

## THE BRITISH HYDROMECHANICS RESEARCH ASSOCIATION

THE Laboratory of the British Hydromechanics Research Association at Harlow was open to visitors during June 13-15, when several hundred representatives from industry and the academic world saw details of the research carried out.

The Association specializes in the industrial application of fluid flow and serves a very wide range of industries. Some recent problems investigated are: the ventilation of mines; the design of centrifugal pumps; water hammer in pipe lines; rotary and reciprocating seals; cavitation; the hydraulic transport of solids; friction losses in pipe fittings; and hydraulic design of civil engineering structures. These problems are typical of the extensive interests of the Association. The numerous and apparently unrelated difficulties which arise in such industrial applications of fluid flow often have a fundamental similarity, and for this reason can sometimes be solved through the experience of specialists in fluid mechanics. The Association has been building up such a team in the twelve years since its formation, and can now offer members a pool of such specialized knowledge. Despite the name 'Hydro' in the title, the Association is interested in all fluids, both gaseous and liquid, and its membership includes such diverse industries as hydraulic machinery, instruments, paper, chemicals, aircraft, oil, brewing and the nationalized industries of coal, electricity and transport.

In its research on centrifugal pumps, the Association aims at establishing the sources of loss within a pump, which should lead to a better understanding of the way in which the efficiency of the pump can be improved. This work involves investigations of the Reynolds number effects on pump performance, the relation between impeller and volute characteristics and the overall machine characteristic, and the measurement of disk friction loss. The exhibits demonstrated the refined instruments necessary to study the distribution of velocity and pressure within a rotating impeller. This approach to the problem of centrifugal pump research will incidentally assist in the establishment of acceptable laws for the scaling up of model-pump tests, and for the use of air tests for the prediction of water-pump performance.

Of additional interest to those involved in the testing of hydraulic machinery was an exhibit summarizing the variety of items which have been studied relating to the design of pump test-circuits. These have included the use of guide vanes to prevent swirl and the development of a cascade design which will be more rigid than conventional cascades, and less sensitive to upstream-flow conditions. A 'pepper-pot' valve has also been developed which has the dual advantages of good control characteristics and low loss when fully open. For any circumstances where it is required to produce a good velocity distribution upstream of a test pump or flow-measuring device, a 'flow straightener' has been designed. This combines the features of a graded resistance and a honeycomb, and will reduce considerably the extent of straight pipe required upstream of a pump or flow-meter. A new understanding of the conditions of flow within a shielded pitot tube has

enabled a simple shield configuration to be devised, which renders the pitot tube insensitive to the direction of flow over an angle of about 40°.

The Association has been able to assist in the solution of several mixing problems, and an exhibit devoted to this subject illustrated several different aspects of mixing. One of these is a study of the mixing of a jet of water discharged into a shallow lake. The purpose of the research was to check that adequate mixing took place when power-station cooling water was discharged into a lake, so as to avoid the risk of warm water re-circulating into the intakes, and to reduce the danger to the fish population. Another application of techniques of mixing is the development of an in-line blending unit which successfully mixes, in given proportions, fluids of widely differing viscosities. This uses an orifice designed to have a discharge coefficient which does not vary with Reynolds number.

Two recent items of research were on show, which were of particular interest to makers and users of control valves. The incidence of cavitation in such valves introduces risk of material damage to the valve seat, and, by increasing the loss through the valve, interferes with its effective operation as a control unit. The exhibit reminded makers and users of the importance of checking for cavitation, and showed the importance of a dimensionless 'cavitation number' in defining the incidence of cavitation. Research is also being undertaken on the oscillation of relief valves, a frequent source of trouble in hydraulic engineering. The model valve on show demonstrated that unstable oscillations could occur at several frequencies, depending on the damping.

The water-driven vacuum pump is a device familiar to laboratory workers, but it may not be appreciated that the same technique is becoming more widely used as an economic means of maintaining vacuum in power stations and chemical plant. The essential design features of these pumps were demonstrated with the aid of a transparent model, which showed the importance of ensuring good mixing between the driving fluid and the entrained gas.

When air is released under water from a line source a rising vertical current is induced which, when it reaches the surface, divides into two surface water currents. The windward side current is capable of breaking approaching waves, so that relatively calm water is found in the lee side of such a 'pneumatic breakwater'.

At the request of a Government research establishment, the British Hydromechanics Research Association has studied the relationship between air flow and jet velocity, and has found means of accounting for the effects of slip of the air bubbles.

The exhibits relating to models of civil-engineering structures and pump sumps demonstrated the increasing use of models to ensure the achievement of design requirements, and to devise modifications which could lead to economies in head loss.

For spillways, the function of the model is primarily to study the most suitable design of stilling basin to dissipate the energy of the water at the bottom of the

structure. This aspect was illustrated by a model, at present being tested, of the spillway for the Sasuma Dam in Nairobi.

Models of the cooling-water intakes for the Sizewell nuclear power station were also on show. One, an air model, was being used to determine the head losses at the junctions between the intake shafts and tunnels. As a result of the tests made on this model, modifications to the hydraulic design which naturally had to be compatible with the structural engineering requirements have reduced the head losses due to the junctions by 40 per cent.

The diversity of interests of the Association was of advantage in this case, as the modifications were based on experience gained previously in the study of ventilation schemes of mines. These intakes will be located in a tidal estuary, and a water model has been constructed to examine the effects of tidal flow and tide-level on the flow and head loss in the intakes, and the possibilities of the formation of air entraining vortices.

The Association is also active in the rapidly expanding field of 'industrial hydraulics'. There are many problems involved in the design and utilization of high-pressure oil hydraulic machinery, and a particular example is the use of slipper pads to transmit the thrust from a swash plate to the pistons in an axial-piston pump. An analysis of the conditions for minimum power consumption of these slipper bearings has shown that the minimum occurs when the viscous drag loss is three times as large as the flow loss, although this ideal cannot always be attained as the resulting film gap would be too small. A new apparatus has been built to test slipper bearings under dynamic conditions.

Examples of machines embodying design features of this nature were seen in the form of two experimental power transmissions. One is for applications which require a rapidly variable speed, and is a 2 horse-power ball-piston pump/motor machine. The extremely low inertia of this unit is demonstrated by the fact that full reversal of rotation at 3,000 r.p.m. takes about 0.01 sec. The second exhibit was designed for a motor-vehicle drive where a prime requirement is high efficiency. This unit employs a differentially coupled pump and motor and has an

efficiency exceeding 90 per cent, over a wide range of speed.

The Association has been active in work to ensure compatibility between a hydraulic system, and the hydraulic fluid. A rig was demonstrated for the evaluation of hydraulic brake fluids to study, over a wide range of temperatures, such factors as brake response, leakage, seal life and fluid deterioration. A committee has recently been formed to draw up a specification which will define adequately the properties required of a fluid to be used in particular applications.

Recently, the efforts of the Association in research on fluid sealing have been increased considerably by special contributions from members. This research is directed towards studying the physical processes involved in sealing in mechanical seals, stuffing boxes, and reciprocating shaft seals. A new test rig has been built to study the behaviour of mechanical seals at pressures up to 3,000 p.s.i. In particular, the rig will be used to investigate the possibility that the present limits on the pressure rating of this type of seal are due to mechanical distortion.

In reciprocating-shaft seals it has been found that the leakage is proportional to the square of the shaft speed, and independent of pressures above 1,000 p.s.i. The leakage increases and the friction decreases as the fluid viscosity is increased.

Although the exhibition was primarily of the present research work, an equally important function of the Association is to assist members in the solution of day-to-day problems involving fluid flow, and in issuing an *Abstract Bulletin* and technical reports which keep the membership in touch with the work carried out in other laboratories.

A problem common to all research associations is that of ensuring that the designers and development engineers, who will benefit most from the experience available at the laboratory, are kept informed of the service which is available. To this end, a mobile unit has been fitted out with exhibits demonstrating all the aspects of the work of the Association. The visits made so far by the unit, to member firms, have resulted in a fruitful interchange of ideas between the research staff of the Association and their colleagues in industry. S. T. BONNINGTON

## BLOOD GROUPS OF ANIMALS OTHER THAN MAN

A CONFERENCE on "Blood Groups in Infra-human Species", organized by the New York Academy of Sciences, was held in New York during May 15-16. The programme of papers arranged by Drs. D. B. Amos and C. Choen very fully covered much present-day research on the identification of blood groups in animals other than man, and their use in a variety of pure and applied sciences. On the first day several papers described work with animals useful in medical research. Drs. R. D. Owen (California Institute of Technology) and D. R. Anderson (School of Aviation Medicine, Brooks Air Force Base, Texas) had collaborated on a study of blood groups in the rhesus monkey, with the object of providing markers for transplanted erythropoietic tissue in irradiated animals. Blood group systems in the dog had been thoroughly investigated by

Drs. S. N. Swisher, L. E. Young and N. Trabold (Rochester School of Medicine, N.Y.), and used in experimentation of clinical interest. The rabbit is valuable in comparative research on hæmolytic disease of the new-born, and for this a knowledge of its blood groups was an essential pre-requisite. Dr. C. Cohen (Battelle Memorial Institute, Columbus, Ohio) pointed this out in his review paper, while making an eloquent plea for research workers to co-operate more closely in establishing nomenclature of blood group systems. Dr. Cohen also provided an illustration of the wider interest of the conference with his discussion of genetical aspects and natural selection. The usefulness of rats as laboratory animals was exemplified by the inclusion of three papers about them. Dr. R. D. Owen reported on genetic systems of antigens which had proved abun-