on a large scale has presented the designer with many new problems.

Developments of shipbuilding during the Second World War, particularly in the United States, brought to light the importance of notch toughness in mild steel, several major failures occurring due to lack of this quality. This problem of notch toughness which, so far as it relates to ship structures, was isolated in Great Britain in the Engineering Laboratory, Cambridge, as long ago as 1944, is being attacked by metallurgists and engineers in many countries.

Changes in the design and arrangement of dry cargo ships over the past fifty years have tended to increase the bending moments for the loaded condition at sea. In the case of the larger tankers, where there is considerable flexibility of loading in the ballast condition, a stage has been reached where the design must be developed with defined limitations on service schemes of loading.

Another paper, "Proposed Design for a Combined Research, Training and Cargo Ship", by Prof. H. E. Jaeger and J. C. Arkenbout Schokker, must have been of particular interest to shipbuilders in Great Britain owing to the very extensive work in the same field which is being carried out for the Admiralty Ship Welding Committee. It developed the interesting idea of building a dry cargo ship of about 9,500 tons deadweight which would serve the triple purpose of: (*a*) a training ship for officers and engineers for the merchant marine; (*b*) a research ship in which problems on ships' structures and performance could be investigated; and (*c*) a cargo ship engaged in normal trade partly to give realistic conditions for both training and research and partly to offset the cost of the project. This use of the ship for trading purposes would be subordinated to the needs of training and research.

The authors suggested that the most suitable size for such a vessel would be about 472 ft. length (B.P.) and 68 ft. breadth. The displacement would be 15,000 tons and the desirable speed 17 knots, requiring engines of about 8,700 S.H.P. The initial installation should be a diesel electric set installed aft with provision for the substitution of a gas-turbine motor at a later date. Suitable accommodation is planned for the large number of officer cadets and research workers, in addition to the normal complement.

The structure of the ship would include examples of several different types of construction. For example, the fore part would be longitudinally framed, whereas the after part would be transversely framed. Several different types of bulkhead stiffening would be fitted, including some corrugated bulkheads. All bulkheads would be designed to allow the holds to be filled with water up to the level of the shelter deck. This would enable large bending moments and other actions to be applied to the ship during structural tests. Various types of roll-stabilizing equipment would be installed for testing the relative merits of different systems.

No details were given by the authors of the equipment for measuring and recording the forces acting on the ship at sea and the strains induced in the structure. There would, of course, be the great advantage over the recent British experiments on the S.S. *Ocean Vulcan* that the installation of instruments could be made while the ship was under construction.

More rational methods of designing ship structures can only be developed with confidence when more is known of the actual forces to which the structure is likely to be subjected, so that the authors' proposal that several research ships should be built and operated in all parts of the world is attractive. Unfortunately, such experiments are costly, not only in the initial outlay on the ships and in their running, but also in the reduction to useful form of the vast amount of records collected on each voyage.

The cost of such full-scale experiments compels naval architects, as it does engineers in so many fields, to attempt to collect information from model tests such as those described by J. C. Niedermair, of the Bureau of Ships, in his paper "Ship Motions". The paper describes a series of experiments on the behaviour of five ship models of widely differing forms under steady wave conditions. In most of the tests a constant propelling force was applied to each ship in turn, and the amplitudes and periods of the resulting motions were measured together with the mean speed of advance through the waves. In the testing tank used, it was only possible to propagate waves the direction of advance of which was parallel to the ship's course. The full-scale dimensions of the waves used ranged from 300 ft. to 900 ft., and the full-scale heights lay between 19 ft. and 33 ft., while the lengths of the ships were from 380 to 550 ft.

Remarkable changes in the mean speed of advance were shown with changes in wave-length. Despite a great difference in form of the ships, the five models showed like characteristics. Each model exhibited a minimum speed for constant propelling force when the wave-length was about equal to the ship's length.

Curves giving the pitch amplitude as a function of wave-length show that the ratio of maximum pitch to maximum wave slope continues to increase with increasing wave-length at least until the wave-length equals twice the length of the ship. It is significant that no irregularities occur in these curves around the value of wave-length which should theoretically cause resonant pitching. The experimental records have been related to the theoretical analysis recently published by Weinblum and St. Denis, and found to be in general agreement. The pitching periods during these tests were those of the period of encounter, although it is generally accepted that a ship in a seaway pitches usually to its own natural period. It appears that the severity of the forcing motion used has masked the natural oscillations of the ship.

Not unnaturally, the authors feel the need for the verification of the similarity of ship and model motions, and they point out that this would involve instrumenting a ship fully, both to record ship motions and to record simultaneously the surface of the sea. All ways, therefore, seem to point to the need for more research ships.