The FULMER RESEARCH INSTITUTE

THE FIRST FIFTEEN YEARS

1947 - 1962

The

FULMER RESEARCH INSTITUTE

Main Building

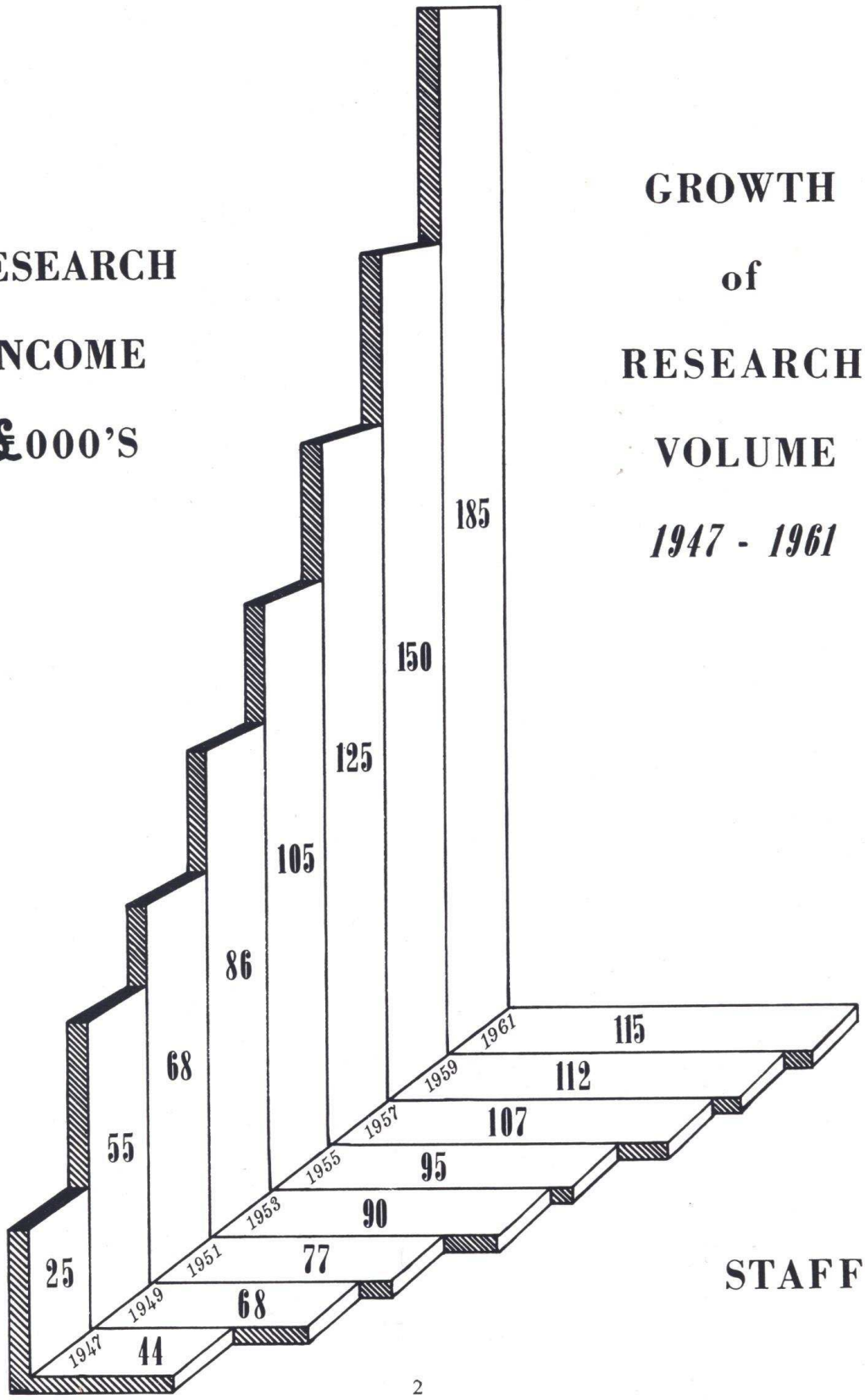
31962-C(1)

THE FULMER RESEARCH INSTITUTE LIMITED

STOKE POGES

BUCKINGHAMSHIRE

GROWTH of RESEARCH VOLUME *1947 - 1961*



BOARD OF DIRECTORS

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SCOPE AND FUNCTIONS OF THE INSTITUTE

THE Fulmer Research Institute was founded in 1946 by the late Colonel W. C. Devereux to carry out contract research for Industry. In 1947 there were 44 members of staff and the income was £25,000. The annual income for 1961 was £185,000, and the staff numbered 115, of whom 38 were graduates or had equivalent qualifications.

The main fields of activity are metallurgy, physical and inorganic chemistry, and solid state physics, but there are no prescribed limits to the type of work undertaken. Patents arising from an investigation belong to the sponsor, and all results are confidential and are divulged or published only with the sponsor's permission.

A large part of the research work is for Government departments and the U.K.A.E.A., and a substantial proportion of the Institute's income is from overseas. Nevertheless, there is increasing use of the Institute by industry. Larger firms, with their own laboratories, find it economical to sponsor work in fields where the Institute has specialised experience and equipment. Smaller firms can call upon the Institute for far more extensive research facilities than they have available internally, without being involved in capital outlay on expensive items of equipment and the employment of specialised staff.

Small firms make extensive use of the facilities for mechanical testing, chemical analysis and consulting services, and short term investigations are undertaken to solve specific production difficulties. This work represents only about 15% of the Institute's total income but shows a tendency to increase annually.

STRUCTURE

The principal divisions within the Institute are:

(1) Physical Metallurgy.
(2) Foundry, Metal Working and Ceramics.
(3) Physical Chemistry, Thermodynamics and Extraction Metallurgy.
(4) Physics (including Electron Microscopy).
(5) Engineering and Mechanical Testing.
(6) Corrosion and Electrodeposition.
(7) Chemical and Spectrographic Analysis.

Ancillary services at the Institute include well equipped workshops (in which much of the Institute's specialised apparatus has been made) and an extensive library which receives more than 200 scientific and technical periodicals. Information and advice based on published work can be supplied quickly to sponsors, and a translation service is available.

The internal organisation of the Institute is flexible. Most researches are done by team work employing all appropriate available man power and equipment from different departments, but work of a highly specialised nature may be the responsibility of one man working virtually alone. Where possible, contacts are made direct between the investigator and the sponsor's technical staff. In general, personal contact is preferred to committees for progressing the work.

Physics Laboratory (left) and Workshop Building (right) 3196-E

CONDITIONS OF SPONSORSHIP

SERVICES PROVIDED AND COSTS

(i) Certain work, generally of a routine nature, such as mechanical testing or chemical analysis, can be undertaken for a fixed agreed fee.

(ii) Investigational work of short duration dealing with service failures, etc., is charged on the basis of the time devoted to the solution of the problem.

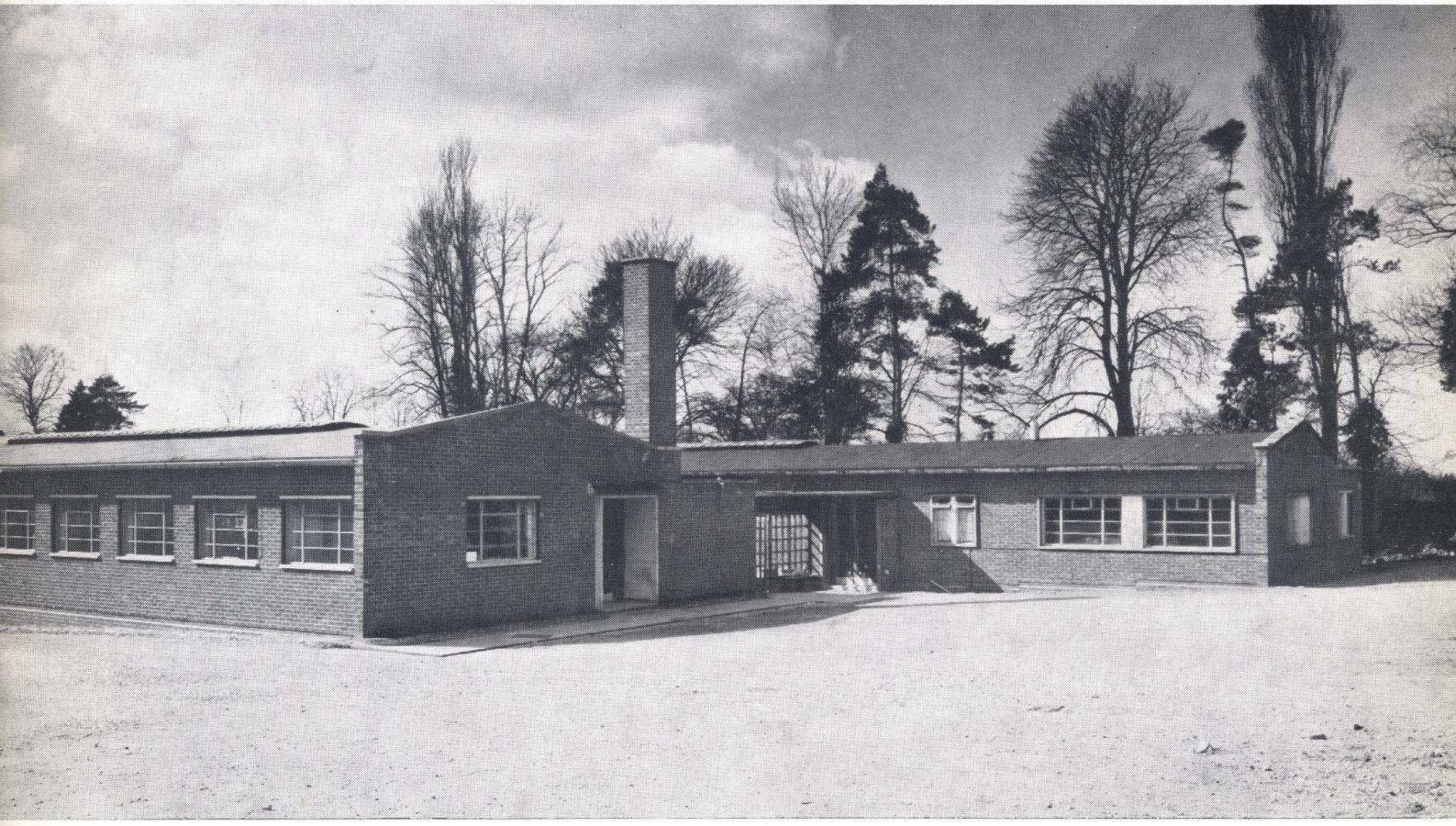
(iii) Other work is carried out on a contractual basis, a standard research contract being drawn up between the Institute and the sponsor after the terms of reference and the experimental programme have been agreed, and the costs of the programme estimated.

(iv) Results of experimental work carried out under contract (and patents arising therefrom) belong to the sponsor, and are treated as confidential, together with any information given to the Institute by the sponsor.

(v) Contract research is not carried out on the same subject for more than one sponsor, except by agreement, but routine or consulting work is not subject to this limitation.

(vi) Nominees of sponsors may work in the Institute's laboratories, thus facilitating the development and application of research results in industry.

(vii) Publication of contract research results is only made with the sponsor's permission.



Engineering Laboratory (left) and Metallurgy Laboratory (right)

31962-D.

EQUIPMENT AND SPECIALISED TECHNIQUES

X-Ray Crystallography

Phase transformations in metals, and atomic and molecular structures generally are studied by X-rays in the Physics Laboratory where there are six generators. An X-ray diffraction camera has been designed for studying reactive metals such as titanium and zirconium at temperatures up to 1000°C. in a vacuum of better than 10^{-6} mm Hg. A Geiger counter spectrometer has been developed for studying the structures of liquids including metals liquid at elevated temperatures. Facilities for examining crystal structures at sub-zero temperatures are also available.

Particular attention has been paid to the development of high sensitivity single crystal techniques using monochromatic radiation. These have proved most useful for studying precipitation in aluminium and beryllium alloys. X-ray diffraction is used extensively for identification and analytical purposes.

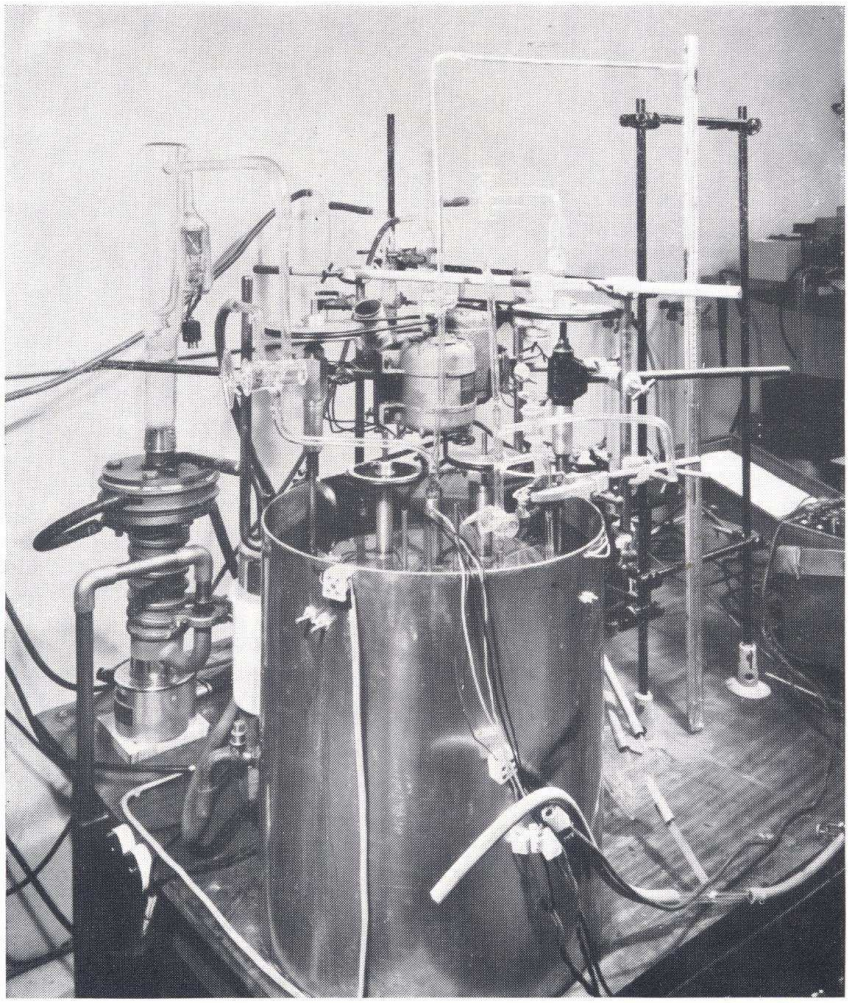
Electron Microscopy

A.E.I. EM3A and EM6 electron microscopes are used for reflection and transmission (thin film) electron microscopy and electron diffraction. A magnification of 50,000 times can be obtained with a resolution of 20 Angstroms on the EM3A instrument and the EM6 has a magnification range of 600-120,000 times with a resolution of 10 Angstroms or better.

In recent researches, the electron microscopes are being used to study the fundamental nature of slip lines in metals, the influence of surface oxide growths on the build-up of deposits in oil-burning furnaces and the wear of thin evaporated metal films, as well as in a variety of short term investigations such as particle size determinations, the examination of paint pigments and the examination of razor blade profiles.

Metallography and Physical Metallurgy

A Bausch & Lomb metallograph, a Reichert MeF metallurgical microscope and several bench microscopes (one of which is equipped for phase contrast microscopy and micro-hardness testing) are available for metallography. Various specialised pieces of equipment have been developed for studying phase changes, particularly in reactive alloys. These include a hot hardness tester that will operate at temperatures up to 1000° C. in a vacuum of 10^{-5} mm. Hg, and a dilatometer incorporating a linear differential transformer which is used for studying isothermal transformations and can be adapted for examining martensitic changes on quenching. There is also a sensitive stress-strain machine of Polanyi type for studying yield point phenomena and machines for examining the effect of strain rate changes during slow creep.



19759-B

CALORIMETER USED FOR DETERMINING HEATS OF FORMATION OF INORGANIC COMPOUNDS

The calorimeter consists of an inner calorimetric vessel containing the calorimetric fluid and the reaction bomb, and an outer constant temperature bath controlled to within $\pm 0.001°C$. *The interspace between the two vessels is maintained under high vacuum. The calorimetric fluid is usually water but other substances have been used for reactions which must be carried out at elevated temperatures (e.g. metal bromides). The amount of chemical energy liberated by the reaction is determined from the temperature rise of the calorimeter, which is measured by a semi-conductor resistance thermometer having an accuracy of* $2 \times 10^{-4}°C$.

The values obtained for the heats of formation of compounds vary from 20 *K.cal., for heats of alloying, to* 500 *K.cal. for heats of formation of metal fluorides. The overall uncertainty of a determination is usually less than* 0.1%.

Physical Chemistry

Specialised techniques are available for equilibrium and activity measurements at temperatures up to 2000° C., thermochemical work of high precision, and for thermochemical measurements on reactions which proceed only at elevated temperatures (up to 1200C°.).

Equilibrium measurements have been applied to studying the stability of normally non-existent radicals (A1C1, A1F, BF) and the activities of alloy constituents. The gas transference method has been used at total pressures of about one atmosphere, and the effusion method for pressures below about .1 mm mercury; for the latter a vacuum micro balance and a torsion cell are available. The "capillary vessel" method, in which an unknown reaction or vapour pressure inside a vessel is compared with the known pressure of a simultaneous reaction or vapour pressure, has been developed in the Institute for measurements in the intermediate pressure range.

For thermochemical work, calorimeters of various design, resistance thermometers for different temperature ranges and ancillary equipment for the calibration of calorimeters and thermometers are available. Calorimeter vessels and "bombs" of both the static (pressure) and flow types have been constructed and used, particularly with bromine, chlorine, fluorine and other gases. A solution calorimeter made from platinum for use with hydrofluoric acid is available. There is also equipment for the direct determination of heats of alloying or heats of formation of intermetallic compounds and for the extreme purification of basic reactants including fluorine.

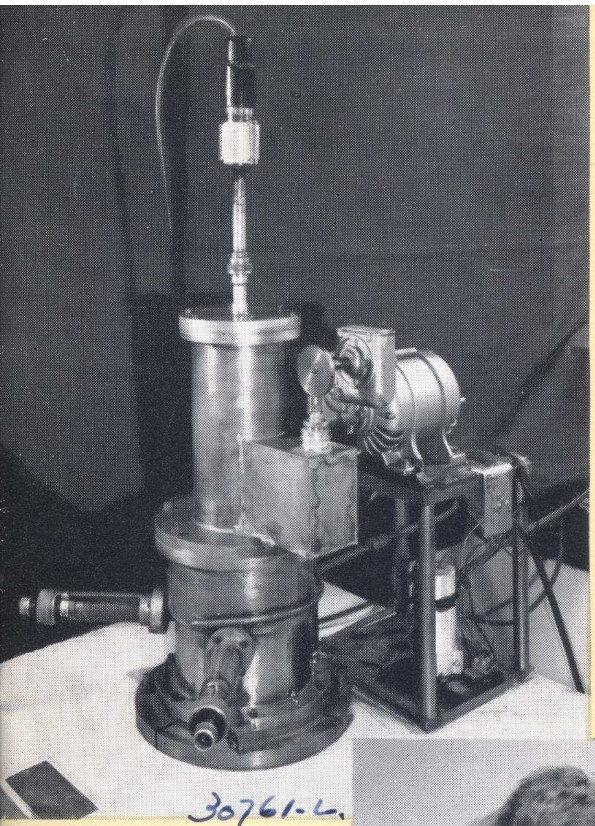
Physicochemical measurements have been made on chemical kinetics and the radiation of gases at high temperature, and equipment constructed for these and more conventional investigations is available.

Ceramics

The laboratories are equipped for making, applying and testing ceramic materials, including special enamels and refractories. A kiln for firing ceramics at temperatures up to 2000°C., and a hot pressing apparatus are available for ceramic preparation. Special automatic spraying techniques have been developed for enamelling. Petrological techniques are in use for mineral identification.

Electrodeposition

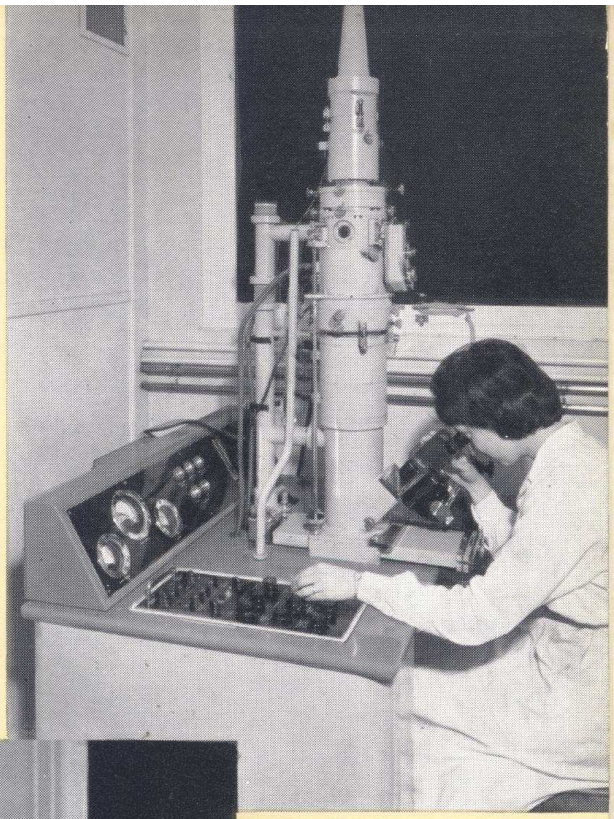
Laboratory facilities are available for small scale experimental plating, anodising, etc. On a larger scale, there are two rectifiers with an output of up to 250 Amps; these are at present in use for electro-winning chromium of very high purity using a fluoride bath. The output is in the region of 8 lb. per week.



30761-L.

Apparatus for determining hardness at elevated temperatures in vacuo

Aligning single crystal for precipitation studies by X-ray diffraction

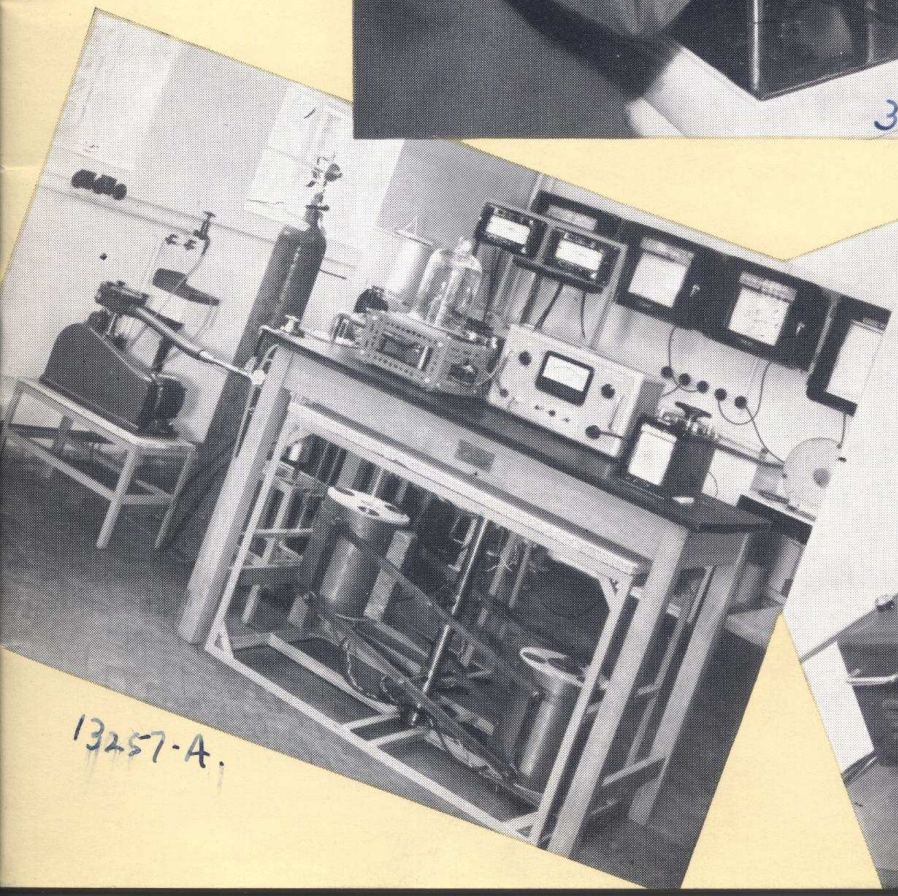


Electron Microscope

31962-L

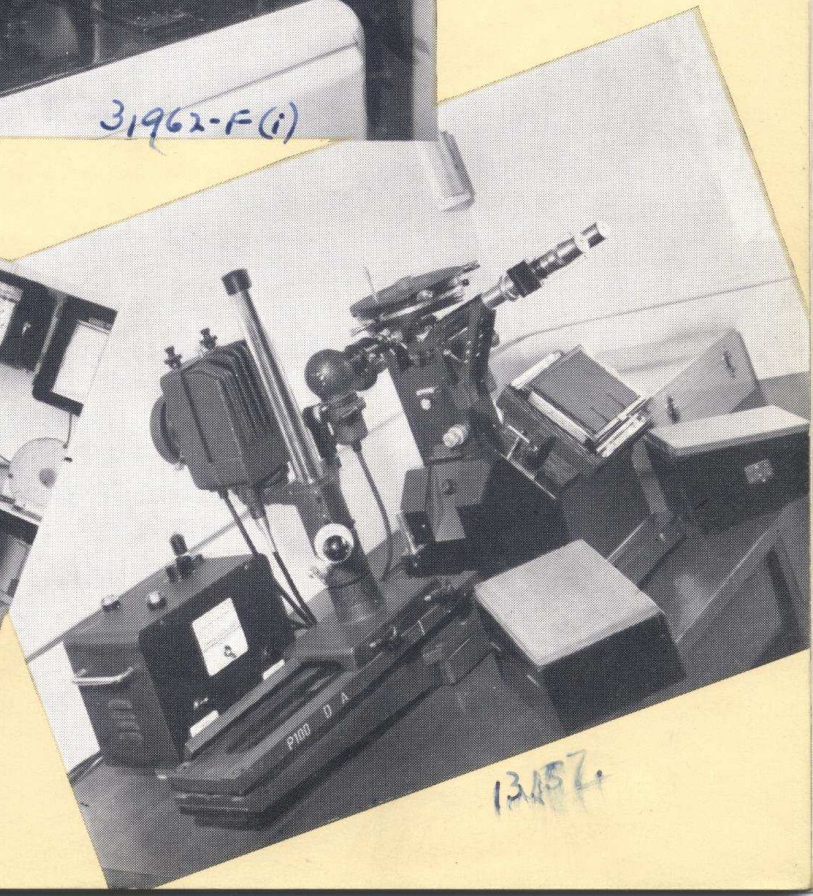
31962-F(i)

Continuously recording dilatometer



13257-A.

Reichert MeF Metallurgical Microscope



13257

Corrosion

The corrosion laboratory is equipped with salt spray, humidity and SO_2 cabinets and the Institute has atmospheric exposure sites in industrial, marine and rural environments. Various types of stress corrosion rig are used and a novel technique has been developed for non-destructive assessment of corrosion damage in terms of loss of strength, enabling a corrosion/time curve to be derived on a single specimen. Electronic equipment such as valve voltmeters, potentiostats and constant current devices are used for studying the effect of applied potentials and currents on corrosion reactions, particularly during corrosion fatigue.

Chemical and Spectrographic analysis

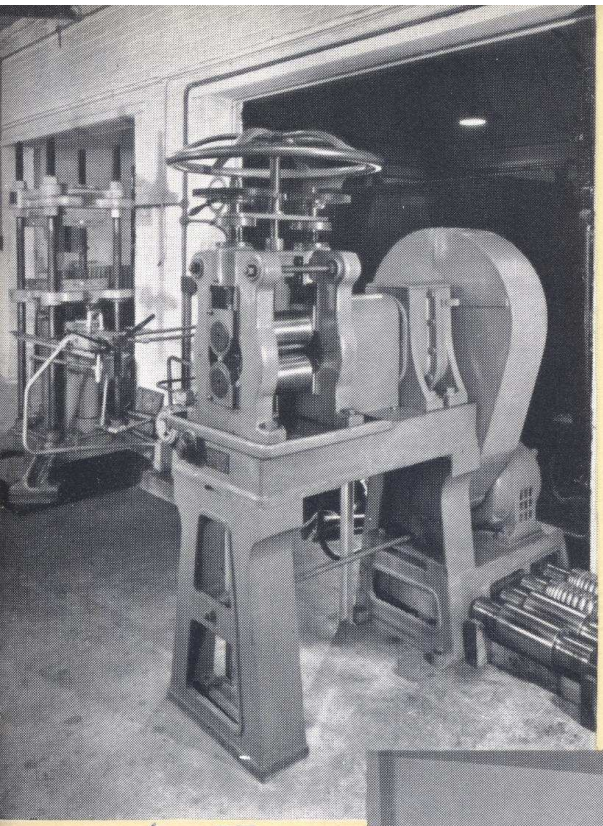
The Institute is equipped for inorganic and metallurgical analysis and the analytical staff have extensive experience of working with alloys and compounds. The equipment includes large and medium quartz spectrographs, a recently-installed Wild-Barfield vacuum fusion apparatus and a cathode ray polarograph.

Melting and Casting

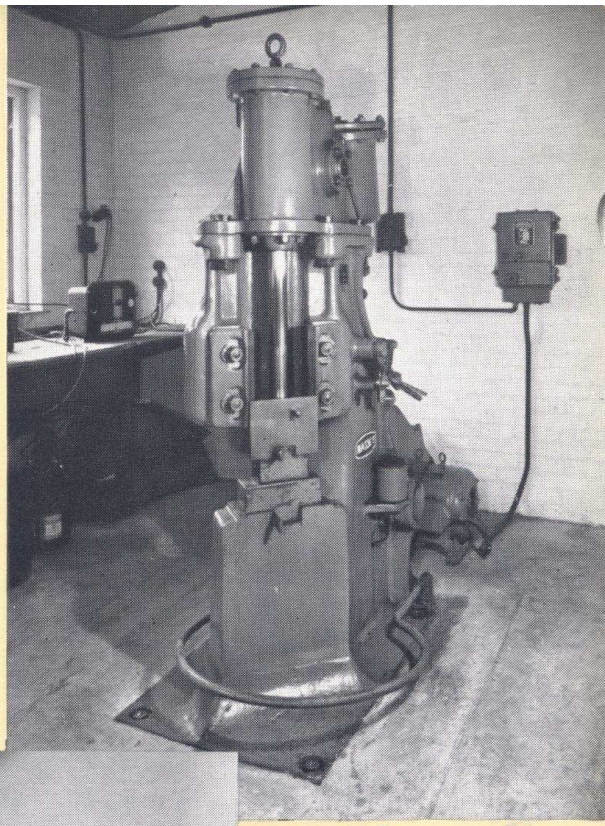
The experimental foundry is equipped with conventional oil, gas and electric furnaces for melting. More specialised equipment includes induction furnaces for melting and casting, with or without special atmospheres, or in vacuo. Reactive alloys are prepared in small argon arc furnaces. A consumable electrode argon arc furnace, capable of melting ingots 4 in. or less in diameter is in use for chromium base alloys. Apparatus is available for electron bombardment melting and is also used for zone refining and growing single crystals.

Metal Working

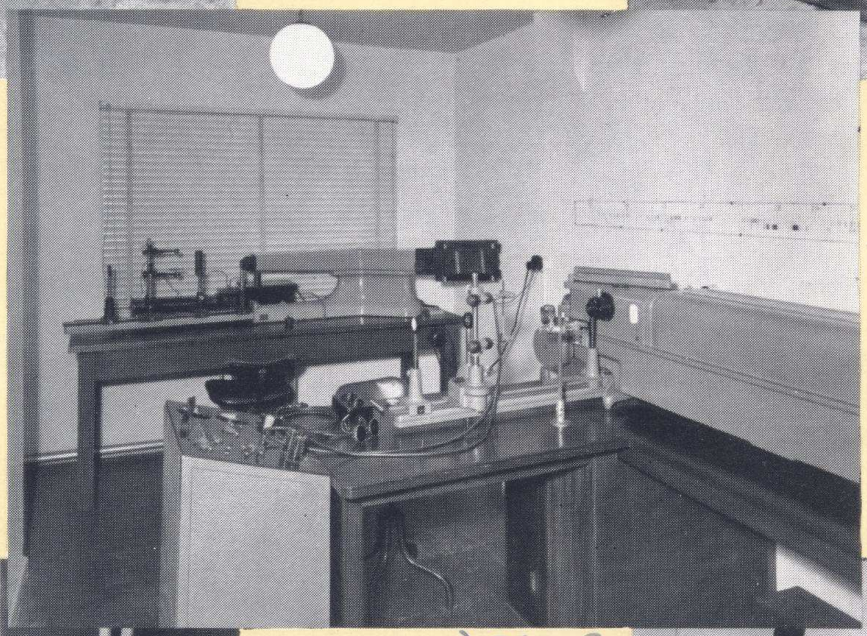
Metal working equipment includes a forging hammer, a rolling mill with plain and grooved rolls for hot and cold work, and small jewellers' rolls. Metals and alloys can be fabricated into sheet, rod and large diameter wire forms. There is also a 60-ton press, used for hot pressing metal powders, and a small laboratory extrusion press.



10757
Rolling Mill

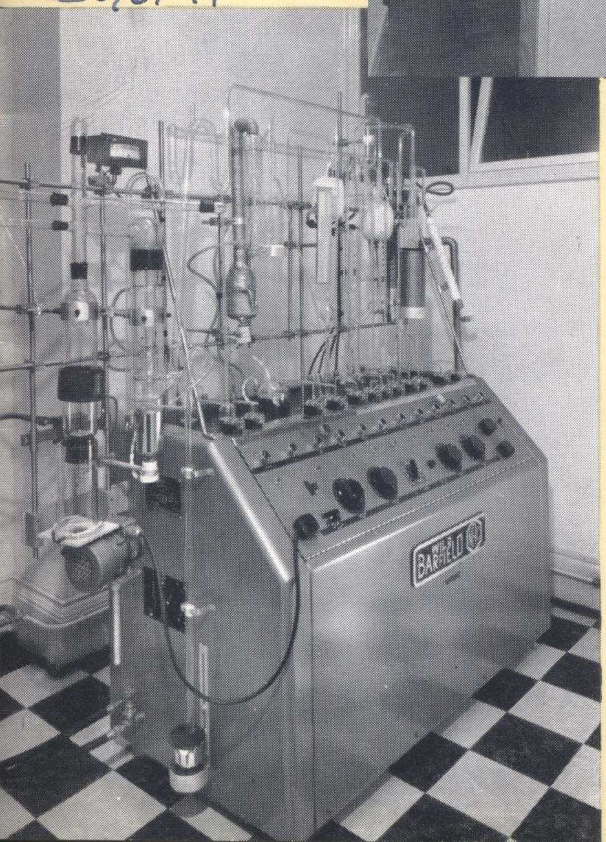


58754
Forging Hammer

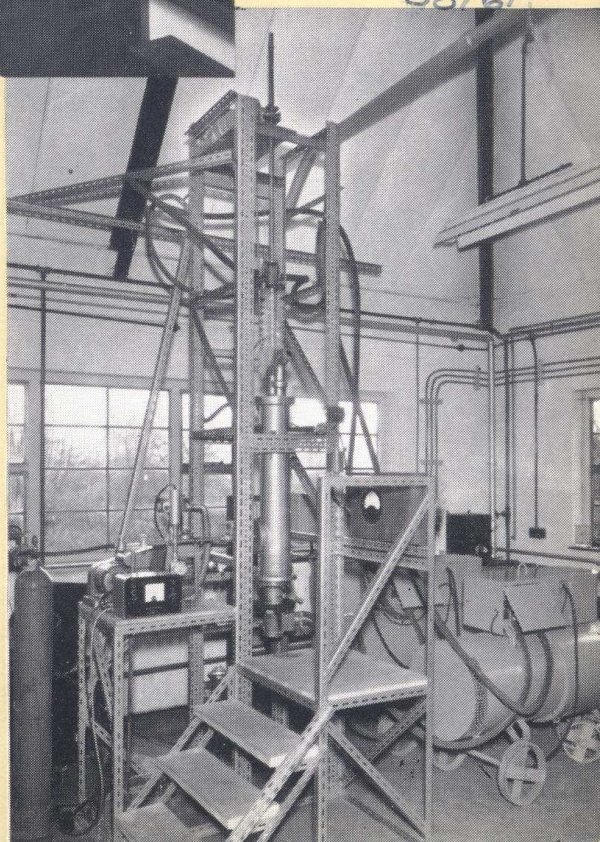


Apparatus for vacuum fusion analysis.
30761-N

Consumable electrode argon arc furnace
30161



30761-B.
Large and Medium Quartz Spectrographs



Engineering and Mechanical Testing

The Engineering Laboratory is equipped to carry out all normal mechanical tests and the design and construction of apparatus for non-standard testing is undertaken. Equipment available includes impact and hardness machines and a Dennison 50-ton universal testing machine with ancillary equipment for high and low temperature testing. For fatigue testing there are Wöhler, Haigh, "slipping clutch" and Rolls-Royce machines. Equipment has been specially designed for high temperature reverse bend fatigue testing of sheet and for fatigue testing of bar at low temperatures down to —50°C. A number of the fatigue machines have been adapted for corrosion fatigue testing.

A "slipping clutch" (N.P.L.) type machine designed and built in the laboratories has attracted considerable attention and arrangements have been made to build these machines under licence for sale to outside laboratories. They have already been supplied to A.I.D. Harefield & A.W.R.E. Aldermaston.

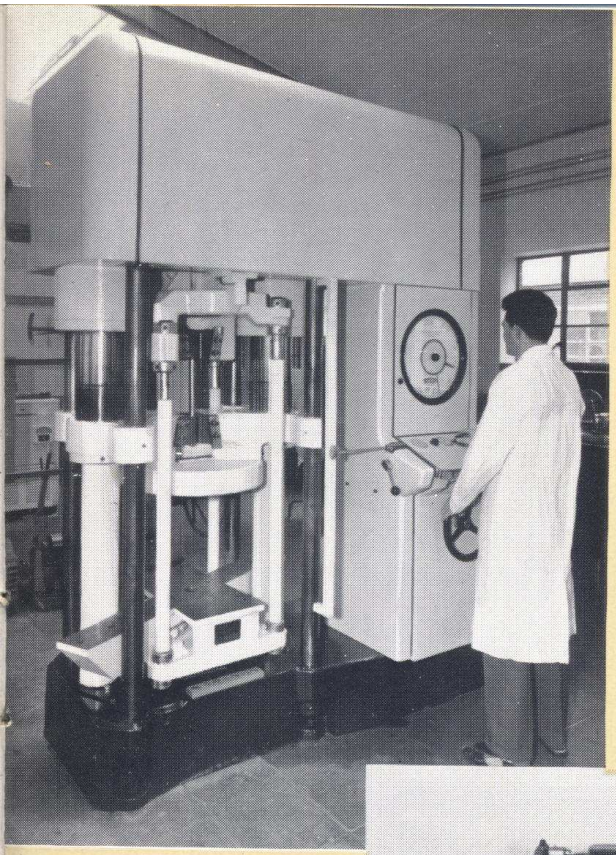
Facilities are available for conventional creep testing and also for compression creep testing; the compression machines have been used with special atmospheres.

Recent researches have included studies of the creep and fatigue properties of Mg base nuclear fuel element canning materials, the effect of notches on the fatigue strength of RR58, and the effect of heat treatment during secondary creep on the creep life of Nimonic 90.

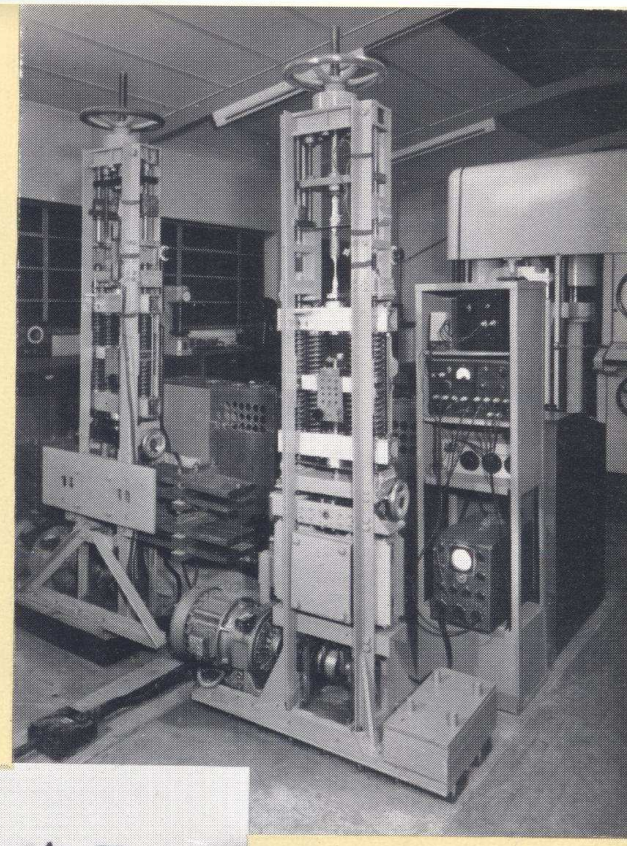
Static and dynamic strain gauge measurements have been made on structures under load, both in the field and in the laboratory.

Laboratory Workshops

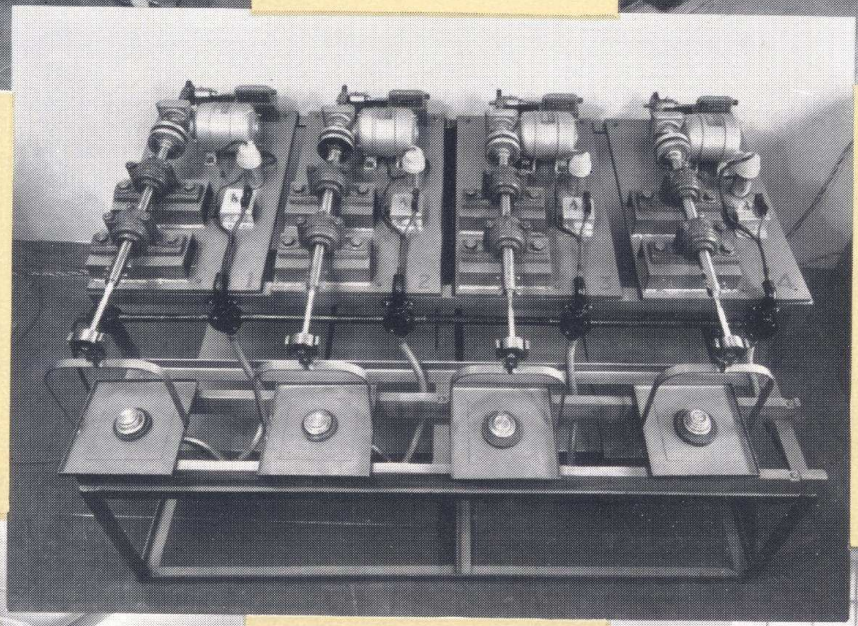
A large proportion of the laboratory apparatus is designed by the research staff and constructed in the Institute's workshops. The workshop equipment comprises precision lathes, universal millers, grinders and an ultrasonic drill as well as normal metal and wood working facilities. Members of the staff are encouraged to acquire glass blowing skills and a glass blowing lathe is available.



Dennison 50 ton Universal Testing Machine
3962-N.



"Slipping Clutch" Fatigue Machines
1845.



Tensile Creep Machines
10557.

Creep testing in vacuo with continuous photographic recording
3962-M.

Wohler-Type Fatigue Machines
3962-A (1)

FIELDS OF INVESTIGATION

The following notes contain brief descriptions of some of the work completed or in progress. Work is confidential to the sponsor and the account given is confined to those investigations which have been published or otherwise made available with the permission of the sponsor.

Thermochemistry

A knowledge of the relevant thermodynamic data is essential for assessing the feasibility of such metallurgical processes as extraction, refining, coating and alloying. Where the data are not available, new determinations of heats and free energies of formation are required. Values have already been obtained for:

Aluminium and magnesium fluorides.
Cryolite.
Titanium tetrachloride, tetrabromide and tetrafluoride.
Sulphur hexafluoride, boron trifluoride and phosphorus pentafluoride.
Zirconium, hafnium and vanadium tetrachlorides.
Niobium and tantalum pentachloride and pentabromide.
Boron nitride, uranium silicides and uranium nitrides.

Fluorides are potentially interesting as rocket propellants because of their high heats of formation, and special facilities and techniques are available at the Institute for handling fluorine and its compounds.

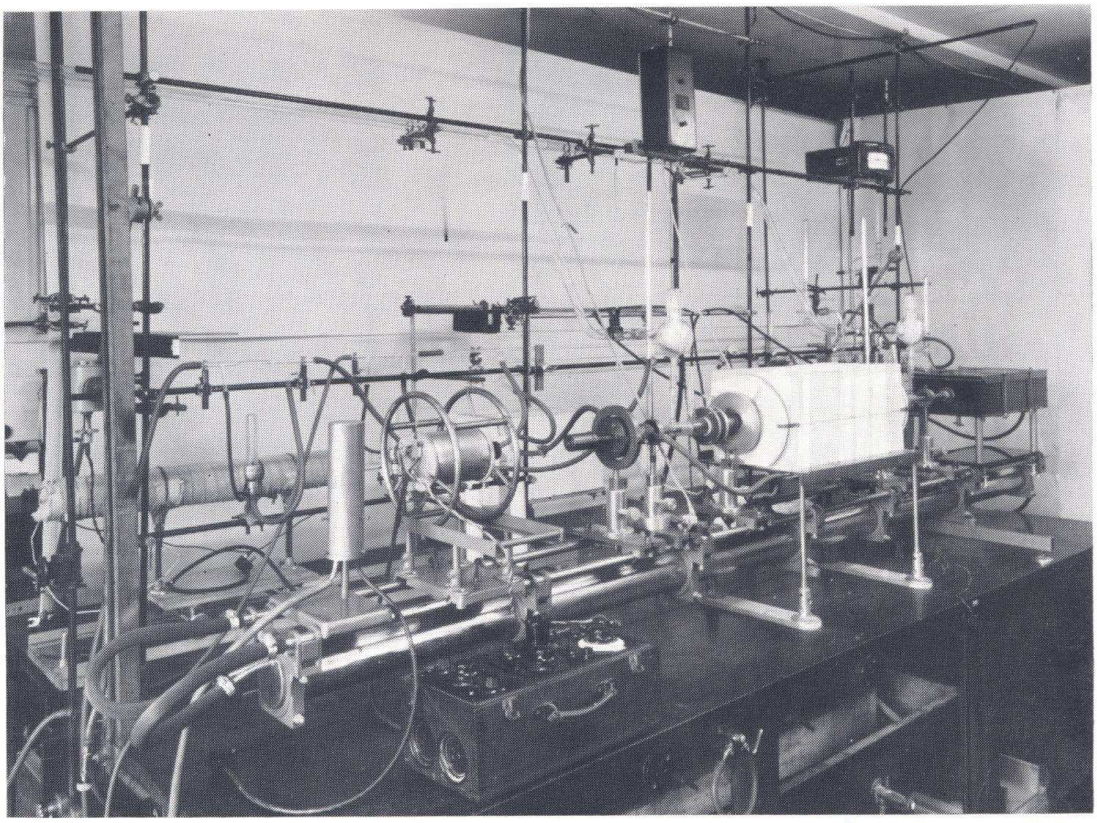
Thermodynamic data are also important in physical metallurgy, where alloy phase diagram information is sometimes most conveniently obtained by determining heats and free energies of formation. Free energies of alloys in the following systems have been measured: iron-aluminium-silicon arc furnace alloys, iron-chromium-carbon, aluminium-manganese, iron-titanium, iron-aluminium, uranium-bismuth, thorium-bismuth.

Comparable thermochemical studies are also currently in progress on a number of binary oxide systems.

In this work, each system requires a special approach and novel techniques have been developed, for example in the preparation and handling of highly reactive materials, or in overcoming problems arising from the difficult experimental conditions frequently encountered.

Ore Benefication

An increasing amount of work is being done in the field of ore benefication and ores have recently been treated by solid state reduction with anthracite to achieve enrichment in manganese, titanium and vanadium.



30761-M(iii)

APPARATUS FOR MEASURING EMISSIVITIES OF GASES AT HIGH TEMPERATURES

At high temperatures radiation from gases plays an important part in heat transfer, and emissivity data are therefore important for the design of equipment. Measurements are made of total radiation from a flowing column of gas contained in a refractory tube which is open at both ends, the length of the gas column being defined by use of exactly balanced opposing streams of argon to form a "gas barrier" at each end of the tube.

The emitted radiation is measured by a sensitive thermopile in conjunction with an optical system containing a concave mirror as the image-forming element, with a diaphragm placed close to its focal plane to exclude radiation from the furnace components surrounding the gas. Provision is made for measuring total radiation from the gas with black body backgrounds at various temperatures. The entire apparatus is mounted on a water-cooled optical bench. Emissivities of gases have been measured at temperatures up to 1000°*C.*

Extraction Metallurgy

The catalytic aluminium distillation process invented by Dr. P. Gross is well known and is thought likely to be competitive with the conventional electrothermic extraction process. Aluminium trichloride is passed over a molten aluminium alloy formed by arc melting bauxite or other suitable ores. The aluminium monochloride formed is decomposed to high purity aluminium and aluminium trichloride which is recirculated. The process can also be used for refining scrap aluminium and aluminium alloys. Extensive development has been carried out and laboratory work is continuing at the Institute.

A chloride process has also been developed for the extraction of titanium. Titanium tetrachloride is passed over ferro-titanium or titanium scrap, forming titanium di- and tri-chlorides which are subsequently decomposed to relatively pure titanium and further titanium tetrachloride for recirculation. The process has been developed on a laboratory scale and can be extended to the pilot plant stage.

A related method has been applied to the purification of beryllium, with promising results.

Uranium Alloys and Compounds

In unalloyed uranium, the orthorhombic α phase is stable up to 660°C. The anisotropic nature of the α phase can result in dimensional instability of fuel elements in the reactor. This can be avoided by quenching dilute alloys from the β phase region to give a fine grained structure, free from preferred orientation, or more highly alloyed uranium from the γ region to obtain the isotropic γ phase.

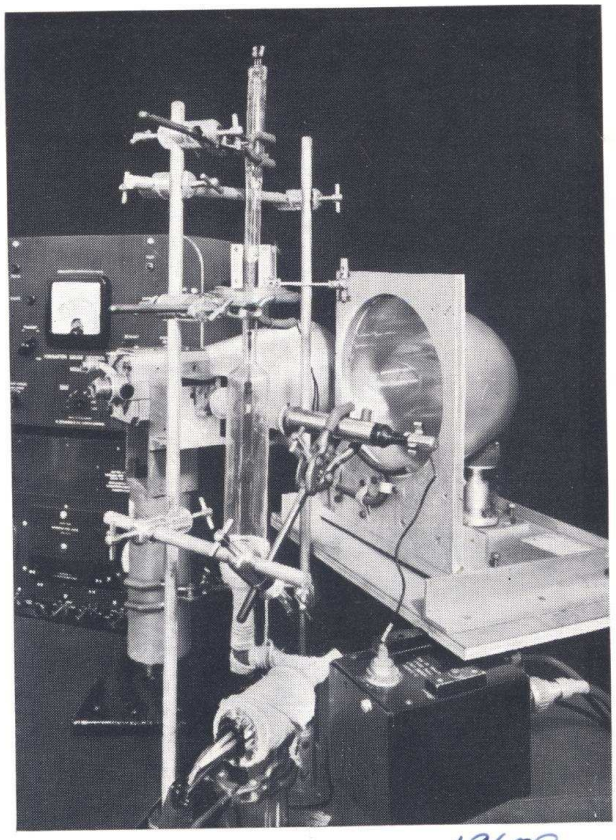
At Fulmer, research on the crystal structure of the β phase has been carried out by X-ray diffraction, and the mode and kinetics of transformation of the β phase are being investigated in various alloys using hot hardness, thermal analysis, metallographic examination and X-ray diffraction techniques.

By quenching various alloys at different cooling rates a sequence of transformation structures between γ and α have been obtained. The physical properties, kinetics and mechanisms of transformation of these alloys have been studied. This provides basic knowledge, useful in understanding what happens in cooling fuel elements.

The structure of uranyl nitrate tri-ethyl phosphate has been determined by X-ray diffraction. A low temperature technique has been developed for crystallising the tri-butyl complex, which is liquid at room temperature, for X-ray diffraction examination.

High Temperature High Vacuum X-ray Diffraction Camera

To minimise atmospheric contamination, the camera is constructed in glass without demountable seals and the source of heating is a 1 KW bulb at the first focus of the ellipsoidal reflector. The specimen, in the form of a single crystal grown in thin sheet, is at the second focus and can be oriented magnetically. The camera is shown with X-ray tube and recording Geiger counter. Temperatures up to 1000°C. can be achieved with a vacuum of better than 10^{-6} mm. Hg.



18659.

Zirconium and its Alloys

Zirconium has a low neutron absorption cross section and can be used in nuclear reactors as a canning and constructional material. The alloying behaviour of zirconium and kinetics of transformation of its alloys have been studied at the Institute. The reactive nature of zirconium has necessitated the design of a high vacuum, high temperature X-ray camera for structural studies at elevated temperatures up to 1000°C. The brittle metastable "omega" phase, which has a pronounced effect on mechanical properties, has been studied in detail in a number of binary zirconium systems. The nature of the omega transformation and its derivations from the high temperature body centred cubic zirconium structure has been determined.

The mechanism of oxidation of zirconium and zirconium alloys in CO_2 and steam has recently been studied. Reflection electron microscopy was used to investigate the behaviour of grain boundaries in the initial stages of oxidation.

Aluminium and its Alloys

Mention has been made of the Institute's work on the age-hardening of aluminium alloys and the development of the aluminium-copper-cadmium alloys under "Age Hardening". Other work in progress on aluminium alloys includes an investigation of the relative roles of electrochemical and purely mechanical components in stress corrosion and corrosion fatigue. The influence of metal spraying and grit blasting on the corrosion fatigue of high strength aluminium alloys is being studied. The effect of copper based preservatives on the corrosion fatigue and stress corrosion characteristics of aluminium alloys has recently been investigated. Samples of anodised aluminium and aluminium alloys are being exposed in marine, rural and severely industrial environments to study the effect of anodised film thickness on corrosion resistance. An aluminium-tin bearing alloy containing up to 30 per cent, developed in conjunction with the Tin Research Institute, is being widely used in Industry.

Ferrous Metallurgy

Recent work at the Institute and at the laboratories of Shell Research Ltd. has shown that the resistance of pearlitic cast irons to corrosion by condensed sulphuric acid is markedly dependent on the silicon content in the range 1-3% Si. This is of importance since a high proportion of "wear" in diesel engine cylinder liners is thought to occur by sulphuric acid corrosion. The influence of copper and nickel on the resistance of these irons to corrosion by sulphuric acid has been investigated at Fulmer.

Work has recently been carried out on the purification of austenitic stainless steel for use as a fuel element canning material in nuclear reactors. The effects of compositional, manufacturing and heat treatment variables on the properties of cast iron shot are being investigated.

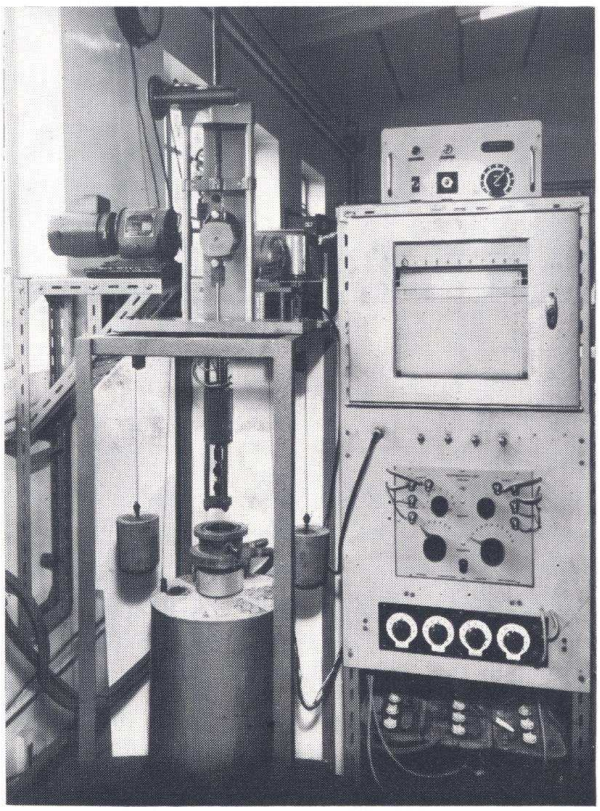
Chromium and its Alloys

Chromium and its alloys have high strength and oxidation resistance at elevated temperatures, but use of chromium is restricted by room temperature brittleness. Research is in progress at the Institute to increase room temperature ductility and improvements have been effected by using chromium of high purity, extruding to give a fine grained structure, and critical warm working below the recrystallisation temperature.

High purity chromium is produced electrolytically in a fluoride bath and the deposited flakes are argon-arc melted to form electrodes for ingot production in a consumable electrode furnace. Small ingots are sheathed in steel and extruded using glass and graphite lubrication. Larger ingots, having lower heat losses, have been extruded directly after heating in an inert or hydrogen atmosphere.

Fundamental Studies of Deformation

The spacing of slip lines in Cu-Zn alloys has been studied by electron microscopy and is being followed by an examination of the effect of zinc content on the relationship between yield stress and grain size in brasses. The deformation characteristics of beryllium are being studied. Research is in progress on the effect of alloy trace additions on the formation of intergranular cavities during creep. The objects are to study the role of minor solute additions on the density of nucleation and rate of growth of cavities, and on grain boundary migration during creep.



36761-H.

High Accuracy Polanyi Type Tensile Testing Machine Used for Deformation Studies.

The strain rate is continuously variable over a range 50 : 1, *and can be varied instantaneously. The load is measured by strain gauges and the output continuously recorded. Sections of the stress/strain curve can be enlarged during the test. Tests can be carried out at elevated and sub-zero temperatures and in controlled atmospheres.*

Enamelling

Low and high emissivity enamels for high temperature work have been developed, as well as oxidation resistant ceramic coatings. Vitreous enamels are being developed for application to uranium. Automatic spraying techniques have been used to produce vitreous enamelled aluminium of high quality, particularly for electrical resistance and freedom from pinholes.

Liquid Metals

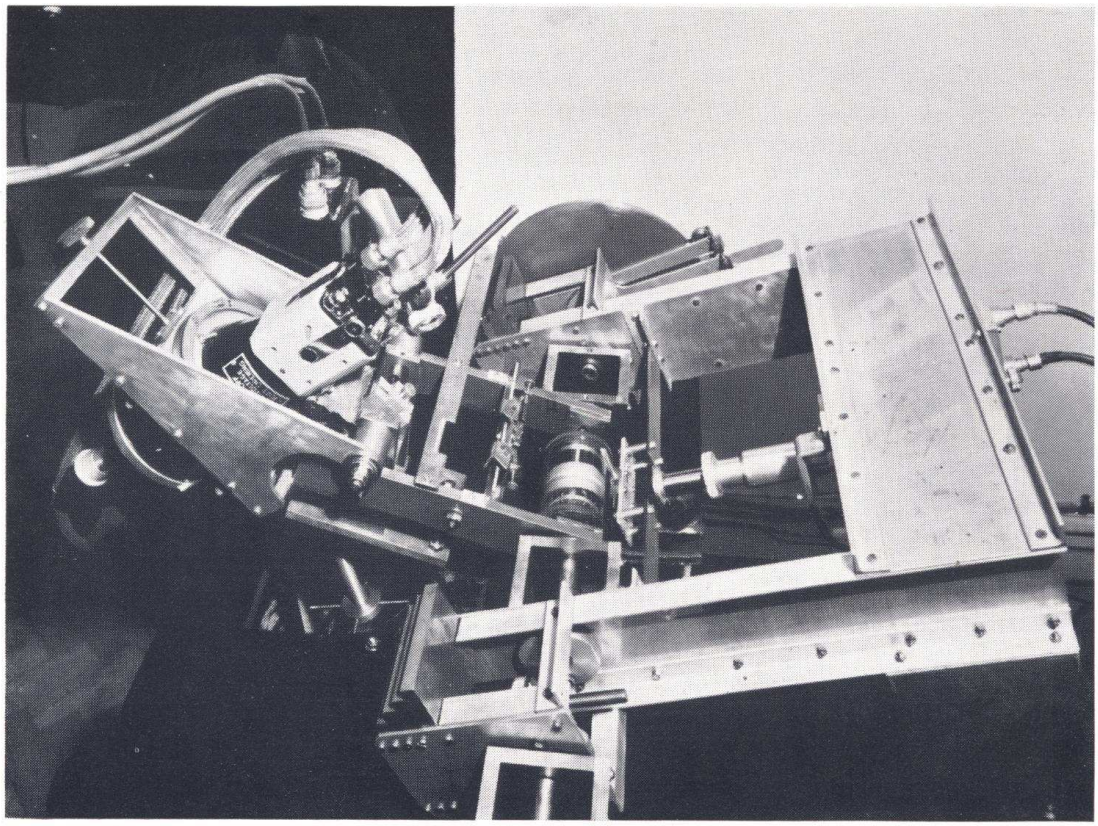
The structures of liquid metals and alloys are being investigated using a specially designed X-ray diffractometer and camera. A knowledge of the structure of liquid metals, while being of direct interest where metals are used in liquid form, may also help to explain the mechanisms of various metallurgically interesting solidification processes such as eutectic formation, modification of aluminium-silicon alloys and graphite formation in inoculated cast iron.

Liquids of the sodium-potassium system were first studied at the Institute using a recirculating loop system. These had relatively simple X-ray patterns, indicating that the "order" existing in such liquids is only of a statistical nature. Other liquids, such as gallium, bismuth and tin gave more complicated patterns, indicating molecular grouping within their liquids. Recent work on liquid tin, for example, has shown that a proportion of the atoms are selectively grouped as in tetragonal grey tin, the low temperature allotropic form of the solid, while the arrangement of the remaining atoms is random, as in simple liquids such as sodium and potassium. Work on alloy systems shows that liquids of certain alloys, e.g. Au-Sn, Cu-Sn and Au-Ga have a high degree of order. A general interpretation in these cases is that a "double" stable configuration exists over a wide range of composition. Thus, in the Au-Sn system the liquid may be regarded as divided, on an atomic scale, into Au_3Sn clusters and "shells" of a complementary composition.

Feathering of Lead Cable Sheaths

Extruded lead cable sheathing sometimes exhibits a surface defect known as "feathering". The causes of feathering have recently been investigated and the occurrence of this defect was found to be associated with antimony segregation in the billet.

Methods of eliminating segregation were developed in the laboratory and recommendations were made for overcoming the trouble on an industrial scale.



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X-Ray Diffraction Camera for Studying the Structure of Liquid Metals

The X-ray camera is shown in position on the central axis of the diffractometer. The X-ray tube, together with the monochromator and monitor counter (left) can be pivoted about this horizontal axis by means of the capstan screw. The diffracted information is recorded by means of the counter (right), which is also pivoted about this axis.

Various designs of camera are used. Where necessary the liquid metal under investigation can be recirculated, thereby providing a clean surface suitable for examination.

Age Hardening

The Institute's work on the effect of trace elements in age hardening alloys is widely known. The aluminium-copper system has received most attention, and this work has led to the development of the aluminium-copper-cadmium alloys in which the addition of 0.1 % cadmium to aluminium-4 % copper as a trace element suppresses room temperature ageing. Maximum properties, approaching those of duralumin type alloys, are obtained by heat treatment, and the alloy has excellent pressing and machining characteristics. The stress corrosion characteristics of the alloy are being investigated and full-scale trials are in progress to assess its performance as a structural material.

More recently the work has been concerned with the effects of quenching and heating to ageing temperature on the ageing characteristics of high purity aluminium-copper alloys containing small ternary additions such as indium and magnesium. This has shown that magnesium also reduces the rate of room temperature ageing by inhibiting G.P. zone formation. A different type of zone, containing magnesium, is formed when accelerated hardening occurs with higher magnesium contents.

Two types of hardening have been detected during room temperature ageing of Al-Cu alloys, and both are retarded or prevented by certain elements present in trace quantities ($\backsim$ 0.01 $^{a}/_{o}$). The first is believed to be caused by locking of dislocations by solute atoms and confirmation is being sought by electron microscopy of thin foils and by studies of yield point effects; the second, and later stage is associated with G.P. zone formation.

A study of the influence of small ternary additions in Mg-Pb, Al-Mg and various copper-base alloys has indicated that their effects can be rationalised in terms of atomic size factor, particularly where they modify the distribution of precipitate rather than its structure, and where they influence grain boundary phenomena such as over-aging.

Thin Film Potentiometers

Work is in progress on the properties of thin metal films for use in potentiometers. Contact resistance and the wear produced by a sliding contact are being studied under varying electrical and physical conditions using various designs of contact. Optical and electron microscopy are employed to follow wear damage.

ANCILLARY SERVICES

Testing and Consulting Work

The Institute's main function is to carry out research of a relatively long term nature, but there is a growing demand from Industrial firms for testing and consulting work. Many firms regularly send samples for chemical and spectrographic analysis, mechanical testing and weld examination (for which the Institute is A.I.D. approved). Facilities for metallography, crack detection, radiography, X-ray and electron diffraction, and electron microscopy are also available. In this routine work, X-ray diffraction techniques find their principal application in the identification of corrosion products and surface films. Electron microscopy is employed for particle size and shape studies and in the examination of a variety of different samples, including razor blade edges, asbestos and fungal cells. Special tests are devised to meet individual requirements where there is no established testing procedure. For example, procedures have been devised for assessing the efficiencies of domestic heating devices and an invention for eliminating domestic cooking smells.

The Institute undertakes the examination of service failures and recommendations are made for improvements in design and the choice of material. Gear cutters, electric motor windings, electric contact arms, bearings, shafts and studs are among components received for examination. Members of the staff act in a consulting capacity in connection with production difficulties; the occurrence of excessive porosity in castings, the uneven solution of plating anodes and earing in spun and deep drawn sheet are examples of problems investigated. Members of the corrosion section investigate corrosion and plating problems and give advice on the selection of materials and protective finishes for particular environments.

31962-B.

Apparatus for Studying Wear Resistance of Thin Metal Films.

The probe is maintained in contact with a circular track on the rotating turntable. Wear of the film can be followed by electrical measurements.

Supply of Special Materials and Equipment

The Institute provides special materials, melting and fabricating facilities, and items of equipment for outside firms and laboratories. Materials supplied include high purity chromium and iron, small quantities of experimental steels for research purposes, and reactive alloys, in both the as-melted and rolled conditions. Fabrication techniques are being developed for manufacturing superconducting alloys such as Nb_3Sn, Nb/Zr and V_3Ga.

The manufacture of equipment to meet individual requirements is undertaken and a recent development contract was concerned with the design and construction of specialised equipment for making thin-walled castings.

Scale of Charges

The Institute's charges are based on time of staff, plus materials at cost, with overheads at 110 per cent of salaries and wages. Major researches are the subject of separate contract agreements which normally specify the rate of expenditure. The total cost per graduate with appropriate assistants and services is roughly £5,000 per annum. Small investigations and consulting work are charged on the same basis of about £20 per day. Rates for analytical and test work can be quoted on application but will vary with the nature and number of samples. Typical charges are:

	£	s.	d.	
Chemical analysis	1	1	0	per element
Spectrographic analysis (Qualitative)	3	3	0	per sample
Metallographic specimen	2	2	0	(or £2 15s. 0d. with photograph)
Tensile Test, room temperature ...	1	1	0	
Tensile Test, sub or super normal temperature	3	10	0	
Fatigue S/N curves (8 tests)	55	0	0	(10^7 cycles)
Creep—exclusive use of one high accuracy machine	500	0	0	per annum
Electron micrograph	4	4	0	

30761-G.

The Library

Library and Information

The Institute's library contains some 3,500 volumes and approximately 200 scientific and technical periodicals are currently received. It maintains close contact with other technical libraries and the staff prepare reviews and bibliographies of particular subjects for sponsors, as well as for investigators. Translations of foreign language articles of wide interest are available for loan or sale. Reprints of most of the published papers are available.

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(as at 30th May, 1962)

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Assistant Development Officer	J. J. Day, A.I.M.
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Director's Secretary and Clerical Supervisor	Elizabeth S. Duckett
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G. Wilson, M.A.	Physical Chemist
*D. Nicholas	Spectroscopy

* In charge of Department or Section

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A. H. Bowry	P. J. C. Kent	M. C. Stuart
B. Bradford	R. H. Lewin‡	W. Warr
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E. F. Crosswell		

‡ Higher National Certificate in Chemistry

In addition to the above there are 60 laboratory assistants and other staff.

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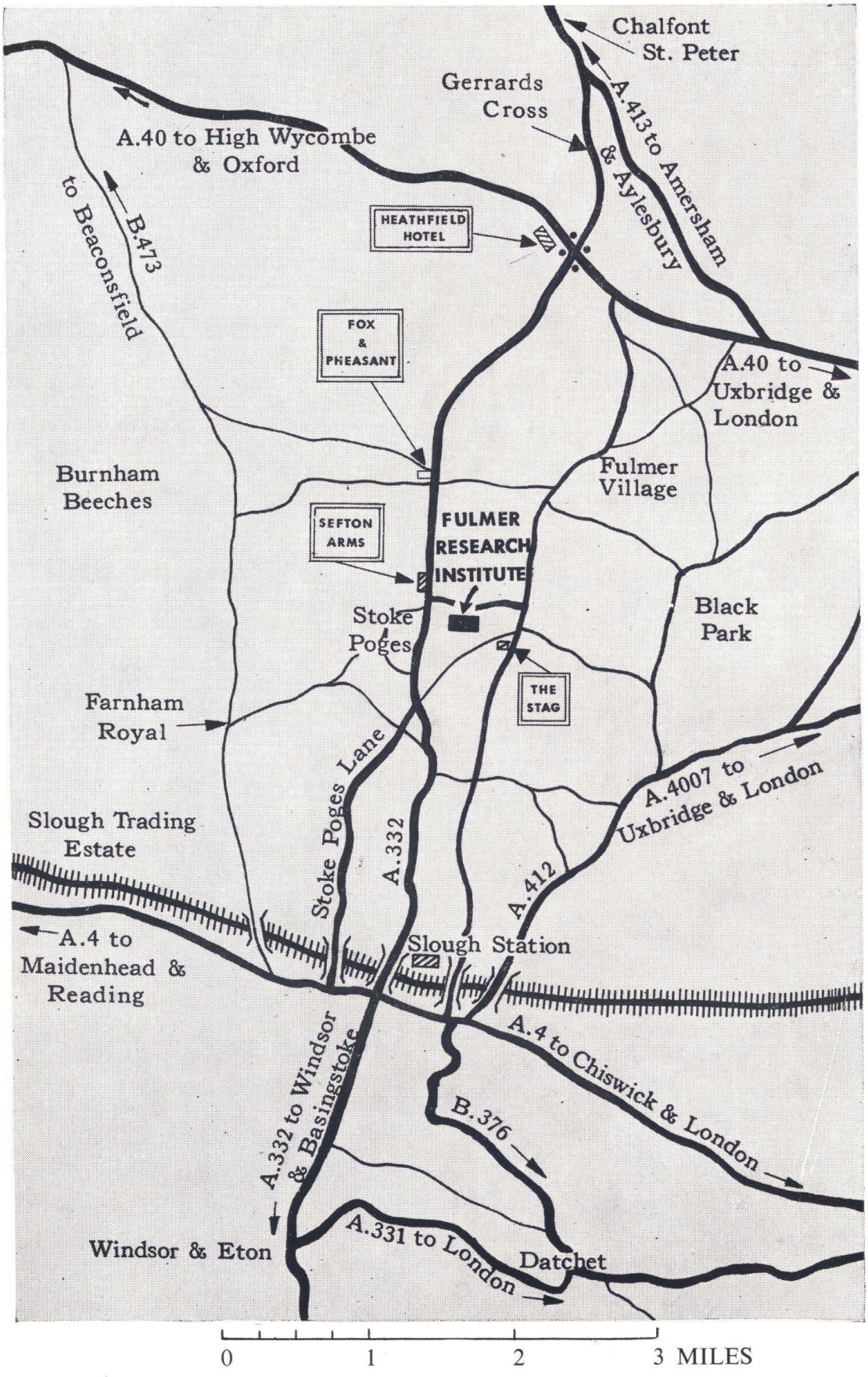
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