



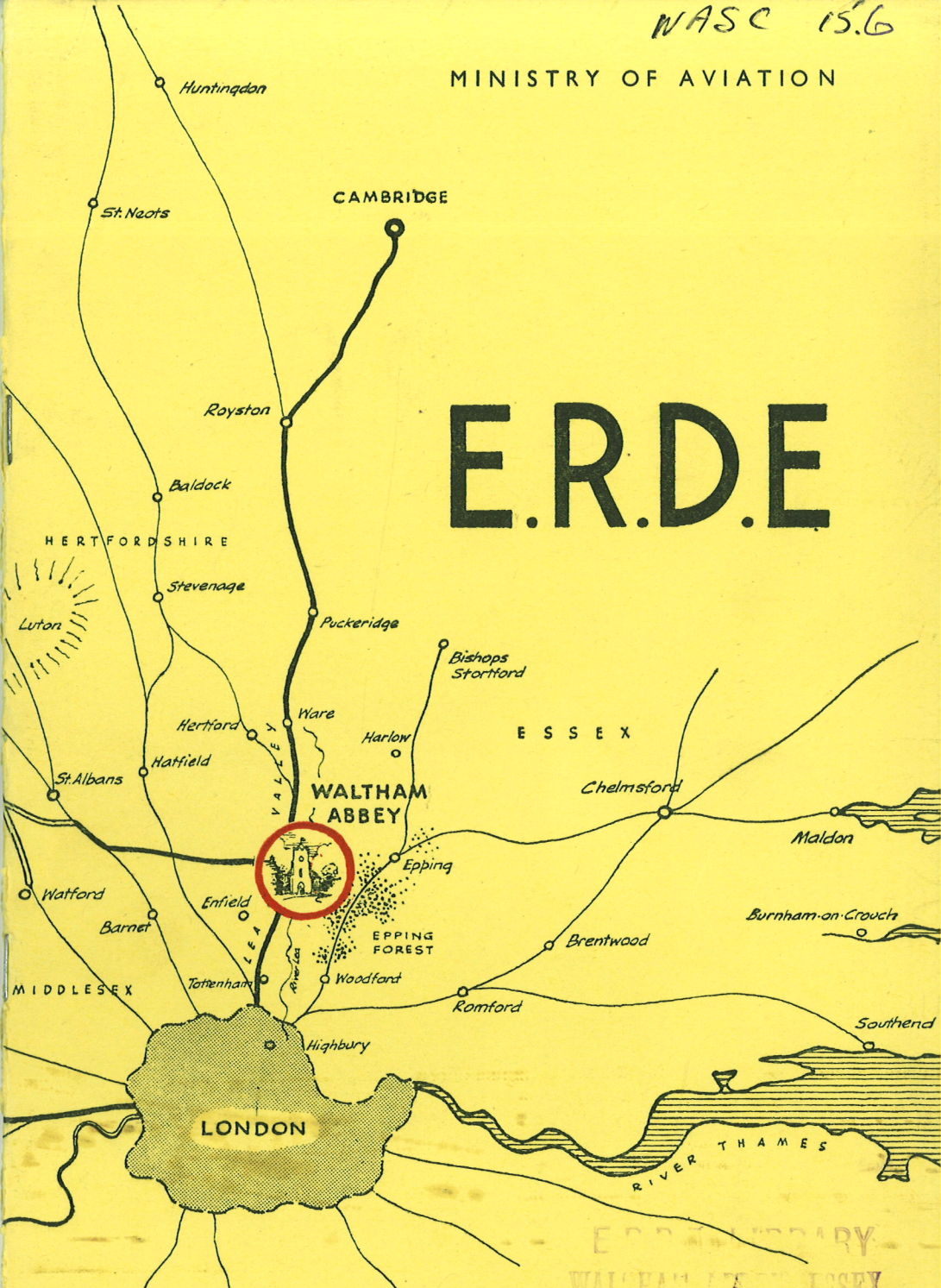
1963

MINISTRY OF AVIATION
ERDE/WALTHAM ABBEY
BOOKLET PREPARED FOR
SCIENTIFIC RECRUITMENT

NASC 15.6

MINISTRY OF AVIATION

E.R.D.E

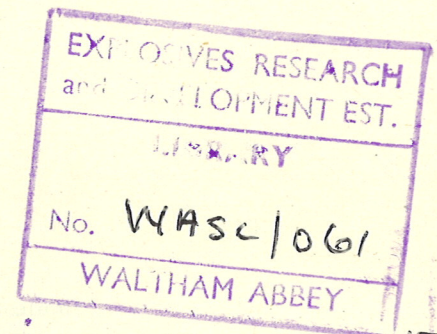


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WALTHAM ABBEY, ESSEX

EXPLOSIVES RESEARCH & DEVELOPMENT

E. R. D. E.

**WALTHAM ABBEY
ESSEX**



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"Choose money and Gunpowder."

—Bernard Shaw in Major Barbara.

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THE ESTABLISHMENT

E.R.D.E. is a centre of chemical research, a substantial part of the work carried out being academic in character and having mainly long-term implications for defence. Among such activities are combustion studies, polymer chemistry, and infra-red spectroscopy, while its interests in explosives and propellants are very comprehensive and contribute to the needs of guided missiles and stratospheric rockets as well as to a variety of specialised applications. The establishment is divided into seven groups. Three of these undertake applied research in propellant design and development, and in chemical engineering. Three others support them, as well as working on their own account in organic chemistry, kinetics, rheology, chromatography, and so forth. The seventh group deals with polymeric materials (plastics, rubbers and fibres) its investigations ranging over synthesis, thermodynamics, physico-mechanical behaviour, radiation and photochemistry, and small-scale production.

MINISTRY OF AVIATION

The establishment now forms part of the Ministry of Aviation but it continues to serve all the Defence departments, just as it did in the days of the Ministry of Supply. It has no responsibilities for weapons or for the design of ammunition, its purpose being to do research and follow up ideas. The end products, apart from rocket propellants and the like, are new scientific data which assist the staff in their efforts to proffer soundly-based chemical advice to Government and Service Departments.

SCOPE

The organisation of E.R.D.E. is such that no young man of ability and originality will be denied a satisfying research outlet. Generally, new entrants who are suited to academic type work join one or other of the research groups. Many interesting and important problems also arise on the applied side, and in order to ensure

that the development staff continue to keep in touch with pure science they are encouraged to spend a proportion of their time on longer term investigations. The present staff consists of about 60 within the grades of Scientific Officer (chemists forming the majority, with a sprinkling of physicists and research engineers) and 170 Experimental Officers and Scientific Assistants. Most of the research is carried on by small teams of two or three headed by a Senior or Principal Scientific Officer.

EQUIPMENT AND FACILITIES

The establishment is housed in numerous well-equipped laboratories, with plenty of working space and good general facilities. Specialised equipment is designed in the drawing office and fabricated in one or other of the main machine shops, but most groups have minor facilities of this type of their own. A team of glass blowers under expert supervision produces apparatus for research purposes, and experiments with novel designs of their own devising. There is no difficulty about the provision of any type of instrumentation which may be required. For example, several infra-red spectrometers are available, and the establishment is equipped for work in electron microscopy, very high speed photography, mass spectrometry, preparative vapour phase chromatography, precision calorimetry, to mention some well-known techniques of measurement.

SITUATION AND HOUSING

E.R.D.E. is about thirteen miles north-east of Charing Cross on the edge of Epping Forest, and is bordered on two sides by open country. There are pleasant residential districts within a few miles. The housing estate contains more than a hundred houses, a few of them being within the six hundred acres occupied by the establishment. These are allocated as they become vacant by a committee composed of staff. The waiting period varies some-

what, but the average time for a new entrant, a married Scientific Officer, say, has been about one year.

RESEARCH AND DEVELOPMENT ACTIVITIES

The broad basis of our research interests is illustrated in Appendices 1 and 2 at the end of this brochure, the former listing some of our latest publications, and the latter including brief accounts of the sort of scientific investigations for which we should like to recruit new staff. The nature of our applied work can be indicated by quoting some recent achievements. We pioneered the development of composite propellants which have been widely used in connection with the International Geophysical Year programme. We have developed polyurethane compositions suitable for very large rockets, and at the other end of the scale designed special propellants for engine starter and pilot-seat ejection cartridges. Chemical engineers have put these compositions through full pilot plant trials and their studies have extended to such diverse subjects as high-precision measurements of thermal conductivities and the control of growth of crystals. Fundamental investigations into the nature of electrostatic discharges, and of the manner in which they initiate explosions, have done much to reduce the hazards of handling large quantities of sensitive materials in factories.

PUBLICATIONS

Relatively little of the basic work carried out here is of a secret nature and the research staff are encouraged to write-up their work for publication in the scientific journals. Some examples are given in Appendix 1. When security requirements restrict or prevent open publication, or when the patentable character of the work makes it unsuitable for immediate communication outside, the establishment's reports are circulated, nevertheless, to University consultants as well as within the Defence departments.

SCIENTIFIC CONFERENCES AND MEETINGS

We try to maintain personal contacts at all levels with members of the staff of Universities and Research Associations. Our staff make visits, give lectures and present papers at conferences. Some research in pure science is financed on our behalf at Universities and this makes for close ties with the people concerned. We are in the fortunate position of being able to ask the help of a number of distinguished scientists who serve on Government consultative committees with which we are associated.

Representation at scientific meetings is supported whenever these bear generally on our work. Many staff go abroad to attend conferences and to stimulate co-operation with other countries. During 1960, for example, journeys have been made to the U.S.A. (9), Canada (3), Australia (1), India (2) and various European countries (7).

CURRENT VACANCIES

Details of posts which we wish to fill with Scientific Officer grades are given in Appendix 2. A list of vacancies is liable to get out of date and therefore no-one should be put off from applying simply because he does not feel well suited to any of those mentioned. Applicants having specialised interests in parts of our work will be particularly welcome. The best way of finding out whether we have vacancies of a sort likely to interest you, is to write and ask, or visit us and talk things over. We shall be glad to arrange this.

SALARIES

A summary of the salary scales is given in Appendix 3 at the end. Below the age of 26, you would join us as a Scientific Officer and your salary would be determined by your age and length of post-graduate experience. For example, at age 24 and with two years research experience the commencing salary would be approximately £845 p.a. Promotion to S.S.O. (£1,330-£1,640) is

decided solely on merit, and the outstanding man can achieve it at 26, or may join in this grade at that age. The average graduate will attain the S.S.O level at about 28 or 29. The long S.O. salary scale so often quoted in official statements is largely fictional, as very few enter at the bottom and practically all jump the last four or five steps on promotion. Subsequent promotion to P.S.O. (£1,700-£2,375) is similarly a question of merit. Outstanding people attain this in their early thirties and the average man at about 40. There are also higher posts. Our total of just over sixty Scientific Officer grades includes twelve who are Senior Principal Scientific Officers (£2,700-£3,050) or of higher rank.

HOLIDAYS AND PENSION

Holidays for Scientific Officers are initially 22 days per annum (equivalent to 4 weeks plus 2 days), exclusive of public holidays and one or two special days, rising progressively to 30 days (six weeks). The Government's pension scheme for established officers is non-contributory and offers an annual retirement pension based on the average salary received during the concluding three years of service, i.e. in the most senior position reached. It amounts to one-eightieth of this figure for each year of service, so that if a person remained in Government employ for forty years he would retire on half-pay without having made any direct contribution, and in addition receive a lump sum amounting to about one year's salary.

HOW TO APPLY

There are two distinct methods of entry into Government service. The first is to write to us, when we will arrange an interview here, at a time convenient to yourself. You must have a first or second class honours degree, and preferably some research experience. If all goes well we can offer you a post as S.O. or, if you are an experienced man, S.S.O. in what is called a

“ temporary ” capacity. This does not mean temporary in the generally accepted sense; the word is used to distinguish between appointments made by a Ministry and those by the Civil Service Commission, who are the only body empowered by law to engage “ permanent ”, so-called “ established ” i.e. pensionable, civil servants. Alternatively you can, if you wish, apply for employment to the Commissioners who advertise regularly in the Press, and ask to be put in touch with E.R.D.E. Waltham Abbey. However, it is often convenient to make this application after you have acquired a year or two's experience here. Provided we are able to say then that you are doing a satisfactory job, it naturally carries weight with the Commissioners. You lose nothing by going about it in this fashion since when you eventually become “ established ” by the C.S.C. your pension rights are back-dated to cover your whole period of service.

If you are interested you should write to any of the persons named in the next paragraph at the address given on the cover of this brochure, and ask for an interview.

FELLOWSHIPS

In addition to the posts described in Appendix 2 there are openings at E.R.D.E. for Research Fellows. These are intended to be held by outstanding young men who want to do a further two or three years research on a subject of their choice before deciding upon a career. Fellowships are available at E.R.D.E. on infra-red spectroscopy and polymer chemistry (with Dr. L. J. Bellamy), on combustion kinetics (with Mr. G. K. Adams), on polymer physics (with Mr. H. Warburton Hall) and in general and organic chemistry (with Dr. A. Lovecy). A Junior Fellowship carries a salary within the range £875 to £1,175 p.a., and a Senior Fellowship from £1,275 to £1,575 p.a. Transfer to a regular post of equivalent status in the Government scientific service is open to the holder at any time.

APPENDIX 1

SOME RECENT PUBLICATIONS BY E.R.D.E.

During the past four years over 60 publications from E.R.D.E. have appeared in well-known scientific journals. These include *J. Chem. Soc.* (13), *Proc. Roy. Soc.* (5), *Trans. Faraday Soc.* (6), *Combustion and Flame* (5), *Spectrochim. Acta* (5), and several others as widely different as the *Biochemical Journal* and *J. Applied Physics*.

A selection of titles is given below to indicate the fields covered by this work.

Adams, G. K., Holden, J. and Whitbread, E. G. The explosive initiation of a single crystal of cyclotrimethylenè trinitramine. XXXIe Congrès International de Chimie Industrielle, Liege, septembre 1958. *Compte Rendu*, **II**, 216.

Adams, G. K., and Cook, G. B. The effect of pressure on the mechanism and speed of the hydrazine decomposition flame. *Combustion and Flame*, 1960, **4**, 9.

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Anderson, D. M. W., Bellamy, L. J., and Williams, R. L. The infra-red spectra of some gem dihydroxy compounds and their deuterated derivatives. *Spectrochim Acta*, 1958, **12**, 233.

Bellamy, L. J., Hallam, H. E., and Williams, R. L. Infra-red spectra and solvent effects. Part 1. X-H stretching frequencies. *Trans. Faraday Soc.*, 1958, **54**, 1120.

Bellamy, L. J., and Rogasch, P. E. Proton transfer in hydrogen bonded systems. *Proc Roy. Soc.*, 1960. **A257**, 98.

Bellamy, L. J., and Williams, R. L. Solvent effects on the infra-red spectra of hindered phenols. *Proc. Roy. Soc.*, **A254**, 119.

"temporary" capacity. This does not mean temporary in the generally accepted sense; the word is used to distinguish between appointments made by a Ministry and those by the Civil Service Commission, who are the only body empowered by law to engage "permanent", so-called "established" i.e. pensionable, civil servants. Alternatively you can, if you wish, apply for employment to the Commissioners who advertise regularly in the Press, and ask to be put in touch with E.R.D.E. Waltham Abbey. However, it is often convenient to make this application after you have acquired a year or two's experience here. Provided we are able to say then that you are doing a satisfactory job, it naturally carries weight with the Commissioners. You lose nothing by going about it in this fashion since when you eventually become "established" by the C.S.C. your pension rights are back-dated to cover your whole period of service.

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Bellamy, L. J., and Williams, R. L. Solvent effects on the infra-red spectra of hindered phenols. Proc. Roy. Soc., **A254**, 119.

- Blay, N. J., Dunstan, I., and Williams, R. L. Boron hydride derivatives. Part III. Electrophilic substitution in pentaborane and decaborane. *J. Chem. Soc.* 1960, 430.
- Cachia, G. P., and Whitbread, E. G. The initiation of explosives by shock. *Proc. Roy. Soc.*, 1958, **A246**, 268.
- Conduit, C. P. Ultra-violet and infra-red spectra of some aromatic nitro-compounds. *J. Chem. Soc.* 1959, 3273.
- Dyment, J., and Ziebland, H. The tensile properties of some plastics at low temperatures. *J. Appl. Chem.*, 1958, **8**, 203.
- Hall, H. W. Mechanical properties of plastics at high speeds of stressing. International Symposium on Plastics Testing and Standardisation. 1958. Philadelphia, A.S.T.M. (Special Technical Publication No. 247), 1959. pp. 137-151.
- Hollingsworth, B. L. The reaction of nitrogen dioxide with some methylnitroanilines. *J. Chem. Soc.*, 1959, 2420.
- Jest, B., and Phillips, L. The reaction of methyl radicals with methyl nitrite. *Proc. Chem. Soc.*, 1960, 73.
- Johnson, C. H. New fuels. *Proc. Chem. Soc.*, 1959, 212.
- Powling, J., and Smith, W. A. W. The combustion of the butane-2,3- and 1:4-diol dinitrates and some aldehyde-nitrogen dioxide mixtures. *Combustion and Flame*, 1958, **2**, 157.
- Watts, H. The oxidation of charcoal by nitric oxide and the effect of some additives. *Trans. Faraday Soc.*, 1958, **54**, 93.
- Williams, R. L., and Pace, R. J. The structure of sodium stannate. *J. Chem. Soc.*, 1957, 4143.
- Wyatt, R. M. H., Moore, P. W. J., Adams, G. K., and Sumner, J. F. The ignition of primary explosives by electric discharges. *Proc. Roy. Soc.*, 1958, **A246**, 189.
- Ziebland, H., and Burton, J. T. A. The thermal conductivity of nitrogen and argon in the liquid and gaseous states. *Brit. J. Appl. Phys.*, 1958, **9**, 52.

APPENDIX 2

POSTS WE WISH TO FILL AT E.R.D.E.

Vacancies for graduate students, preferably with two or more years research experience, exist in certain areas of work at E.R.D.E., particularly in those which are just starting up or are taking a new direction.

The causes of the remarkably varied behaviour of liquid and solid compositions, and pure compounds, when reaction is started in them are still in many respects obscure and present numerous facets of scientific interest. Some burn quietly, some very rapidly, and some at enormous speeds. To understand and to be in a position to exercise control over such behaviour is of great practical importance for future developments in jet propulsion; rockets in particular. For these and related investigations we need :—

- (1) A physicist or physical chemist to carry out research on the mechanism of initiation of combustion and detonation. The equation-of-state properties of substances at very high pressures and temperatures will be investigated by ultra-high speed photography and other methods.
- (2) Physical chemists (two) to study various aspects of chemical kinetics in self-sustaining reactions by means of the mass spectrograph and emission spectroscopy. Also (possibly another post) to look into the phenomenon of sensitisation of crystalline explosives to mechanical impact by polymorphic transitions.
- (3) An applied mathematician or physicist having knowledge of fluid dynamics and a good mathematical background to work on problems of unsteady state detonation waves.

In order to put ourselves in a position to give the necessary help and advice to Defence and Service departments responsible for planning and design, with so much depending on having just the right propellants and materials of construction, we need to engage continuously on general chemical research and broaden our knowledge of the lesser-known elements and their compounds. Like many others before us, we sometimes discover that data which have been widely accepted are substantially inaccurate.

The necessity a few years back for drastic revision of the value for the bond energy of the fluorine molecule, from about 63 Kcal to 38 Kcal is a case in point, and one which E.R.D.E. were amongst the first to recognise hence :—

- (4) A chemist, organic or physical-organic, having an interest in the theory of molecular structure and some experience of the methods of chemical synthesis.

Solid explosives and propellants are selected by virtue of their capacity for generating energy; but their physical and mechanical properties are at least equally important. Especially is this the case in large solid rocket charges, in which connection there are numerous opportunities for basic research, partly physico-chemical and partly physico-mechanical in nature. Hence vacancies exist for :—

- (5) A physical chemist and a physicist with some knowledge of colloid chemistry (e.g. gels) and rheology, and possessed of better than average mathematical equipment.

A large proportion of structural materials of the non-metallic sort with which our Materials Research group is concerned falls into the category of "high polymers". We prepare type polymers and make a thorough study of their behaviour and reaction kinetics. To strengthen the team engaged on this work we require :—

- (6) An organic chemist to work on heteratomic and other classes of polymer; and a physical chemist for this and for general investigations in the field.

Production on other than a small scale is not undertaken at E.R.D.E., but the establishment acts in an advisory capacity to the Royal Ordnance Factories on the strength of laboratory and semi-technical assessment of manufacturing processes carried out on its own initiative. Illustrative of our interests are the necessity to control the physical form of crystals and of grit size, to discover means of improving such qualities as pourability,

non-aggregation, electrical conductivity and so forth. To enable any of these to be done on a manufacturing scale calls for the re-interpretation of our laboratory methods and data into chemical engineering practice and the design of plant. The technology of rocket production involves many problems, the solutions to which can only be obtained by simultaneous chemical and engineering effort. We have vacancies for :—

- (7) Chemical engineers (two) and graduates in chemistry (two) who wish to gain experience of applied research and development. We should also like to fill another post by a graduate student with the object of furthering our studies of the non-destructive testing of materials by X-rays, ultra-sonics and other means.

RESEARCH FELLOWSHIPS

As mentioned on page 10 of this brochure, we have vacancies for Research Fellows of high ability, Junior and Senior. The research topics are decided to a great extent by the interests and experience of the applicants although, of course, they usually bear on some aspect of our current work, but not invariably. At this moment we should welcome Fellows for work in infra-red spectroscopy, reaction kinetics in a rather difficult medium, and the physics of high polymers. The last mentioned Fellowship might be held initially at Bristol University.

APPENDIX 3

SALARY SCALES IN THE SCIENTIFIC OFFICER CLASS

The following salary scales apply equally to men and to women (from January 1961) working in the London area where Waltham Abbey is situated.

Scientific Officer	Senior Scientific Officer	Principal Scientific Officer	Senior Principal Scientific Officer
£	£	£	£
730	1,330	1,700	2,700
761	1,380	1,775	2,800
794	1,430	1,850	2,925
840	1,505	1,925	3,050
885*	1,589	2,000	
930	1,640	2,075	
960		2,150	
990		2,225	
1,022		2,300	
1,055		2,375	
1,085			
1,115			
1,145			
1,175			
1,205			

* For starting salaries see page 8.

FELLOWSHIPS

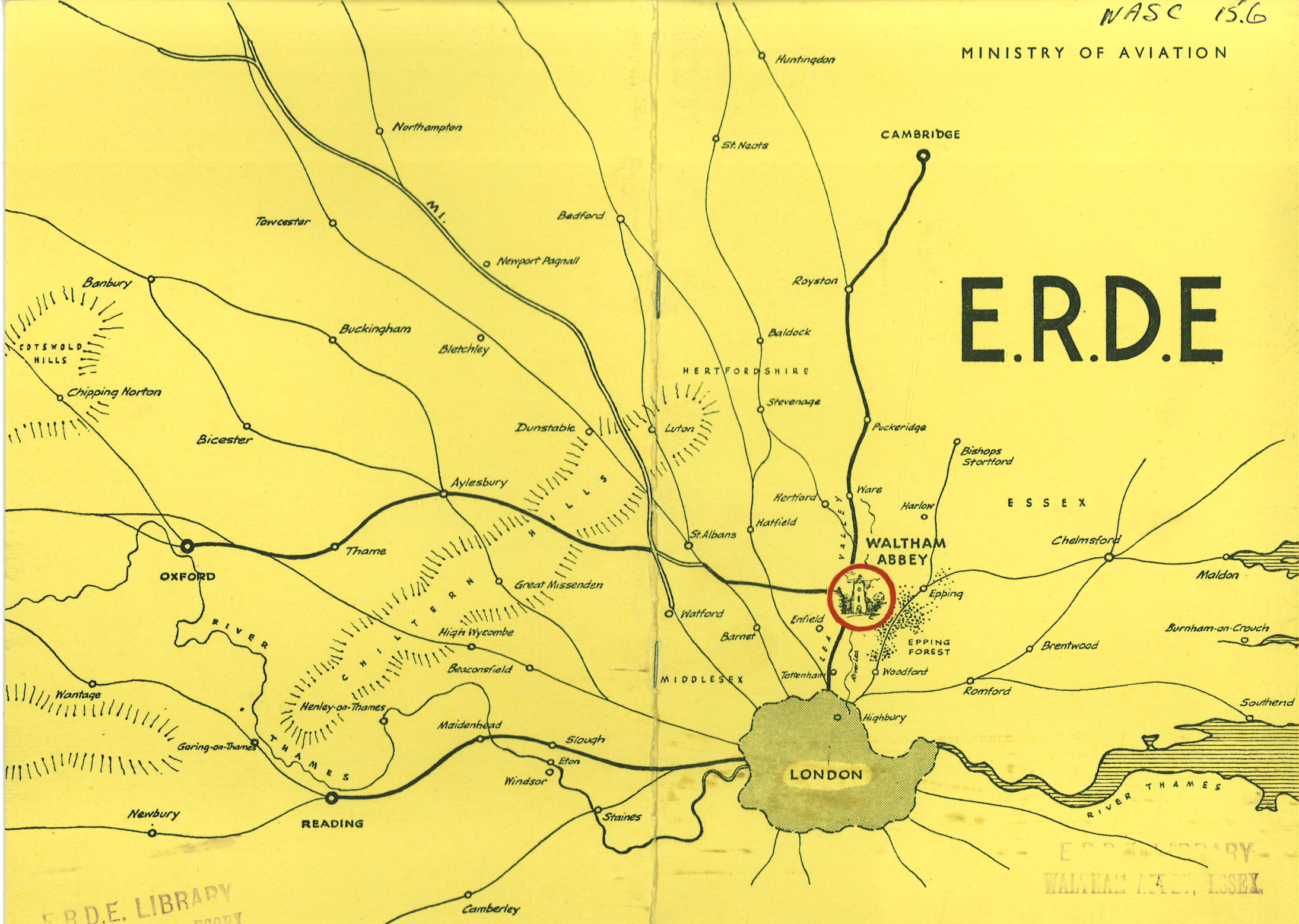
Junior Fellowship, within the range £875 to £1,175 p.a.

Senior Fellowship, „ „ „ £1,275 to £1,575 p.a.

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MINISTRY OF AVIATION

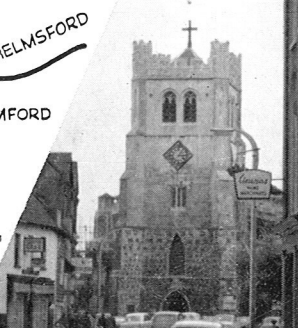
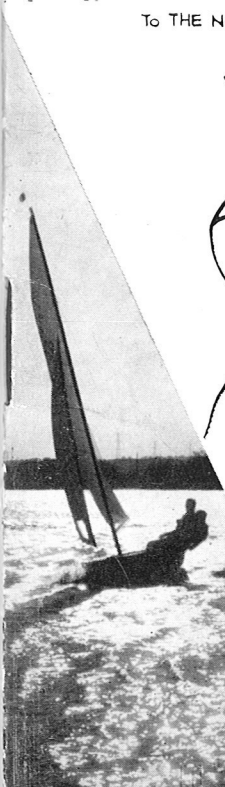
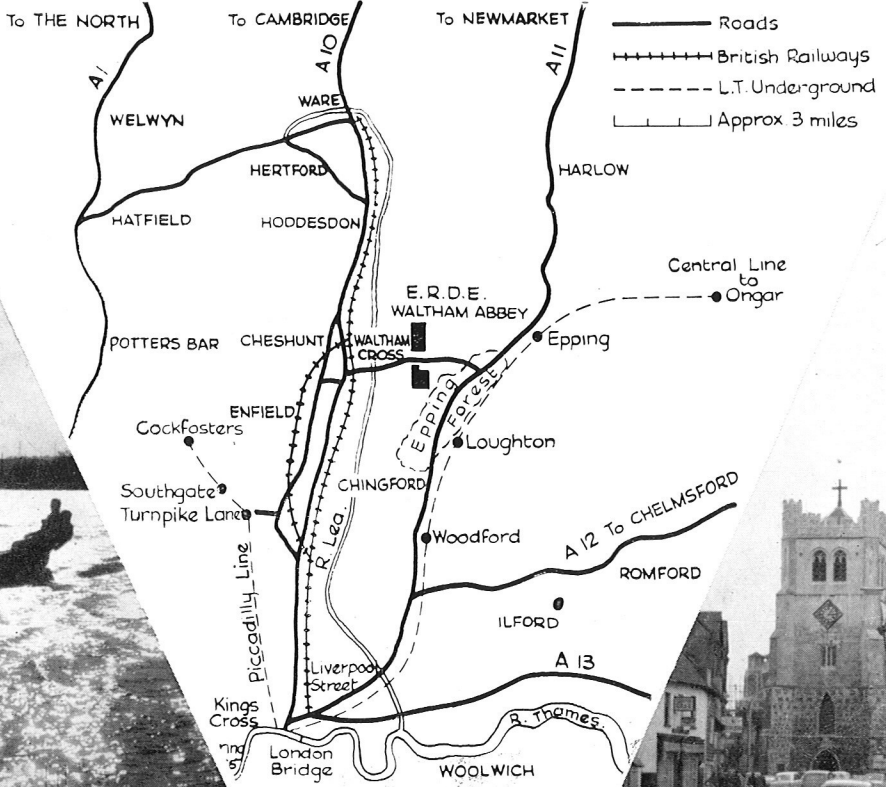
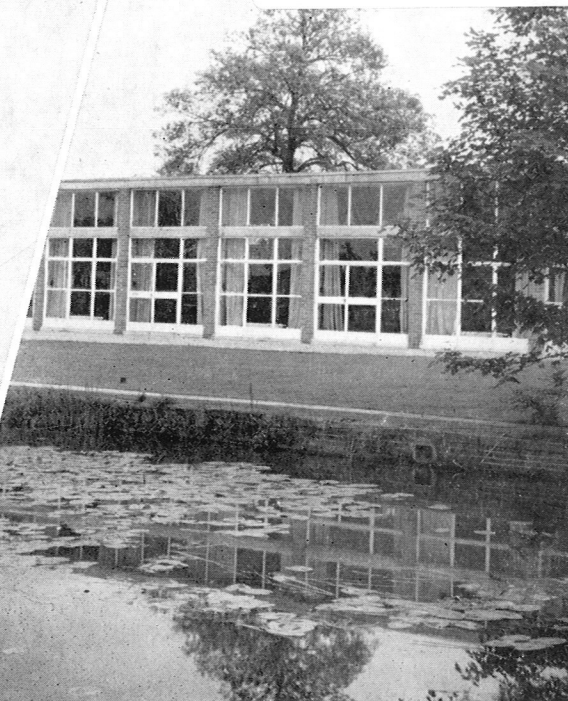
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EXPLOSIVES RESEARCH & DEVELOPMENT



EXPLOSIVES RESEARCH AND
DEVELOPMENT ESTABLISHMENT
WALTHAM ABBEY

"Choose money and Gunpowder."

—from "Major Barbara," by Bernard Shaw.

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1963

EXPLOSIVES RESEARCH AND
DEVELOPMENT ESTABLISHMENT
WALTHAM ABBEY

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The Explosives Research and Development Establishment

Ministry of Aviation

Waltham Abbey, Essex.

'Phone: Waltham Cross 23688

SENIOR STAFF

Director	Dr. C. H. Johnson, C.B.E. (C.S.O.)
Deputy Director	Dr. G. H. S. Young (D.C.S.O.)
Heads of Branches (S.P.S.O.)	Mr. P. R. Freeman
	Mr. J. E. Gordon
	Dr. A. L. Lovecy
	Mr. R. G. Ross
	Mr. H. Warburton Hall
	Mr. E. G. Whitbread
	Dr. R. L. Williams
	Dr. W. G. Williams

Individual Merit Appointments

(D.C.S.O.)	Mr. G. K. Adams
	Dr. L. J. Bellamy
(S.P.S.O.)	Dr. A. W. H. Pryde
	Mr. G. W. C. Taylor
	Dr. N. Uri
	Mr. H. Ziebland

HISTORY AND PRESENT FUNCTIONS

Essentially E.R.D.E. is a centre of chemical and physical research. It was set up immediately after the last war on the site of the old Royal Gunpowder Factory which had an unbroken history stretching back at least to Stuart times and possibly earlier. Waltham Abbey is the only Government Department carrying out research on all aspects of military explosives and propellants, although, as will be seen later, much work is done on non-metallic materials. Because of our special position in the explosives field a very wide variety of questions are put to us from all three Services—on topics ranging from guided missile and stratosphere rockets to pilot ejector seat cartridges and even smaller components. Our primary function is to provide the answers to such questions, but this does not mean that we are restricted to *ad hoc* technological problems. We can only properly fulfil our function as expert consultants if we are actively engaged on research in the subjects with which we are concerned. For this reason our interests cover a quite surprisingly wide field of science.

MINISTRY OF AVIATION

E.R.D.E. is part of the Ministry of Aviation but serves all the Defence departments, Navy, Army, and Air, as it did in the days of the Ministry of Supply. Close working arrangements exist with other Government establishments, notably with the Rocket Propulsion Establishment (Westcott) and the Royal Armament Research and Development Establishment (Fort Halstead) on explosives; and with the Royal Aircraft Establishment (Farnborough) and Royal Radar Establishment (Malvern) on materials research.

SCOPE AND SIZE

The organisation of E.R.D.E. is such that no young man of ability and originality will be denied a satisfying research outlet. Generally, new entrants join one or other of the research teams. Interesting and important problems also arise on the applied side, and in order to ensure that the development staff continue to keep in touch with science many of them devote a proportion of their time to longer term investigations. The present strength is between seventy and eighty Scientific Officer grades (chemists forming the majority, with a sprinkling of physicists and research engineers) and some hundred and sixty Experimental Officers and Scientific Assistants. Most of the research is carried on by small teams numbering two to six, headed by a Senior or Principal Scientific Officer.

EQUIPMENT AND FACILITIES

The establishment is housed in numerous well-furnished laboratories, with plenty of working space. Specialised equipment is designed in the drawing office and fabricated in one or other of the main machine shops, but most groups have minor facilities of this sort of their own. A team of glass blowers under expert supervision produces apparatus for research purposes, and makes experiments with designs of their own devising. There is usually no difficulty about the provision of any type of instrumentation which may be required. For example, several infra-red and other spectrometers are available, and the establishment is equipped for work in X-ray and electron microscopy, very high speed photography, mass spectrometry, preparative gas chromatography, precision calorimetry, and radio-chemistry, to mention some well-known techniques of measurement. A nuclear magnetic resonance outfit has been ordered since there is now the prospect of application to our specialised problems.

LOCATION AND HOUSING

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Press, and ask to be put in touch with E.R.D.E. Waltham Abbey. However, it is often convenient to make this application after you have acquired a year or two's experience here. Provided we are able to say then that you are doing a satisfactory job, it naturally carries weight with the Commissioners. You lose nothing by going about it in this fashion since when you eventually become "established" by the C.S.C. your pension rights are back-dated to cover the whole period of service.

If you are interested you should write to any of the persons named on page iv of this brochure at the address given on that page, and ask for an interview.

RESEARCH FELLOWSHIPS

In addition to the posts described in Appendix 2 there are openings in E.R.D.E. for Research Fellows. These are intended to be held by outstanding young men who want to do a further two or three years' research before deciding upon a career. For this reason the research topics chosen tend to be of an academic type and are always suitable for open publication. Fellowships are therefore as valuable to those who wish ultimately to follow an academic career as they are to those who elect to stay in government service. It is always our hope that a large proportion of Fellows, having seen something of the facilities and conditions of government research will want to transfer to the permanent staff. A regular post of equivalent status is open to the holder at any time.

The research topics are largely decided by the interests and experience of the candidate although, of course, they usually bear on some aspects of our current work. We are therefore prepared to consider applications for fellowships in any of our various fields of interest. We would particularly welcome applicants experienced in autoxidation, spectroscopy, crystal growth phenomena or in chemical engineering.

A Junior Fellowship carries a salary within the range of £985 to £1,320 p.a. and a Senior Fellowship from £1,430 to £1,765. Further details can be obtained by application to the Director or to any of the senior staff listed on page iv known to the candidate.

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Bellamy, L. J., and Williams, R. L., "Solvent Effects on Infrared Group Frequencies," *Proc. Roy. Soc.*, 1960, **A255**, 22.

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Blay, N. J., Pace, R. J., and Williams, R. L., "Boron Hydride Derivatives. Part VIII. Some Reactions of Sodium Decaborate in Relation to Decaboranylmagnesium Iodide," *J. Chem. Soc.*, 1962, 3416.

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Dukes, W. A., "The Endurance of Polythene under Constant Tension whilst Immersed in Igepal," *Brit. Plastics*, 1961, **34**, 123.

Dunstan, I., and Griffiths, J. V., "Determination of Carbon by Wet Combustion. Application to Explosives and Initiators," *Analyt. Chem.*, 1962, **34**, 1348.

Golden, J. H., "The Degradation of Polytetrafluorethylene by Ionising Radiation," *J. Polymer Sci.*, 1960, **45**, 534.

Gooding, R. W., and Parratt, N. J., "Solid Titanium Nitride and other Refractory Compounds made by Direct Gas-Metal Reaction," *Powder Metallurgy* (in the press).

Harding, G. W., "An Improved Suspended Level Viscometer," *J. Polymer Sci.*, 1961, **55**, S.27.

Maxwell, W. R., and Young, G. H. S., "Solid Rocket Motors," *J. Roy. Aero. Soc.*, 1961, **65**, 252.

Owen, A. J., "The Electronic Structure of Some Heteroatom Conjugated Compounds," *Tetrahedron*, 1961, **14**, 237.

Powling, J., Smith, W. A. W., and Thynne, J., "The Flame Decomposition of Some Substituted Ethyl Nitrates," *Combustion and Flame* 1960, **4**, 201.

Powling, J., and Smith, W. A. W., "Measurement of the Burning Surface Temperature of Propellant Compositions by Infrared Emission," *Combustion and Flame*, 1962, **6**, 173.

Roberts, J., "Estimation of Dynamic Modulus and Dynamic Yield Stress for 'Perspex'". *Nature*, 1961, **190**, 799.

Ziebland, H., "The Thermal Conductivity of Toluene. New Determinations and an Appraisal of Recent Experimental Work," *Int. J. Heat Mass Transfer*, 1961, **2**, 273.

Ziebland, H., and Patient, J. E., "Thermal Conductivity of n-Octadecane. New Measurements and a Critical Appraisal of the Article by Sutherland, Davis and Seyer," *J. Chem. Eng. Data*, 1962, **7**, 530.

APPENDIX 2

POSTS WE WISH TO FILL AT E.R.D.E.

Vacancies for graduate students, preferably with two or more years' research experience, exist in certain areas of work at E.R.D.E., particularly in those which are just starting up or are taking a new direction.

We have recently set up a new branch in E.R.D.E., which will be primarily concerned with the properties of inorganic materials. Their chief research interests lie in the preparation and study of whisker crystals of refractory materials such as silicon nitride. These whiskers exhibit remarkable physical properties in that, if properly grown and of the right size, their strength is many times greater than that of the normal bulk compound. They may therefore have application as reinforcing agents in metals and possibly in ceramics. The chemical features of this work—apart from those met with in the preparation of the whiskers themselves—arises from problems of incorporation within a matrix. Data are required, for example, on the chemical stability of silicon nitride in nickel alloys at high temperatures. For this work we need:

1. An inorganic chemist, preferably with some experience of crystal studies or of refractories.

Many problems of general physics are thrown up by this work, including electron microscopy, and the measurement of elastic properties. We therefore have a vacancy for:

2. A physicist or physical chemist with specialist experience in one or other of these subjects.

This group is also active in other directions including semi-conductor chemistry and materials for optical lasers. Although we are not primarily looking for recruits in these latter fields we would be very willing to consider applicants possessing specialised knowledge or experience.

We are also anxious to expand our research in chemical engineering. Routine production work is not envisaged, but experimental work on many

products, processes, and problems is carried on up to the semi-technical scale. We have a number of vacancies in this area, as follows:—

3. To take part in research and development work in connection with controlled crystallisation; typical materials being studied are ammonium perchlorate and cyclotrimethylene trinitramine. Also to take part in research into technical methods of drying fine powdered materials to exceptionally low water content.
4. To lead a small team in the study of methods of conveying and metering flows of materials, particularly solids; the mixing of pastes and powders; the design of furnaces for special purposes.
5. To study methods suitable for remote control, and their application in the experimental processing of normally hazardous materials. This work will be done in collaboration with the Instrumentation Section, and one of the Development Branches.

APPENDIX 3

SALARY SCALES IN THE SCIENTIFIC OFFICER CLASS

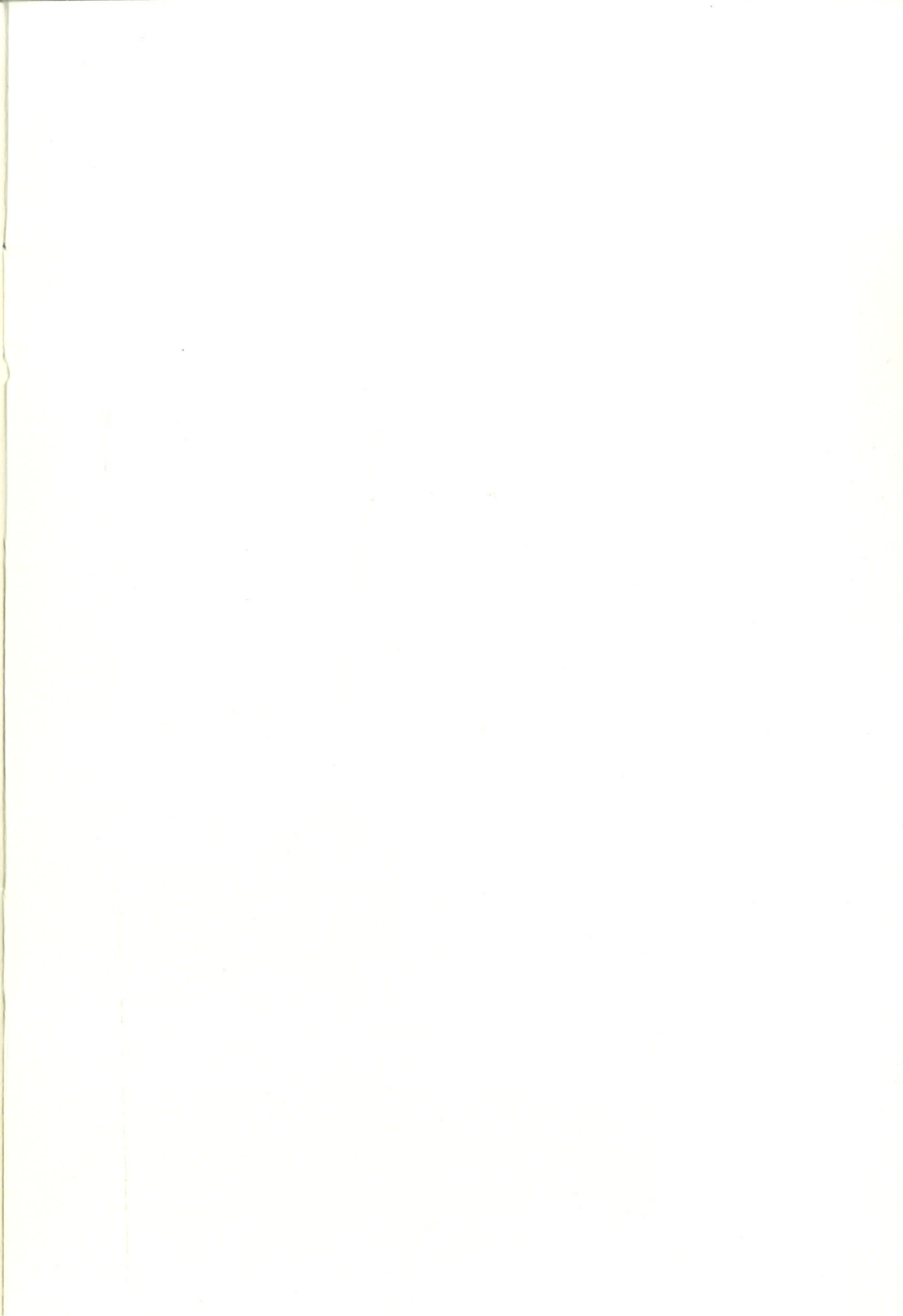
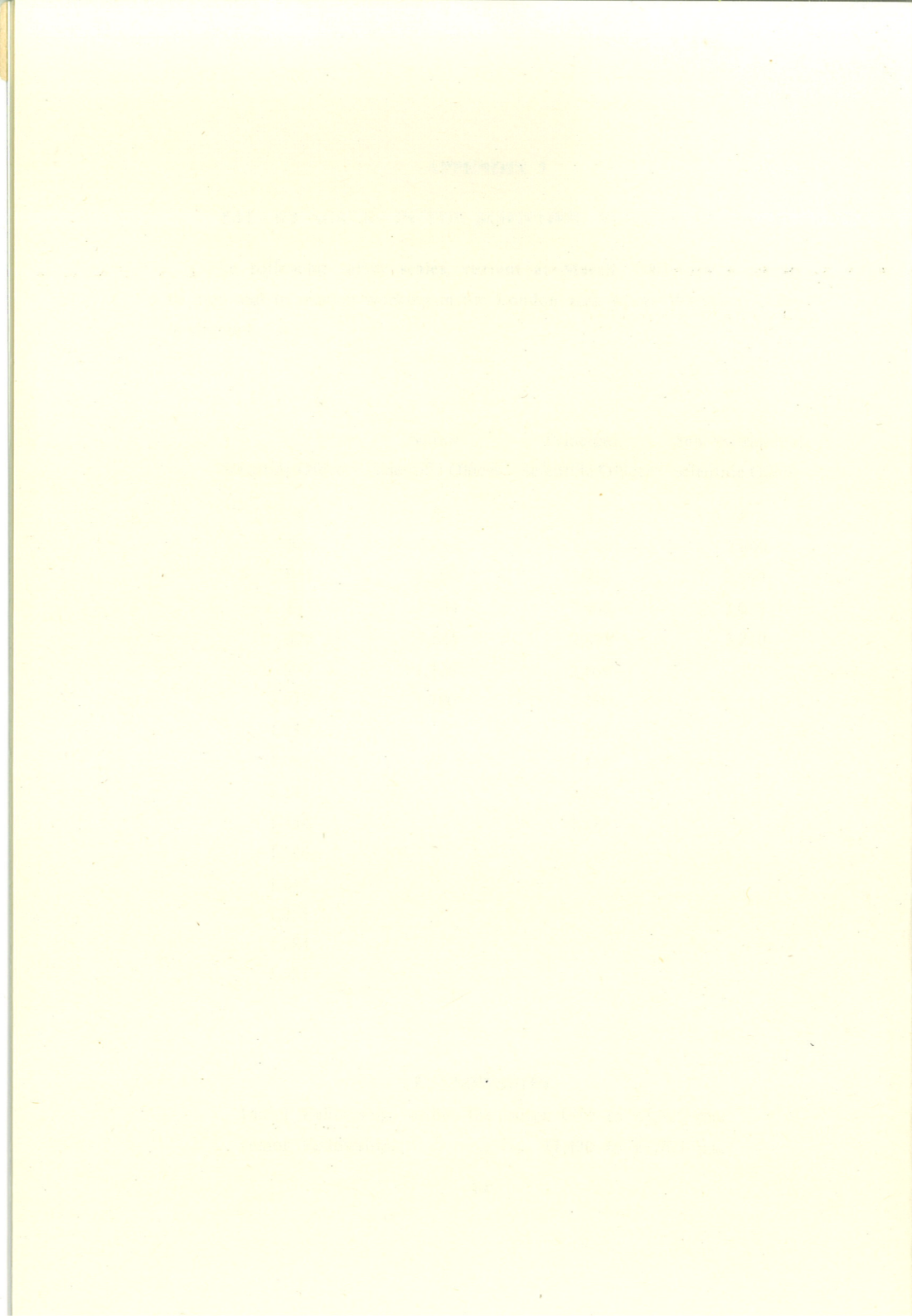
The following salary scales, current at March, 1963, apply equally to men and to women working in the London area where Waltham Abbey is situated.

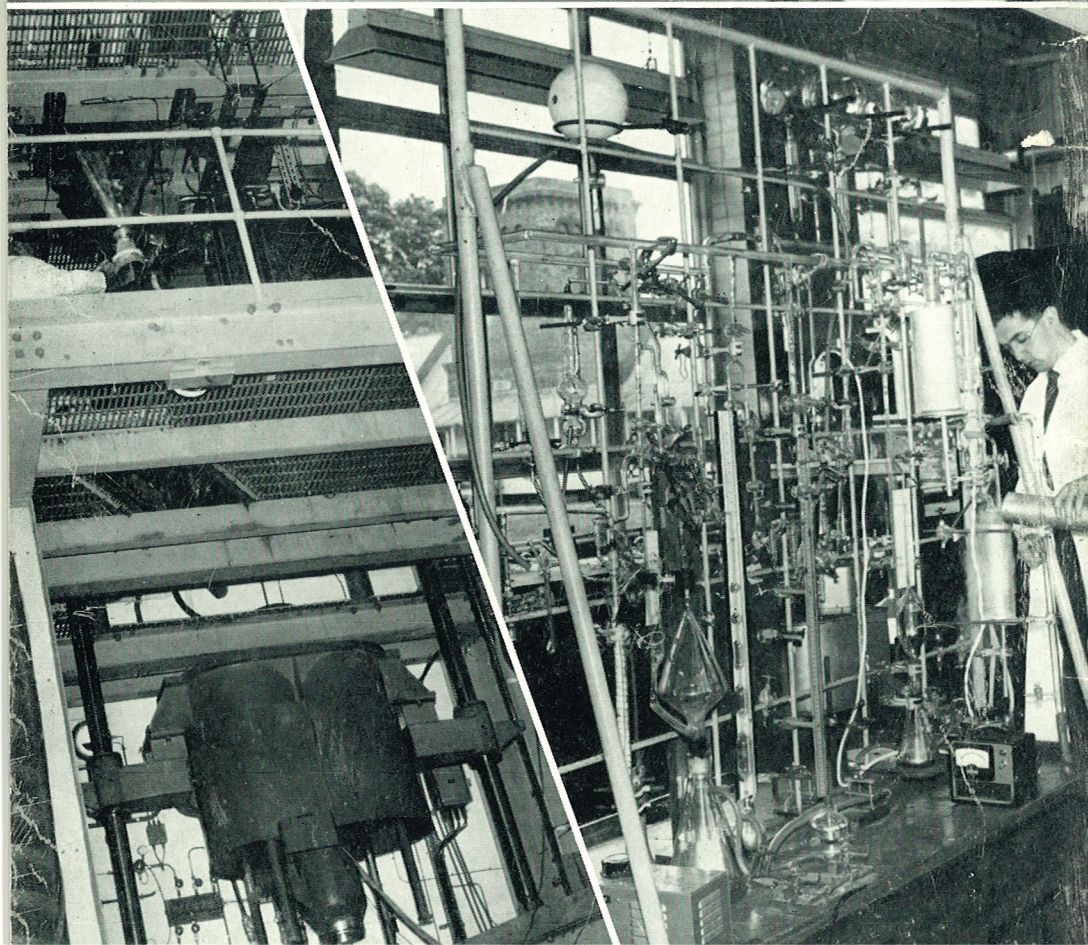
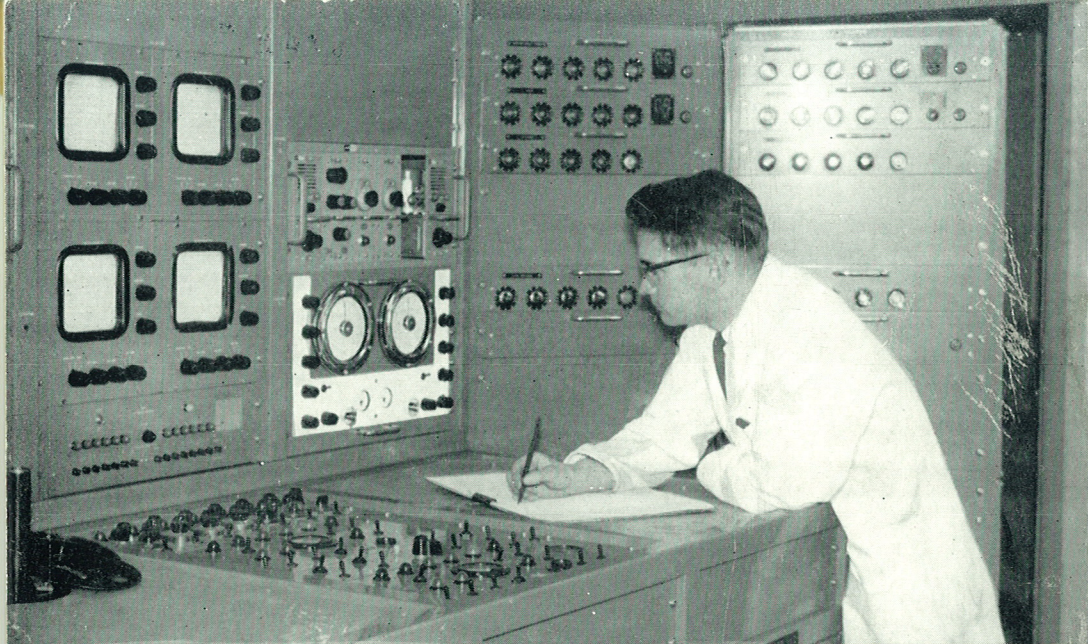
	Senior Scientific Officer	Principal Scientific Officer	Senior Principal Scientific Officer
£	£	£	£
808	1,446	1,845	2,860
841	1,500	1,926	2,960
873	1,564	2,007	3,085
922	1,645	2,088	3,210
970	1,726	2,169	
1,019	1,780	2,250	
1,056		2,331	
1,089		2,412	
1,121		2,494	
1,154		2,575	
1,186			
1,218			
1,251			
1,284			
1,321			

FELLOWSHIPS

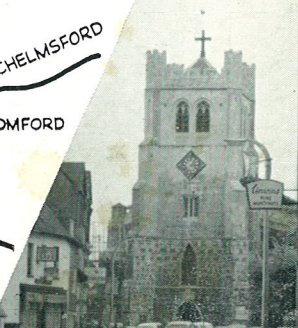
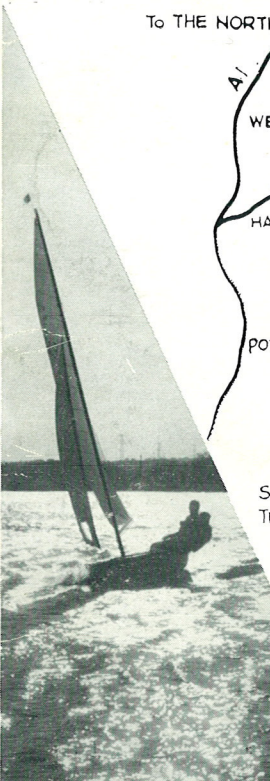
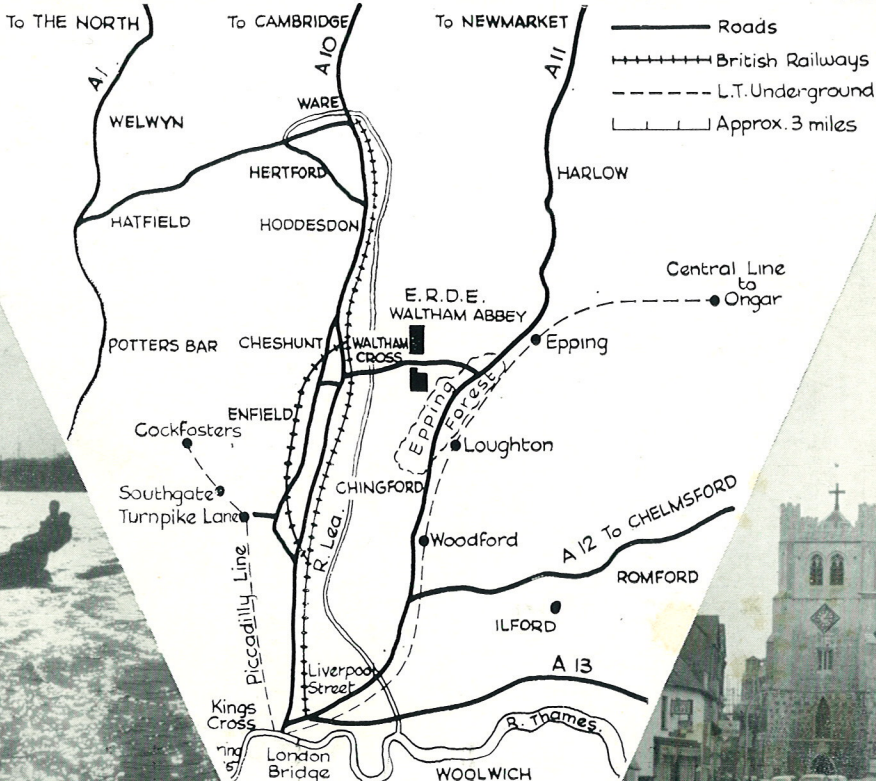
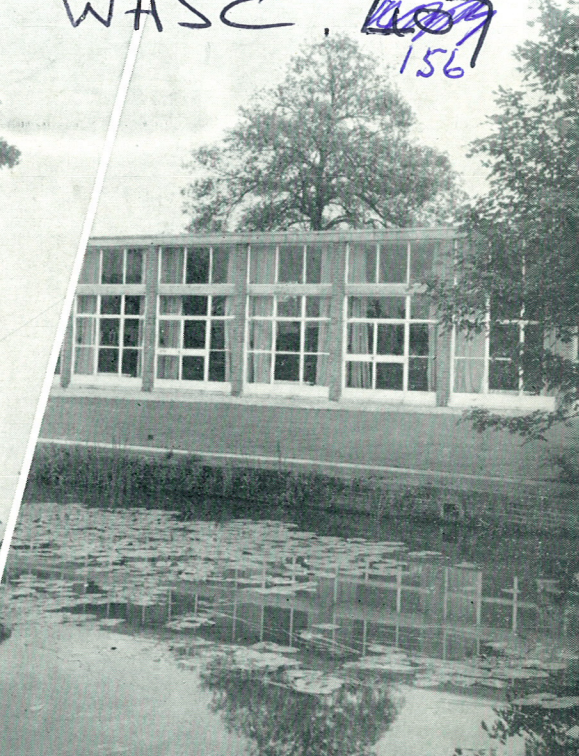
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EXPLOSIVES RESEARCH AND
DEVELOPMENT ESTABLISHMENT
WALTHAM ABBEY

“Choose money and Gunpowder.”

—from “Major Barbara” by Bernard Shaw.

This quotation is used with the permission of the Public Trustee and the Society of Authors.

1965

The Explosives Research and Development Establishment

Ministry of Aviation

Waltham Abbey, Essex

Phone : Waltham Cross 23688

SENIOR STAFF

Director	Dr. L. J. Bellamy (C.S.O.)
Deputy Director	Dr. G. H. S. Young (D.C.S.O.)
Heads of Branches (S.P.S.O.)	Mr. P. R. Freeman
	Mr. J. E. Gordon
	Dr. A. L. Lovecy
	Mr. R. G. Ross
	Mr. E. G. Whitbread
	Dr. R. L. Williams
	Dr. W. G. Williams
	Dr. I. Dunstan

Individual Merit Appointments

(D.C.S.O.)	Mr. G. K. Adams
(S.P.S.O.)	Dr. A. W. H. Pryde
	Mr. G. W. C. Taylor
	Dr. N. Uri
	Mr. H. Ziebland

HISTORY AND PRESENT FUNCTIONS

Essentially E.R.D.E. is a centre of chemical and physical research. It was set up immediately after the last war on the site of the old Royal Gunpowder Factory which had an unbroken history stretching back at least to Stuart times and possibly earlier. Waltham Abbey is the only Government Department carrying out research on all aspects of military explosives and propellants, although, as will be seen later, much work is done on non-metallic materials. Because of our special position in the explosives field a very wide variety of questions are put to us from all three Services—on topics ranging from guided missile and stratosphere rockets to pilot ejector seat cartridges and even smaller components. Our primary function is to provide the answers to such questions, but this does not mean that we are restricted to *ad hoc* technological problems. We can only properly fulfil our function as expert consultants if we are actively engaged on research in the subjects with which we are concerned. For this reason our interests cover a quite surprisingly wide field of science.

MINISTRY OF AVIATION

E.R.D.E. is part of the Ministry of Aviation but serves all the Defence departments, Navy, Army, and Air, as it did in the days of the Ministry of Supply. Close working arrangements exist with other Government establishments, notably with the Rocket Propulsion Establishment (Westcott) and the Royal Armament Research and Development Establishment (Fort Halstead) on explosives; and with the Royal Aircraft Establishment (Farnborough) and Royal Radar Establishment (Malvern) on materials research.

SCOPE AND SIZE

The organisation of E.R.D.E. is such that no young man of ability and originality will be denied a satisfying research outlet. Generally, new entrants join one or other of the research teams. Interesting and important problems also arise on the applied side, and in order to ensure that the development staff continue to keep in touch with science many of them devote a proportion of their time to longer term investigations. The present strength is between seventy and eighty Scientific Officer grades (chemists forming the majority, with a sprinkling of physicists and research engineers) and some hundred and sixty Experimental Officers and Scientific Assistants. Most of the research is carried on by small teams numbering two to six, headed by a Senior or Principal Scientific Officer.

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During the past four years nearly 100 publications from E.R.D.E. have appeared in well-known scientific journals. These include the *Journal of the Chemical Society* (21), *Transactions of the Faraday Society* (7), *Proceedings of the Royal Society* (3), *Combustion and Flame* (3), and many others. A selection of titles is given below.

- Arden, E. A., and Phillips, L., "Reduction and Oxidation of Nitric Oxide in the System Diethyl Peroxide—Nitric Oxide: Reactions of HNO." *Proc. Chem. Soc.*, 1962, 354.
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- Powling, J., Smith, W. A. W., and Thynne, J., "The Flame Decomposition of Some Substituted Ethyl Nitrates," *Combustion and Flame*, 1960, **4**, 201.
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- Ziebland, H., and Patient, J. E., "Thermal Conductivity of n-Octadecane. New Measurements and a Critical Appraisal of the Article by Sutherland, Davis and Seyer," *J. Chem. Eng. Data*, 1962, **7**, 530.

APPENDIX 2

POSTS WE WISH TO FILL AT E.R.D.E.

Vacancies for graduate students, preferably with two or more years' research experience, exist in certain areas of work at E.R.D.E., particularly in those which are just starting up or are taking a new direction.

We have recently set up a new branch in E.R.D.E., which will be primarily concerned with the properties of inorganic materials. Their chief research interests lie in the preparation and study of whisker crystals of refractory materials such as silicon nitride. These whiskers exhibit remarkable physical properties in that, if properly grown and of the right size, their strength is many times greater than that of the normal bulk compound. They may therefore have application as reinforcing agents in metals and possibly in ceramics. The chemical features of this work—apart from those met with in the preparation of the whiskers themselves—arises from problems of incorporation within a matrix. Data are required, for example, on the chemical stability of silicon nitride in nickel alloys at high temperatures. For this work we need :

1. An inorganic chemist, preferably with some experience of crystal studies or of refractories.

Many problems of general physics are thrown up by this work, including electron microscopy, and the measurement of elastic properties. We therefore have a vacancy for :

2. A physicist or physical chemist with specialist experience in one or other of these subjects.

This group is also active in other directions including semi-conductor chemistry and materials for optical lasers. Although we are not primarily looking for recruits in these latter fields we would be very willing to consider applicants possessing specialised knowledge or experience.

We are also anxious to expand our research in chemical engineering. Routine production work is not envisaged, but experimental work on many

products, processes, and problems is carried on up to the semi-technical scale. We have a number of vacancies in this area, as follows :-

3. To take part in research and development work in connection with controlled crystallisation; typical materials being studied are ammonium perchlorate and cyclotrimethylene trinitramine. Also to take part in research into technical methods of drying fine powdered materials to exceptionally low water content.
4. To lead a small team in the study of methods of conveying and metering flows of materials, particularly solids; the mixing of pastes and powders; the design of furnaces for special purposes.
5. To study methods suitable for remote control, and their application in the experimental processing of normally hazardous materials. This work will be done in collaboration with the Instrumentation Section, and one of the Development Branches.

APPENDIX 3

SALARY SCALES IN THE SCIENTIFIC OFFICER CLASS

The following salary scales, current at 1st January, 1967, apply equally to men and to women working in the London area where Waltham Abbey is situated.

Scientific Officer	Senior Scientific Officer	Principal Scientific Officer	Senior Principal Scientific Officer
£	£	£	£
971	1,809	2,315	3,565
1,030	1,888	2,405	3,715
1,094	1,960	2,496	3,890
1,153	2,063	2,594	4,065
1,212	2,159	2,690	
1,255	2,220	2,786	
1,298		2,882	
1,346		2,979	
1,389		3,075	
1,432		3,172	
1,474			
1,517			
1,570			
1,613			
1,639			

FELLOWSHIPS

Junior Fellowship, within the range £1,180 to £1,575 p.a.

Senior Fellowship, within the range £1,745 to £2,155 p.a.

