ination of tensile strength and thermal expansion, the latter by instrumental recording of the rate of expansion, thus eliminating the necessity for lengthy periods of direct observation. This section also demonstrated a pressure test rig for glass panels in which deflexions from fifty individual points on the glass surface were simultaneously displayed on scale instruments and cine-photographed at second intervals during the loading cycle. The performance of different types of refractory materials for glass furnace construction had been the subject of investigation by the refractories section, and a demonstration of a corrosion–erosion test rig was given. The glass technology section showed a novel rotating hearth furnace designed to give identical thermal treatment simultaneously to a number of experimental glass batch mixtures. This apparatus is to be used for study of the influence of raw materials on the rate of founding of glass. The chemical section, in addition to numerous examples of analytical techniques in silicate analysis, demonstrated apparatus for the determination of the durability of glass to aqueous attack, and gave an excellent demonstration of the analysis of gaseous inclusions in glass. The demonstration showed methods of extraction of minute bubbles of gas from solid glass and of their analysis to the component gases carbon dioxide, carbon monoxide, sulphur dioxide, sulphur trioxide and oxygen. Such studies have an important bearing on the problem of melting high-quality glass at maximum rate. The work-study section illustrated the use of one-second interval cine-photography for the study of manual operators in factories, and has shown that this technique can prove of value when a number of individual manual operations have to be co-ordinated with each other or with the operation of a machine.

Speakers at the official luncheon marking the opening ceremony reviewed the origin and future objectives of the British Glass Industry Research Association. Dr. L. H. A. Pilkington, chairman of the Council of the Association, directed attention to the man-power deployed on research in glass technology at the present time, estimating this to be some 200–250, and forecasting that the figure would increase to 750–900 within a five-year period. Although smaller in numbers than a force of some 750 at present employed in research by four of the largest glass manufacturing firms of the United States, these men managed to keep us abreast of developments in many fields and definitely ahead in some. Mr. A. W. Clark, chairman of the Glass Manufacturers' Federation, referred to the value of research associations to smaller firms the resources of which could not justify individual research units.

COIL SPRING FEDERATION RESEARCH ORGANISATION

NEW LABORATORIES

THE Coil Spring Federation Research Organisation, which has been in existence for fourteen years, has for the majority of this time confined its research activities to extra-mural work in universities, although the long-term aim of the spring industry has always been to operate its own research and development laboratories while maintaining the close links it has established with universities. This has now been achieved by the setting up of a new research centre, the construction of which has been financed from reserves set aside for the purpose.

The two-story laboratory block recently completed in Doncaster Street, Sheffield, is probably the most comprehensive of its kind for research into all forms of springs and spring materials.

The ground floor, in addition to the usual reception facilities, contains laboratories for heavy-fatigue testing, general mechanical testing, experimental heat treatment and electroplating. In the fatigue testing laboratory are housed 12½ h.p. machines capable of applying a dynamic load of 9 tons, which are used for fatigue testing heavy coil springs; up to eighteen springs may be tested at one time. Other machines used for fatigue testing springs of the internal combustion engine type are capable of infinitely variable speeds of compression of up to 4,000 per min. Fatigue tests in repeated torsion are carried out on torsion bars, and are used to produce data from which an assessment of the effects of composition, heat treatment and surface condition can be made prior to the manufacture of experimental helical springs. A special feature of this laboratory is the sound-proofing and anti-vibration features incorporated in both the suspended ceiling and the floor.

The mechanical testing laboratory houses a variety of conventional machines used for determining the properties of both specimens and springs, covering the range of material diameters 0·004–2·0 in. One machine, for example, is capable of developing a maximum torque of 120,000 in. lb., and is used to investigate the effects of hardenability on the static torsional properties of large-diameter spring steel bars.

Many researches relate to the load-deflexion characteristics of springs and the Organisation has a comprehensive range of machines, capable of applying static loads from a few ounces up to 30 tons. The determination of fatigue characteristics of drawn wires of diameters 0·01–0·25 in. is provided for by high-speed rotating-beam fatigue machines, which can complete up to 100 million cycles in as little time as one week. The study of corrosion and protection of spring materials and the effects of hydrogen embrittlement due to electroplating has had an important place in the Organisation's programme for many years. The work is being continued in a new laboratory specially fitted out for this purpose; the plant in it has been presented by Messrs. Canning, Ltd., the Birmingham manufacturers of electroplating equipment. Facilities are available for electroplating copper, zinc, tin, cadmium and nickel. The experimental heat-treatment laboratory is equipped with fully instrumented electric furnaces for general heat treatment, and high-temperature heat treatment under various types of protective atmosphere.

The laboratories contain a number of machine tools and a shot-peening unit which automatically rotates the object under treatment while at the same time traversing it with the shot stream. It is being used in a fundamental study of the effects of shot-peening and optimization of it, together with an assessment of possible methods of measuring intensity.

The first floor is devoted to light laboratories (containing small static testing machines, general scientific instruments and equipment), administrative offices, and a conference room. The materials testing laboratory contains machines for determining macro-hardness, tensile and torsional properties of wires and load-deflexion characteristics of small springs. Metallographic facilities are provided in specially fitted rooms for rough sample preparation, fine polishing and etching, microscopical examination and photography. The microscope room contains a high-powered binocular bench microscope, projection microscope and micro-hardness testing equipment.

The Organisation is studying spring materials for elevated temperature applications, in particular the stress-temperature relaxation properties of springs made from a very wide range of alloys. A battery of spring creep testing machines is installed which will enable the behaviour of springs to be determined up to 850° C.

CHEMISTRY OF PROPELLANTS

A MEETING was recently held in Paris (June 8–12) under the auspices of the Combustion and Propulsion Panel of the Advisory Group for Aeronautical Research and Development, with "Chemistry of Propellants" as the main topic. It was felt that such a meeting could contribute to a useful exchange of research information and discussion of current problems among North Atlantic Treaty Organization countries. Its importance can be judged by the attendance of nearly two hundred observers from eleven countries, nominated through their Advisory Group for Aeronautical Research and Development national delegates.

The meeting was opened by Dr. von Karman, who was supported by Dr. Seitz, the science adviser to the North Atlantic Council, and his recent predecessor, Dr. N. F. Ramsey. Later in the week Dr. G. B. Kistiakowsky, the new scientific adviser to the President of the United States, attended and took part in the proceedings. These could be classified under three main headings, namely, propellants or associated features for liquid rockets, solid rockets and air-breathing engines, and the papers presented covered reviews of existing knowledge, reports of recent work and assessments of future problems.

The first technical session was introduced by a paper by S. Greenfield (United States), who reported on an experimental evaluation of liquid-propellant data. This was based on a research programme to compare differences in behaviour of various hydrocarbon fuels when burned with liquid oxygen. The fuels were pure samples of each of the chemical types such as paraffins, aromatics and olefins together with a reference fuel specified as *JP*–5. The main results covered liquid film heat transfer coefficients and their variation with heat flux and combustion stability, specific impulse variations with mixture ratio, and effect of aromatics on available energy in fuel-rich gases suitable for turbo-pump operation. An interesting feature of this work was the precise measurements achieved and the important influence of combustion chamber length (or L^*) on performance. The conclusion was drawn that naphthenics are beneficial in a mixed fuel, but normal paraffins are of doubtful value.

This paper was, to some extent, complementary to another by R. J. Thompson (United States) covering theoretical performance evaluation. This work was carried out on an electronic data-processing machine and presented a vast tabulation of thermodynamic functions and propellant parameters which were discussed and illustrated. The main propellant combination discussed was liquid oxygen and kerosene, although data on fluorine-liquid hydrogen were also used to illustrate the calculations. Additionally, thermodynamic properties as functions of temperature for eleven of the more important elementary monatomic gases were given. It is certain that these two papers will be of great use in future studies of propellants.

The next paper in this group was by D. L. Armstrong (United States) and reviewed the characteristics of liquid propellants desired and achieved in rocket engines. The important physical properties included vapour pressure, density, viscosity, specific heat, boiling and freezing points, and other features which were tabulated and discussed. Chemical properties were also enumerated and mention was made of reactivity, self-ignition, combustion kinetics, stability and corrosion. The author also gave some indication of performance, manufacturing processes and suggested propellants for various missions, but much more detailed and relevant papers on these aspects were presented by W. G. Parker and G. Ruston (Great Britain) on the merits of utilizing high-energy propellants, and S. H. Dole and M. A. Margolis (United States) on the sources, availability and estimated cost of propellants. The former took a slightly unusual line in dismissing the majority of the exotic propellants from consideration, first, because of the unfavourable properties such as extreme reactivity and toxicity, and secondly, because the advantages of higher specific impulse become less marked beyond values of about 320 sec. Their conclusions were that liquid hydrogen was worth developing because of its probable use in nuclear rockets, but it should be in combination with nitric acid or hydrogen peroxide rather than liquid oxygen. The accidental combination of hydrogen and oxygen liquid or vapour could be too great a hazard to risk. The paper on costs pointed out that prices of many propellants would be significantly altered if production demands increased, but even allowing for this, it was clear that the cryogenics would give a better performance than the storable liquids for a given cost. Costs should, however, include the overall system cost, and some curves were given showing flight vehicle cost against total impulse required for solid propellant, storable and cryogenic. At the higher values of total impulse, the cost of using these propellants was in descending order. This was strongly challenged by protagonists of solid propellants during the discussion.

The papers on solid propellants were given by R. Steinberger (United States) on the properties of