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ERDE Open Days Series b/w press photographs. /1-/39 and 8 booklets "Open Days Guide to Exhibits 13, 14th June 1968

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Explosives
Research & Development
Establishment
Waltham Abbey Essex

Open Days Guide to Exhibits

Wednesday 12, Thursday 13
and Friday 14 June 1968
9.30 a.m. to 4 p.m.

MINISTRY of TECHNOLOGY

PATENTS. The open days exhibition is an exhibition certified by the Board of Trade for the purpose of Section 51(2) of the Patents Act 1949 and Section 6 (2) of the Registered Designs Act 1949.

Contents

Foreword

It is a pleasure to extend a warm welcome to our guests, on behalf of the Explosives Research and Development Establishment.

Visitors from organizations concerned with the country's defence effort will be aware that for many years ERDE has made significant contributions to the development of solid propellants and explosives to meet the requirements of the three Services. Our work has covered all aspects of research and development from laboratory synthesis to formulation and manufacture, with related studies on heat transfer, combustion, detonation and safety. Achievements in these different fields are highlighted in many of today's exhibits.

More recently a substantial proportion of the Establishment's effort has been devoted to work on non-explosive materials. For example, we are particularly interested in developing and testing polymers, elastomers and adhesives to improve their stability and performance. This work, originally aimed at Army Department and guided weapons applications, has a direct bearing on the use of these materials for fabricating a wide range of commercial products.

The changing emphasis between defence and civil work is reflected in another aspect of our materials research programme concerned with the preparation and use of refractory whiskers in compositions of ultra-high strength. There is keen interest in this country and overseas in the development and application of these novel materials for engineering purposes.

Last year ERDE became part of the Ministry of Technology and a third area of activity began to develop as we responded to the new Ministry's policy of encouraging establishments to work more closely with industry in the application of research to the solution of current technological problems.

We recognize that our expert knowledge of explosives, propellants and non-metallic materials may be of immediate benefit to industry, and it is our intention to make our special facilities more widely available through the Mintech Interlab and Industrial Liaison schemes.

The Open Days provide our first opportunity to acquaint guests from industrial undertakings with the Establishment's activities and facilities. We hope that they and all our other guests will find much to interest them among the exhibits, and that today's discussions will lead to fruitful collaboration in the future.

ERDE
Ministry of Technology
Waltham Abbey
Essex

Tel: Waltham Cross 23688

Director

Senior Officers at ERDE

Director	Dr. L. J. Bellamy
Principal Superintendent/Development	Dr. G. H. Young
Deputy Chief Scientific Officer (Special Merit)	Mr. G. K. Adams
Superintendents	
Propellants 1	Dr. W. G. Williams
Propellants 2	Mr. P. R. Freeman
Explosives	Mr. E. G. Whitbread
Materials 1	Dr. R. L. Williams
Materials 2	Prof. J. E. Gordon
Chemical Engineering	Mr. R. G. Ross
Analysis and Ingredients	Dr. I. Dunstan
Senior Principal Scientific Officers (Special Merit)	Dr. A. W. H. Pryde Mr. G. W. C. Taylor Dr. N. Uri Mr. H. Ziebland
Chief Administrative Officer	Mr. S. F. M. Whiteside
Chief Safety Officer	Mr. J. V. Griffiths
Chief Engineer	Mr. S. J. Lowdell, I.S.O.
Industrial Liaison Officers and Interlab Correspondents	Dr. I. Dunstan Dr. A. R. Osborn

General Information

Admission and car parks

The Establishment will be open each day from 9.30 a.m. to 4.00 p.m. and admission will be by ticket valid for a particular day only.

Visitors arriving by car will be provided with a windscreen 'sticker' giving admission to one of the three car parks:

North Site	Car Park A	—	Powdermill Lane Gate
	Car Park B	—	Refinery Gate
South Site	Car Park C	—	Sewardstone Gate

Those arriving on foot are asked to use either Refinery Gate (North Site) or Sewardstone Gate (South Site).

Visitors are requested to present their admission badges on arrival and to wear them throughout the day.

Cameras and tape recorders

Cameras and tape recorders must not be brought into the Establishment but may be left in cars or deposited at the left luggage points.

Smoking

Smoking is prohibited throughout the Establishment, except in the canteens and other places of refreshment, and the Library.

Envelopes will be provided for those who have lighters and matches with them. These envelopes must be used to deposit lighters and matches temporarily when visiting certain exhibits.

Catering

A cold, set lunch (price 7/6) will be available in the Main Canteen (North Site) between noon and 2.00 p.m. Tickets, which should be purchased on arrival, may be obtained at the Reception Tent adjacent to Car Park B (North Site) and the Refreshment Point adjacent to Car Park C (South Site).

Tea, coffee and light refreshments will be available from 9.30 a.m. at Refreshment Points near the North Site Canteen and the South Site Fire Station, and from 10.30 a.m. at the other two points indicated on the Maps.

There will be licensed bars at the four Refreshment Points.

General Information (contd.)

Transport

ERDE coaches will leave Oakwood Station (Piccadilly Line) at 9.30 a.m., 9.45 a.m., 10.00 a.m. and 10.15 a.m. on Wednesday, 12th June and Friday, 14th June.

Return coaches will leave from Car Park B (near Refinery Gate, North Site) at 3.30 p.m., 3.45 p.m., 4.00 p.m. and 4.15 p.m. on both days.

A map showing the approach roads to Waltham Abbey and access to ERDE is loosely enclosed.

Internal transport

A coach service will be maintained between North and South Sites, with a service interval of 8 minutes. Bus stops are indicated on the maps.

Information centre

Information desks will be set up in the Library to assist visitors to plan their tour of the exhibits and to provide information about public transport, entertainments in the London area, and other general topics.

Facilities will be available for those wishing to make telephone calls.

First aid

First aid will be available at the surgeries on both North and South Sites (see maps). An ambulance may be called by dialling 222 on any telephone.

Left luggage

Luggage may be left at the Reception Tent near Car Park B on the North Site and at the Refreshment Point near Car Park C on the South Site.

Uniform

Uniform for Service Officers is optional.

General Information (contd.)

Films

A 30-minute programme of short films illustrating some aspects of the Establishment's work will be shown in the Lecture Theatre (Library) on:

Wednesday 12th June Friday 14th June	}	at	10.00 a.m. 11.00 a.m. 12.00 noon 2.30 p.m.
Thursday 13th June		at	10.00 a.m. 11.00 a.m.

Historical Note

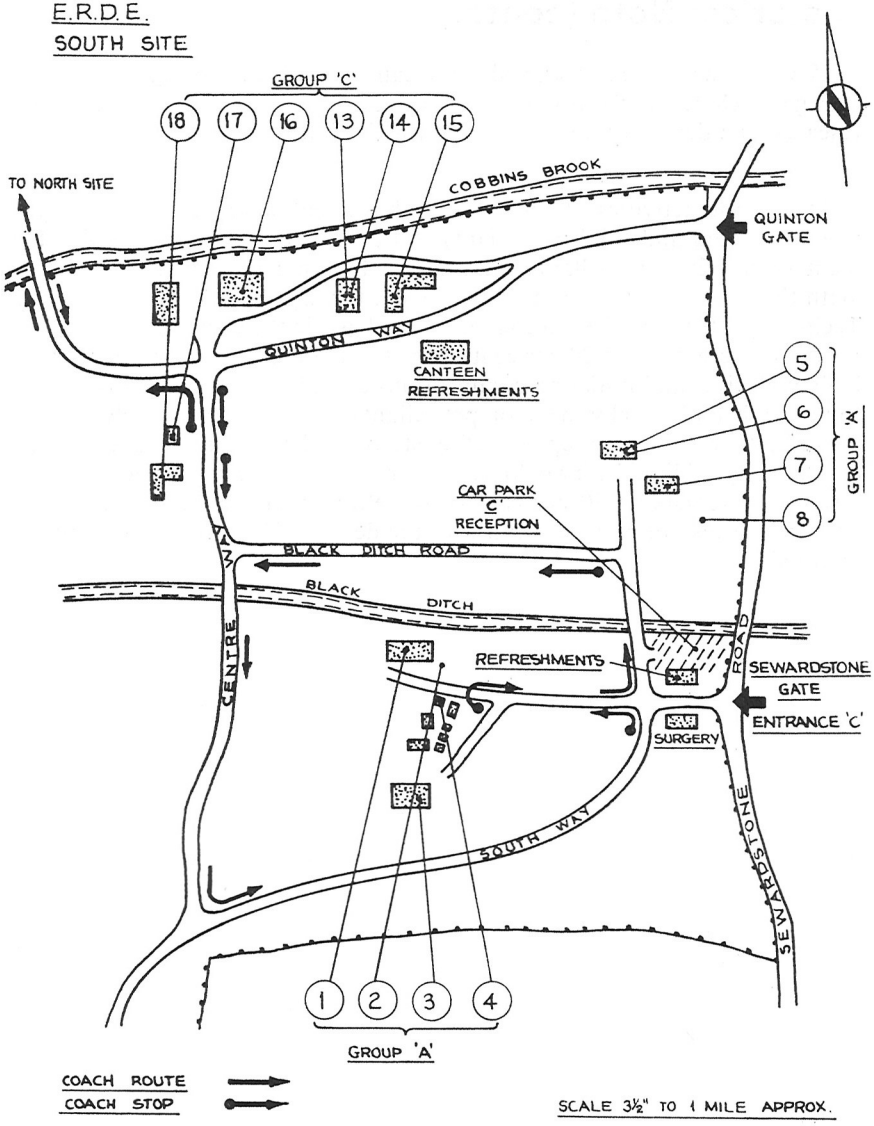
The Establishment occupies a site originally used for the manufacture of gunpowder but the early days of the factory are largely a matter of conjecture and legend. The first positive link between Waltham Abbey and gunpowder is contained in the State Papers of 1561 in the form of a letter to John Tamworth of Waltham Abbey concerning a contract for the supply of saltpetre and sulphur. The importance of the local manufacture was emphasized a century later by the local Minister, Dr. Thomas Fuller, who wrote that there was more gunpowder made by the mills in his Parish 'than in all England besides'. Unfortunately powder-making was a hazardous occupation and the Parish Registers for 1665 record the burials of two workmen killed by a mill explosion. The mills at this time were horse-driven but they were converted to waterpower by the Walton family in whose hands they remained for more than a hundred years until they were bought by the Government in 1787 from John Walton. The man who played the greatest part in this was General Sir William Congreve, who disputed the widely-held belief that the private manufacturers made better and cheaper gunpowder than the Government. Later Congreve demonstrated convincingly the superiority of the powder from the Royal Gunpowder Factory and was still able to show savings of some fifty thousand pounds. Walton's Powder Mills were capable of producing 6000 barrels of gunpowder a year but by the time of the Napoleonic Wars the output was of the order of 25 000 barrels. The quality of Waltham Abbey powder was recognized overseas and both sides in the American Civil War drew on the experience and expertise of the Factory. The United States Ordance Manual for 1862 records that no one makes better powder than the British.

For several hundred years the sole product of the Factory was gunpowder but in the second half of the 19th century the manufacture of other explosives commenced. In 1872 a plant was erected for the production of guncotton but this plant was soon found to be inadequate and the first land on the South Site was acquired in 1885 for a new guncotton factory. A decision of the newly-appointed Explosives Committee, with Sir Frederick Abel as President, resulted in the setting up of further plant in 1891 for the manufacture of nitroglycerine and the first production of cordite. Other explosives produced since the turn of the century include tetryl, TNT and RDX. RDX, or Research Department Explosive, has been described as the high explosive of World War II: it is significant that for the first years of the war the Royal Gunpowder Factory was this country's only source of production, just as it had been earlier for cordite during the two years at the beginning of the First World War. The days of the Royal Gunpowder Factory came to an end in

Historical Note (contd.)

1945 when the present Establishment came into being, bringing with it a change in character from the role of a major production unit to that of a research and development organization with pilot plant facilities.

At first the activities of the new Establishment were devoted entirely to work on liquid and solid propellants and explosives, including the development of flashless propellants for guns and plastic propellant for rockets. With the passing of time and of Ministries, through Supply and Aviation to Technology, there has been a change of emphasis in the work of the Establishment. At present about 20 per cent of the total effort is absorbed by work on high explosives and initiating compositions and about 50 per cent is devoted to research and development of propellants, now confined solely to solid propellants with the exception of a study of heat transfer and thermal conductivity of liquids. Two Materials groups have been formed and these absorb the remaining 30 per cent of the effort with the physics, chemistry and applications of polymers and with the design of high strength composite materials.


E.R.D.E.
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GROUP 'C'
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TO NORTH SITE
COBBINS BROOK
QUINTON GATE
QUINTON WAY
CANTEEN
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GROUP 'A'
CAR PARK
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RECEPTION
BLACK DITCH ROAD
BLACK DITCH
CENTRE WAY
REFRESHMENTS
SEWARDSTONE ROAD
SEWARDSTONE GATE
ENTRANCE 'C'
SURGERY
SOUTH WAY
SEWARDSTONE
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GROUP 'A'
COACH ROUTE
COACH STOP
SCALE 3½" TO 1 MILE APPROX.

Guide to the Exhibits

The Open Day exhibits are arranged in eight groups based on subject matter and geographical location. Exhibits describing work on Solid Propellants (Group A) and Process Research and Development (Group C) are located on the South Site, the rest are on the North Site.

Representative Exhibits

Visitors will probably prefer to plan their own itineraries, but those who wish to inspect exhibits representative of our major fields of interest are recommended to visit those listed below. The exhibits can, of course, be visited in any order desired.

	Exhibit No.	*Group*	
Packaged Power from Solid Propellants	1	A	South Site
Composite Propellant Development and Applications	5–8	A	
Composites: The Right Material for Your Job?	13	C	
Facilities for Advanced Explosives Research	18	C	
Polymers: Development and Applications	21	D	North Site

Demonstrations and Live Firings

Throughout each day there will be frequent, small-scale demonstrations involving combustion of propellants or detonation of explosives.

	Exhibit No.	*Group*	
Propellant Burning	2	A	South Site
Production Drenching Devices	2	A	
Line-throwing Rockets	8	A	
Static Testing of Small Motors	8	A	
Pyrotechnics and Igniter Compositions	9	B	North Site
Explosives: Demonstration Firings	11	B	
Measurement of Ignition and and Explosion Rates	27	F	

Solid Propellants

Group A
South Site (map p. 10)

The Establishment has been closely associated with solid propellants for a long time. Gunpowder was manufactured on the site when it was acquired by the Government in 1787 and the first cordite plant was erected on the South Site in 1891. Since then, almost every British innovation in the field of solid propellants has originated at Waltham Abbey.

Today, ERDE is the only Government Establishment concerned with research on, and development of, solid propellants, and it is the only place in the country where solid composite rocket propellants are developed. All three Armed Services depend on ERDE for the development of propellant compositions to meet the requirements of new weapons and to solve in-Service problems. The propellant development service has been extended to private industry for such purposes as rocket ejection seats, meteorological rockets, and line-throwing rockets.

The Establishment's responsibility for maintaining expertise in solid propellant technology has necessitated unique facilities for processing all types of propellants from laboratory to full production scale plant and associated testing equipment to establish physical, mechanical and environmental characteristics.

Solid propellants present an instantly available source of packaged power and to cover the wide range of characteristics required we work on four types of propellants – plastic (a UK invention), rubber-based, extruded cordite, and cast double-base.

Exhibit No. 1 is designed specifically for the general visitor.

1 **Packaged power from solid propellants** **P708**

A general introduction describes the nature of solid propellants and the need for various types of propellant to meet a great variety of applications in rockets, guns, and pressurizing devices.

Dr. W. G. Williams (*Extn.* 319)
Mr. P. R. Freeman (*Extn.* 414)

2 **Demonstrations of propellant burning, and production drenching devices** **Outside 708**

An understanding of combustion phenomena is important in propellant technology. Some significant aspects are demonstrated in simple visual presentations.

Rapid, fire-drenching equipment operating in about 0.1 second using water pressurized by a small rocket or carbon dioxide cylinders will be demonstrated at intervals.

Dr. J. Powling (*Extn.* 202)
Mr. R. J. Walley (*Extn.* 469)

3 **Processing of double-base propellants** **P716**

This exhibit is housed in our 10.5-inch, 380-ton extrusion press building, designed to withstand a 500 lb 'detonation risk'.

Typical processing equipment is displayed with descriptions of various processes, including the ERDE single-shot process for paper-based cartridge cases.

Mr. R. J. Walley (*Extn.* 469)
Mr. R. A. Wallace (*Extn.* 381)

Solid Propellants (contd.)

Group A
South Site (map p. 10)

4 **Inspection and quality control of double-base propellants** **P730**

Reproducibility of ballistic characteristics depends upon adequate control of chemical purity and particle size. Exhibits demonstrate how quality is assured by analysing ingredients and subjecting finished propellants to ballistic and radiographic inspection tests.

Dr. C. G. Lawson (*Extn.* 545)

5 **Large-scale processing of rubbery propellants** **N550**

Equipment for the mixing of 300 kg of a highly viscous, polymerisable propellant slurry, and casting into rocket motors. The robust, vertical twin-bladed mixer is of special design and all propellant handling operations are remotely controlled.

Mr. J. Scrivener (*Extn.* 301)

6 **Plastic propellant rockets for space and meteorological research** **N550**

The Skylark (RAE, Space Dept.) and Skua (Bristol Aerojet Ltd.) rockets are displayed. These utilize rocket motors designed by RPE, Westcott and filled with plastic propellant developed at ERDE.

The Skylark is the largest solid propellant rocket currently produced in the UK; the Skua is smaller and is mainly intended for meteorological use.

Both rockets have been exported and there are prospects of continuing sales.

Mr. G. J. Spickernell (*Extn.* 487)

Solid Propellants (contd.)

Group A
South Site (map p. 10)

7 **Composite propellants – formulation, evaluation, and applications** **N554**

A display of the development of composite propellants based on a polybutadiene rubber binder to give compositions of high performance and wide temperature range capability.

The wide range of properties which can be obtained from plastic propellant by variations in formulation is demonstrated by reference to its many applications.

Mr. R. P. Ayerst (*Extn.* 225)
Mr. J. Scrivener (*Extn.* 301)

8 **Line-throwing rockets and static testing of small motors** **Quinton Hill Outside N554**

Plastic propellant formulated at ERDE will be shown undergoing ballistic testing on a static firing bed in 2-inch motors. Such testing is applicable to all propellants. Plastic propellant is employed as a safe and cheap power source for line-throwing rockets. Live demonstrations will be given in co-operation with Pains-Wessex Ltd.

Mr. G. J. Spickernell (*Extn.* 487)
Mr. R. P. Ayerst (*Extn.* 225)

Explosives

Group B
North Site (map p. 22)

ERDE has unique facilities for research on, and development of, sensitive explosives. Objectives include safer and more economic processes and products, meeting the functioning requirements for new applications, and improved life under normal and extreme environments. Study of novel methods of crystallization and experimental manufacture on production scale are features which have led to the adoption of many new processes in this country and abroad.

An important function of ERDE is to provide information to almost all users of explosives and propellants on their safety. The hard core of this information is given on a 'Safety Certificate' which incorporates data from a number of standard tests. Ad hoc trials are frequently devised to solve problems arising in particular situations.

The Sensitiveness Collaboration Committee, whose Chairman and Secretary are both members of ERDE, co-ordinates this testing in the UK.

It is necessary to maintain a vigorous research programme into the mechanism by which explosions initiate, both to refine the tests used and to improve the safety of these materials when handled by factory or user. This difficult study demands a range of techniques from simple laboratory tests to the most sophisticated ultra-high speed equipment.

9 Initiators and igniferous explosives **L148**

Research on new substances. Development to production; methods and equipment. **Bay 1**

RD 1300 *series of compositions.* Chemical and physical characteristics; scope of adoption. **Bay 1**

Assessment and applications. Methods of determining properties; examples of initiating devices and end items. Research on crystallization. **Bay 2**

Special pyrotechnics, rocket igniters and delay compositions. New materials with improved properties; preparation and assessment. Demonstration firings will be given outside L148 at 11.00, 12.00, 14.30, and 15.30 hours. **Bay 3**

Mr. G. W. C. Taylor (*Extn.* 358)

10 Safety of explosives **L149**

Safety certificate and hazard tests. For Mintech and MOD Certificates and other appraisals. The Rotter Impact Test will be demonstrated. **Bays 14, 6**

Electrostatic hazards. Demonstrations will be given of the electrification of polythene and polythene loaded with graphite, and of the effect of leakage resistance on the charging of personnel. **Bay 14**

High speed photography. Various cameras are employed to study rapid mechanical movement and explosive phenomena. **Bay 15**

Fragment attack on rocket motors. Attack on representative sections is being studied. **Bay 16**

Shell prematures. A simple laboratory test is being used to simulate a possible mechanism. **Bay 16**

Dr. R. M. H. Wyatt (*Extn.* 307)

Explosives (contd.)

Group B
North Site (map p. 22)

The primary function of the Detonation Section is to study the release of energy from explosives in order to improve the product. This basic need has led to a number of valuable and interesting applications of explosives. For example, a knowledge of blast gave rise to a cheap simulant used to test the reaction of buildings to the so-called sonic bangs produced by aircraft. An attempt is being made to use the enormous pressures of a detonation (about 1,000 tons to the square inch) to make new and improved catalysts for the production of useful chemicals.

11 Demonstration firings

The number of visitors will be limited to 15. Firings will take place at 10.00, 11.00, 12.00, 13.30, 14.30 and 15.30 hours, and the total time will not exceed 45 minutes for each firing.

Gap sensitiveness testing. A small scale gap test on a high explosive. **L109**

Eye and facial protection testing. Goggles and face visors are subjected to high velocity glass fragments. **L199**

Dr. R. M. H. Wyatt (*Extn.* 307)

12 Detonation studies

A *Assessment of underwater explosives.* Equipment and techniques used for investigation of underwater shock-waves; data reduction equipment. **L149 Bay 9**

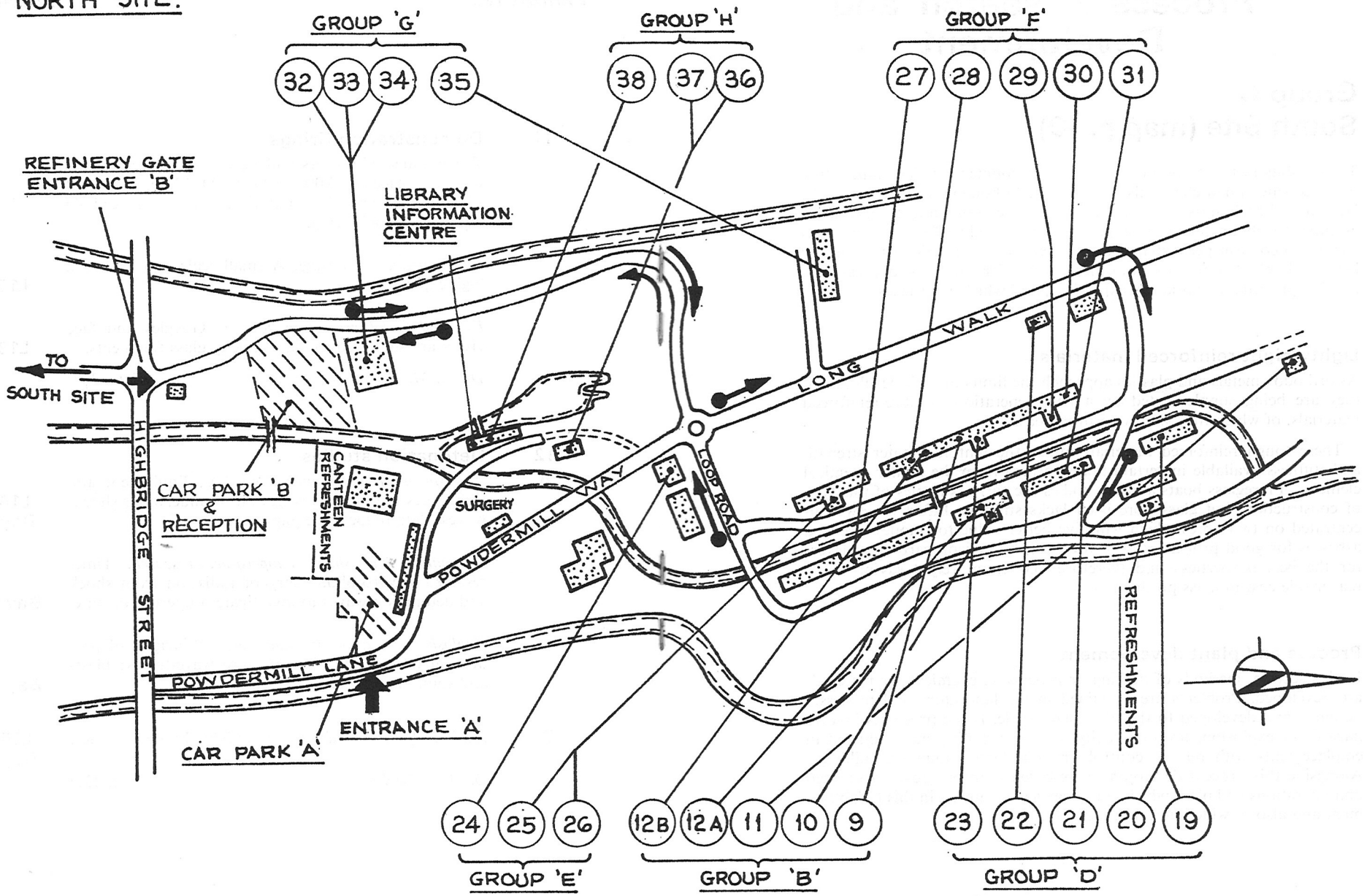
Detonation and shock temperature research. Time-resolved spectro photometry of radiation from shock and detonation waves to investigate properties of state. **Bay 10**

Explosive simulation of sonic bangs. Principles of production of long-duration pressure wave-forms; blast- and sound-recording equipment. **Bay 10**

B *Explosively-generated catalytic activity.* In metal oxides. **L153 Bay 5**

Dr. J. A. Hicks (*Extn.* 436)

E.R.D.E.
NORTH SITE.



COACH ROUTE
COACH STOP

SCALE 6" TO 1 MILE APPROX

Process Research and Development

Group C
South Site (map p. 10)

The exhibits in this Group concern the development of the manufacture or processing of new chemicals or materials. Although this starts off on the laboratory bench, most of the exhibits are of the pilot plant stage, which is essential to obtain operating experience, and product for assessment, as well as to confirm performance and design data. Nevertheless, pilot and large scale plant is also seen in other Groups for particular applications, notably propellants, initiatory explosives, and whisker furnaces.

Lightweight reinforced materials

As orthodox metals and plastics approach the limits of their development they are being supplemented by a new generation of fibre-reinforced materials, of which they simply form the base.

These tough reinforced materials utilize the tenfold greater strength and stiffness available in certain fibres formed from the lighter chemical elements. Fibreglass boats and car bodies are early examples of this type of construction, but glass fibre itself lacks stiffness. Effort is now concentrated on two fibres which will give better value for money – refined asbestos for good properties at lowest cost, but silicon carbide whiskers for the best properties – and therefore maximum weight saving – at a reasonable cost in mass production.

Process and plant development

In this section, methods of making or processing chemicals or materials are developed. Problems are examined in the laboratory and processes designed and developed to the pilot plant scale. If the processes involve hazards of explosion, fire or toxicity, they can readily be conducted in emplacements with remote control or in isolated mounded buildings. Alongside this process development, research is in progress on selected unit operations and plant which are of particular interest in this Establishment and also of wide interest in industry.

13 **Composites: The right material for your job?** **G430**

The exhibit illustrates the development of whiskers and similar fibres, and their incorporation into different plastics and light alloys to give lightweight materials of exceptional strength and stiffness. Some examples of their uses are shown, ranging from cheap everyday hardware to sophisticated applications in weapons, aircraft, and similar environments which justify the use of the most advanced and expensive structural materials.

Prof. J. E. Gordon (*Extn.* 403)
Mr. R. G. Ross (*Extn.* 374)
Dr. R. L. Williams (*Extn.* 390)

14 **Engineering research: Paste mixers** **G430**

Safety design features are most important for mixing propellant pastes, although in industrial applications there is greater interest in performance and reducing power loads.

The exhibits show work on blade clearances, shaft seals and measurement of torque and blade stress and deflection.

Mr. R. Fisher (*Extn.* 597)

15 **Chemical engineering research** **G432**

The following are among items exhibited:

(a) Crystallization research and its application to plant crystallizers.

(b) Precipitation studies using a fast mixer.

(c) Armoured explosion cupboard.

(d) Remote control mechanisms, and a fluid logic system for automatic process control.

(e) Preparation of whisker-reinforced thermo-setting resins as sheets and mechanical test-pieces.

Mr. R. G. Ross (*Extn.* 374)

Process Research and Development (contd.)

Group C
South Site (map p. 10)

Advanced explosives research

Techniques developed in this project are equally applicable to explosive or propellant compositions. Unfamiliar ingredients, which may themselves be explosive, can be compounded and processed, and filled rounds can be inspected and test fired by remote control in a facility which affords complete protection at all stages.

16 **Pilot plants** **G418**

Various processes and some associated plants are exhibited:

(a) Evaporative crystallization.

(b) Ester polymerization.

(c) Whisker sorting for alignment into felted sheets.

(d) Liquid explosives: nitration and drying.

Dr. A. W. H. Pryde (*Extn.* 351)

17 **Remote control laboratory** **M338**

This facility comprises a pair of reinforced concrete emplacements and services annexe, for carrying out potentially dangerous processing (to 10 lb explosive equivalent).

Remote control instrumentation includes TV monitoring with a video tape loop to allow play-back of a three minutes recording before an incident.

Dr. A. W. H. Pryde (*Extn.* 351)

18 **Remote processing facility for advanced explosives** **M343**

Mixing, extruding and injection moulding of hazardous compositions are performed by remote control in an integrated facility in which the process unit, ovens, storage magazines and inspection and manipulation equipment are linked by a 5-inch gauge railway system.

Typical operations will be demonstrated in Exhibits 17 and 18.

Mr. E. G. Whitbread (*Extn.* 306)
Dr. R. Campbell (*Extn.* 571)

Polymer Research and Development

Group D
North Site (map p. 22)

This group covers work going on in what is popularly termed the rubbers and plastic field. The main emphasis has been on the use of these materials in defence equipment particularly for the Army Department, but there is now an increasing emphasis in applying our results to civil technology as well. For example, contributions have been made in the development of the Dracone and the Hovercraft. Items of interest are listed opposite, but they can be summarized by three underlying themes: the study of the ways plastics break down chemically in hostile environments and the search for additives to prevent this; the measurement of the engineering properties of thermoplastics and the development of test equipment to do this; and the attempt to produce fibre-reinforced thermoplastics with much improved mechanical properties.

19 **Polymer chemistry** **L134**

Characterization. Instrumental methods for determination of molecular structure, molecular weights, etc. **Bays 9, 10**

Morphology of polymers. [*Dr. B. J. MacNulty* (*Extn.* 430)].

Synthesis. Special polymers and custom synthesis. **Bay 5**

Stability and degradation. Ageing and stability of polymers under various environmental conditions, including ageing at the Joint Tropical Research Unit. **Bay 4**

Dr. D. H. Richards (*Extn.* 373)

20 **Polymer physics** **L134**

Evaluation of materials. Display and demonstration of standard test equipment. **Bay 6**

ERDE-developed test methods. To provide data for specific stress systems of practical importance. **Bay 3**

Fatigue testing. Demonstration of new test methods. **Bay 3**

Dr. J. Roberts (*Extn.* 212)

21 **Development and applications** **L143**

Proofed fabrics. Aircraft arrester tapes and flexible fluid containers. **Bay 1**

Plastics. Fibre-filled thermoplastics; moulding and evaluation of thermoplastics. **Bay 2**

Rubbers. Examples of rubbers in Service use; conducting rubbers; demonstration of rubber compounding. **Bay 3**

Processing of plastics. Injection and compression moulding demonstrations. **Bays 5, 6**

Dr. B. L. Hollingsworth (*Extn.* 451)

Polymer Research and Development (contd.)

Group D
North Site (map p. 22)

Adhesion and rheology

Sealants and adhesives have been developed primarily for use with explosives and propellants, but also with general applicability. The effect of adhesive joint design on strength is being studied.

The surface chemistry basic to the rheology of rocket propellants, and the behaviour of these under extremes of temperature and mechanical shock, are also being investigated.

Exhibit No.		Location
22	**Autoxidation Research** This research is aimed at preventing or inhibiting oxidative degradation of polymeric materials. New antioxidants are designed and assessed and their mechanism of action studied. Equipment is displayed in the autoxidation laboratory and some aspects of current work are illustrated. *Dr. N. Uri* (*Extn.* 404)	L185
23	**Adhesion and rheology** Adhesive strength measurement, and its effect on sealant efficiency. Wetting, contact angle measurement, and work on large, single crystals of ammonium perchlorate. Mechanical properties of adhesives and rocket propellants; effect of temperature and strain rate. Demonstration of rheological phenomena. *Mr. W. A. Dukes* (*Extn.* 463)	L148 Annexe

ADDENDUM CONCERNING EXHIBIT 22

The section is also concerned with the chemistry of carboxyterminated polybutadiene propellant binders, their stability and the development of new cure catalysts. In autoxidation studies (thermal, photochemical and radiation-induced) emphasis is now placed on the multiple function of metal chelates: catalysis, inhibition, peroxide decomposition and synergistic effects.

'Whiskers'

Group E
North Site (map p. 22)

Exhibits in this group illustrate research on composite materials, reinforced by discontinuous fibres, for use in lightweight, load-bearing structures.

Choice of material affects structure weight through (a) its density, relative to (b) its strength properties and (c) — since many designs are deflection limited — its stiffness. A structural material must also be tough. To meet these requirements, the materials being developed have thermosetting resin or aluminium alloy matrices and utilize the excellent strength and stiffness of whiskers of silicon carbide or nitride as the reinforcement.

The project thus requires the growth of silicon carbide and silicon nitride wool in high-temperature reactors, the sorting and processing of the product and, finally, the fabrication of metal or plastic composites. There is a variety of essential supporting work, ranging from the thermodynamics of whisker growth from the vapour, through whisker nucleation and electron microscopy, to the mechanical testing of individual whiskers and the finished composites.

An alternative balance of smaller weight-saving at lower material cost is provided by asbestos fibres, when correctly processed. Research is carried out on special treatments for these fibres to obtain optimum reinforcement. The use of such fibres in reinforced plastics is shown in Exhibits 13 and 21.

Exhibit No.		Location
24	**Growth of whiskers** High-temperature reactors for the production of silicon carbide and silicon nitride whiskers by vapour phase chemical reactions. *Dr. C. C. Evans* (*Extn.* 519)	**L168 Tower**
25	**Cleaning and sorting of whiskers** Fibre processing equipment and the production of fibrous composite materials. *Mr. N. J. Parratt* (*Extn.* 460)	**L157 Annexe**
26	**Whisker testing and electron microscopy** Measurement of Young's Modulus for whiskers; electron microscopy of fibres. *Mr. J. Cook* (*Extn.* 519)	**L157 Bay 4**

Chemistry and Analysis

Group F
North Site (map p. 22)

ERDE maintains a group of chemists particularly concerned with the synthesis, characterization, and physical and chemical properties of a wide range of ingredients related to explosive, propellant and polymer technology.

As well as providing supporting research for manufacturers and users, the group undertakes basic research connected with the kinetics and mechanism of synthesis and decomposition, and with techniques for observing and assessing the stability of products exposed to severe environmental conditions.

The synthetic work involves preliminary literature surveys, selection of experimental conditions, and consideration of scale-up factors, particularly potential hazards associated with toxicity and exothermic decomposition.

Decomposition studies range from the investigation of thermal behaviour by differential scanning calorimetry to the electrothermal ignition of secondary explosives.

27 **Explosives and synthetic chemistry** **L155 Bay 12**

Synthesis. Explosives, particularly nitrocompounds; ingredients of propellants and polymers (e.g. curing agents, stabilizers, antioxidants); studies to optimize yield and purity, and to reduce hazard; radiochemical labelling.

Characterization. Chromatography, spectroscopy, microscopy, microanalysis and differential scanning calorimetry.

Mr. W. E. Batty (*Extn.* 466)
Dr. R. J. J. Simkins (*Extn.* 361)

Ignition. Demonstration of ignition and explosion rate measurements on miniature samples. **Bay 11**

Dr. A. Lovecy (*Extn.* 302)

28 **Gas kinetics research** **L153 Annexe**

Gas phase reactions involving alkyl and alkoxyl radicals and nitrogen oxides are of importance in the combustion and stability of explosives and propellants.

A number of such reactions are described, and the necessary experimental techniques demonstrated.

Dr. L. Phillips (*Extn.* 276)

Chemistry and Analysis (contd.)

Group F
North Site (map p. 22)

The Establishment offers advice to designers and manufacturers of weapons on problems arising from the stability and compatibility of explosives and propellants with materials. Although well-established techniques are used to investigate these problems the work is complicated by the introduction of many new products (e.g. polymers, plastics, adhesives, varnishes and paints), each of which must be assessed.

Results of this work are made available to a Working Group on Compatibility and Stability Testing.

Chemical and instrumental analysis features prominently in many aspects of the Establishment's work. In order to make the most effective use of new techniques and modern instrumentation a large proportion of the analytical tasks is undertaken by centralized laboratories, specializing in the development and application of physical methods of analysis.

The laboratories provide an analytical service for those parts of the Establishment which do not have direct access to these techniques, and maintain continuous research efforts in fields such as chromatography, spectroscopy, crystallography, and thermochemical and microanalysis. Some of our current interests are highlighted in the Group F exhibits.

29 **Propellants and explosives: Analysis, compatibility and stability** **L145 Annexe**

This exhibit illustrates the Establishment's responsibility for ensuring adequate stability of explosives in service use, and their compatibility with other materials.

Analytical techniques which will be demonstrated include:

(a) Thin-layer and gas chromatography.

(b) Atomic absorption spectrophotometry.

(c) Polymer fractionation.

Mr. N. J. Blay (*Extn.* 237)

Dr. J. C. Wright (*Extn.* 236)

30 **Instrumental analysis** **L145 Bay 3**

On display are the mass spectrometer, infrared and ultraviolet spectrophotometers, and a multipurpose electroanalytical instrument.

Applications of these instruments to specific problems of identification and analysis are described, particularly in connection with propellant and polymer chemistry.

Dr. R. T. M. Fraser (*Extn.* 490)

31 **X-ray crystallography** **L146 Bay 1**

This exhibit emphasises the value of the X-ray powder method for solving a variety of analytical problems involving the solid state, and illustrates the use of a computer-controlled, automatic diffractometer to collect single-crystal data for structure determination.

Mr. J. R. C. Duke (*Extn.* 305)

Thermal Measurement and Instrumentation

Group G
North Site (map p. 22)

Heat transfer and low temperature research

The Establishment is concerned with the investigation of heat transfer phenomena at thermal and flow conditions characteristic of those occurring in high-energy, liquid propellant rocket engines. This knowledge is an essential prerequisite for the choice and correct design of the cooling system of a rocket thrust chamber.

Equipment on display will include a high-pressure combustion chamber for the study of thermal radiation from high-pressure flames, and two test rigs for experimental investigations of convective heat transfer to specific cooling fluids.

Unique equipment for the measurement of the thermal conductivity of fluids over wide ranges of temperature and pressure has been developed, and a service has been provided to other Government Establishments and industry for precision measurements of this property for technologically important liquids and gases.

Instrumentation services

This Section provides a service on instrumentation. It develops special electronic instruments, many of a complex nature, for the varied purposes of the scientific sections, and provides advisory services, installation and maintenance of instruments generally.

Glass engineering

A service is provided in the design and construction of scientific and engineering glassware, including high vacuum and optical work.

Ballistics and thermochemistry

These laboratories provide the Establishment with experimental ballistic and thermochemical data on solid propellants and their ingredients.

32 **Display of heat transfer equipment and measurement techniques** — **H16 Bay 6 Bay 5 (East)**

The display will include:

(a) High pressure hydrogen/oxygen rocket chamber.
(b) Heat transfer instrumentation.
(c) Convective heat transfer to cryogenic hydrogen.
(d) Visual observation of convection to near-critical kerosine.
(e) The Phillips cryogenerator.
(f) Thermal conductivity of high-pressure gas mixtures.
(g) Thermal conduction in highly compressed fluids (lubricants).

Demonstrations will be given at intervals during the day.

Mr. H. Ziebland (*Extn.* 553)

33 **Instrumentation and electronic equipment** — **H16 Bay 5 (West) Bay 4 Bay 3 (East)**

An exhibition of some electronic instruments, developed for particular purposes; and of instrument maintenance work. Items include the ERDE-fender, invented and developed in the Establishment, with the original prototype, and a method of calibration of transducers.

Mr. D. A. G. Eldridge (*Extn.* 522)

34 **Glass engineering display** — **H16 Bay 2 (West)**

The work of the glass engineering team will be exhibited, and some operations will be demonstrated.

Mr. F. A. Branfield (*Extn.* 349)

35 **Ballistics laboratories** — **H67**

Precision calorimetry systems for propellants, and for heat of combustion determinations.

Burning rate measurements for rocket and gun propellants, including strand burners, closed vessels and automatic recording techniques.

Mr. G. W. Stocks (*Extn.* 291)

Library Area Exhibits

Group H
North Site (map p. 22)

Historical collection

The Historical Collection is displayed in a permanent museum occupying two rooms of the ground floor of Walton House, one of the oldest buildings in the Establishment. The Collection, based upon original documents or copies of material held at the Public Record Office and the British Museum, follows the history of the site through four centuries.

Safety section

This Section is responsible for advice on the safe conduct of all activities in the Establishment in relation to Factories Acts, Codes of Practice and Explosives Regulations, including safety training of new staff; safe disposal of surplus explosives, radioactive and other hazardous materials; training of first aid personnel; control of the Fire Brigade; preparation of explosives' Safety Certificates.

Engineering branch

The Engineering Branch provides a support service for the design, fabrication, installation and maintenance of unique chemical engineering facilities including remotely controlled processing plants; laboratory rigs, equipment and fixtures; control and recording instrumentation systems.

Craftsman training can be provided generally for experimental workshop machinists and fitters, millwrights, electrician/electronic craftsmen and occasionally for chemical plumbers and carpenters.

36 **Four centuries of history** **A200**

The exhibits include:

A letter concerning supply of gunpowder ingredients 1561

A description of the mills 1662

An illustration of the mills 1735

John Walton's sundial ca. 1787

A portrait of Lt. General Sir William Congreve ca. 1810

An illustrated treatise on gunpowder manufacture 1830

Mr. M. McLaren (*Extn.* 256)

37 **Safety in ERDE** **A200**

A range of equipment is displayed to illustrate some aspects of the Section's work.

(a) Personal protection against toxic and corrosive chemicals, explosion and noise.

(b) Monitors for toxic and radio-active environments.

(c) Fire-fighting and first-aid training.

(d) Non-slip flooring materials.

Mr. J. V. Griffiths (*Extn.* 229)

38 **Work of ERDE craft apprentices** **Library**

Models and equipment made by the Establishment's Craft Apprentices are displayed.

Mr. S. J. Lowdell (*Extn.* 249)

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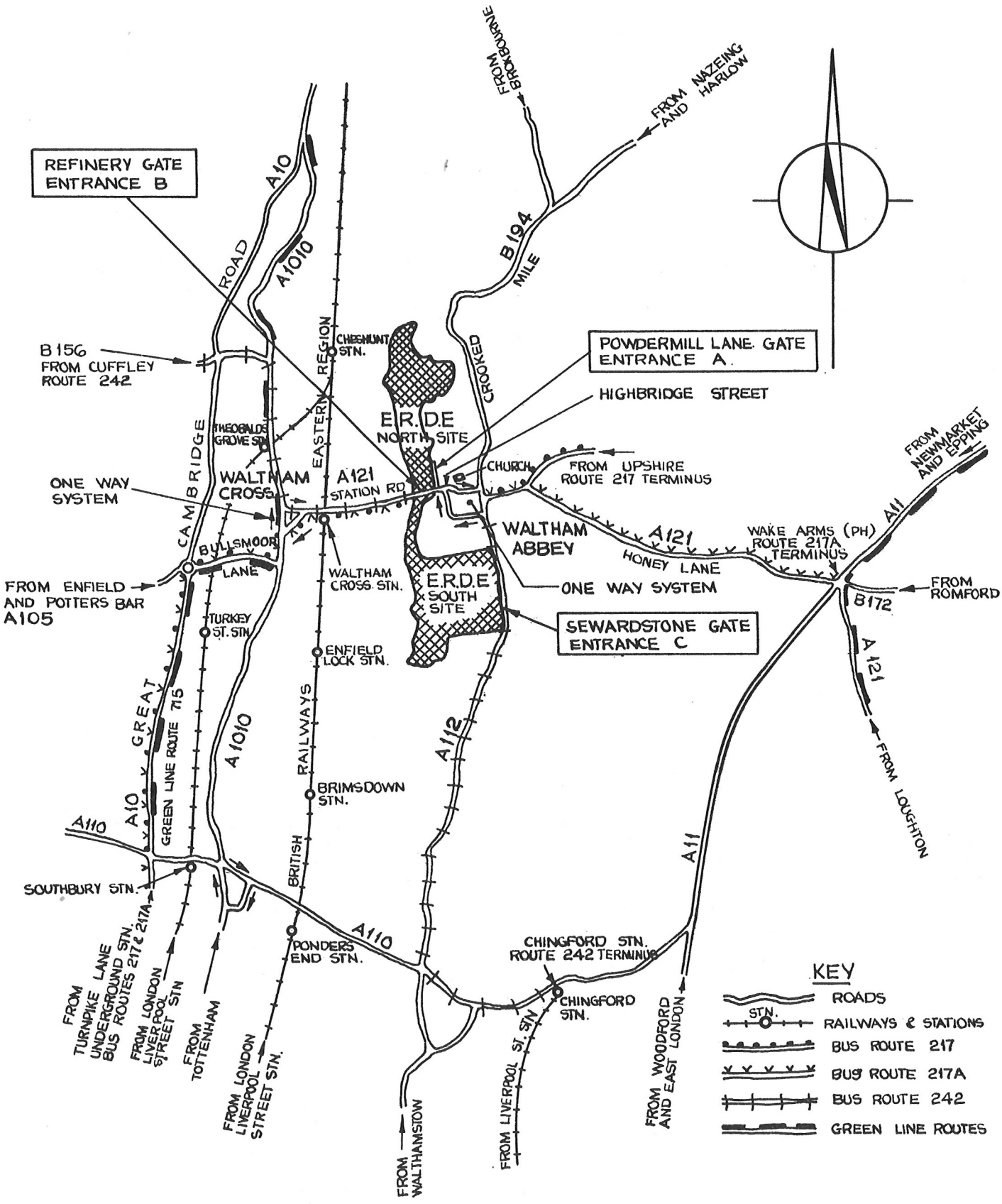

ACCESS TO E.R.D.E., WALTHAM ABBEY ESSEX.

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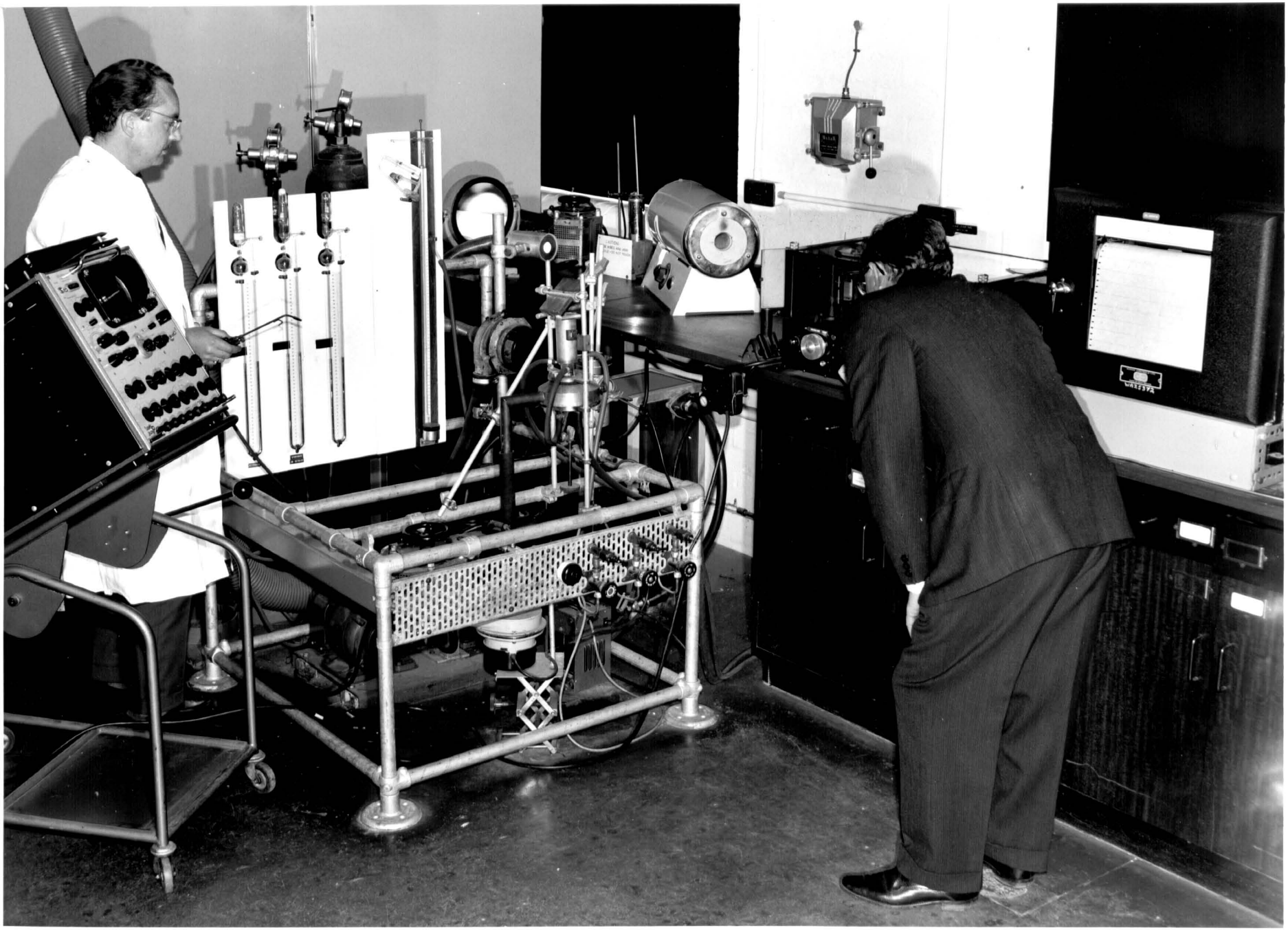

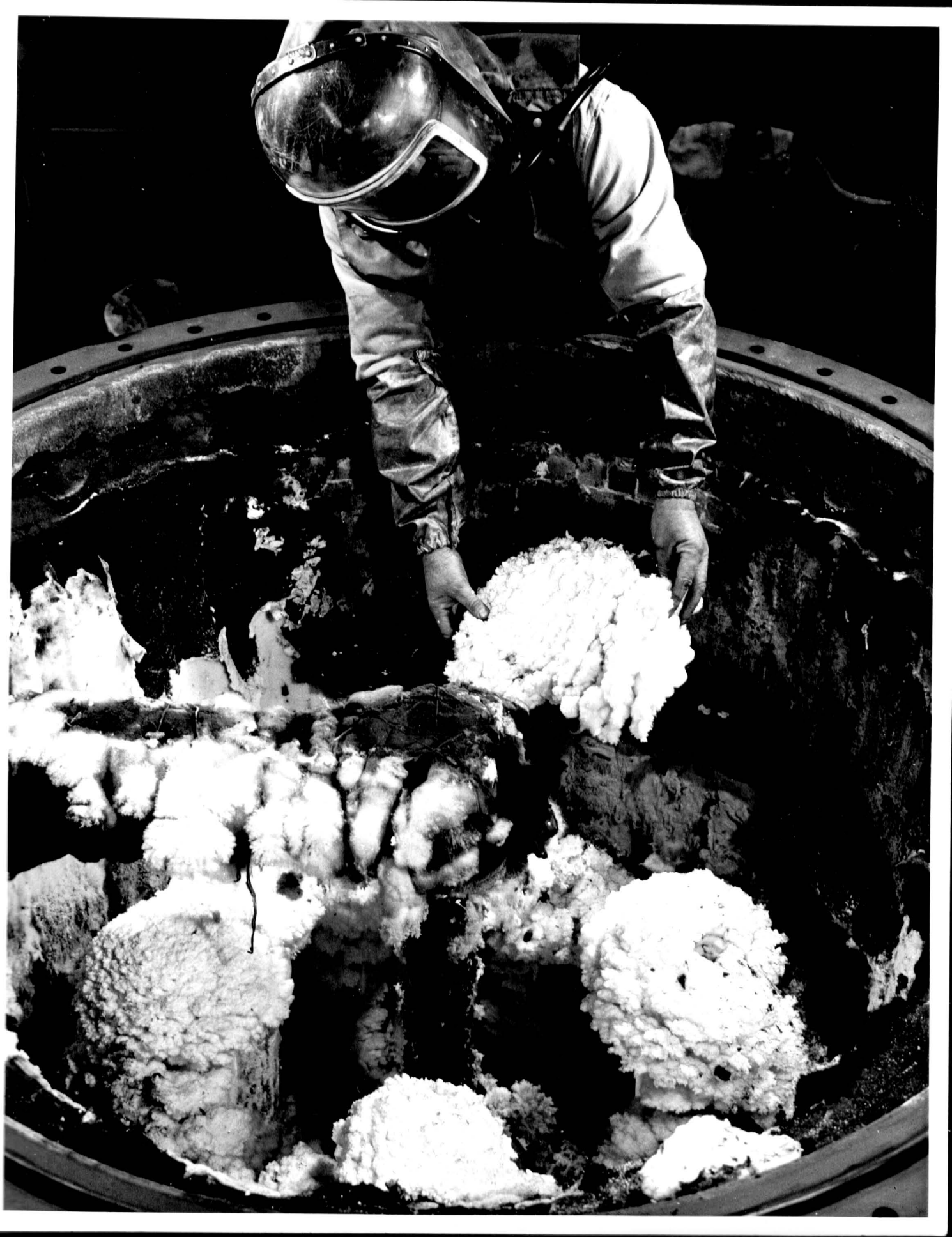

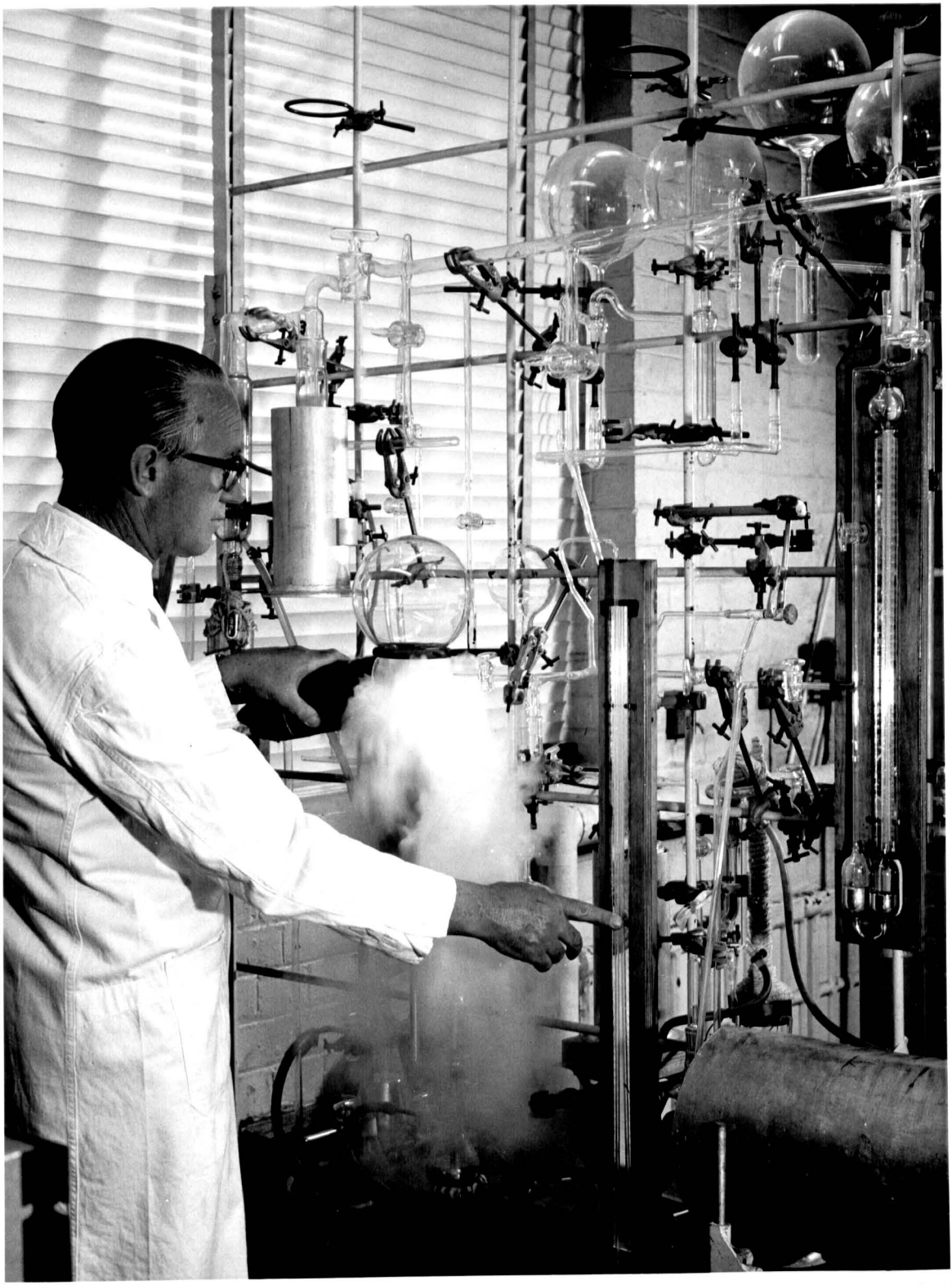

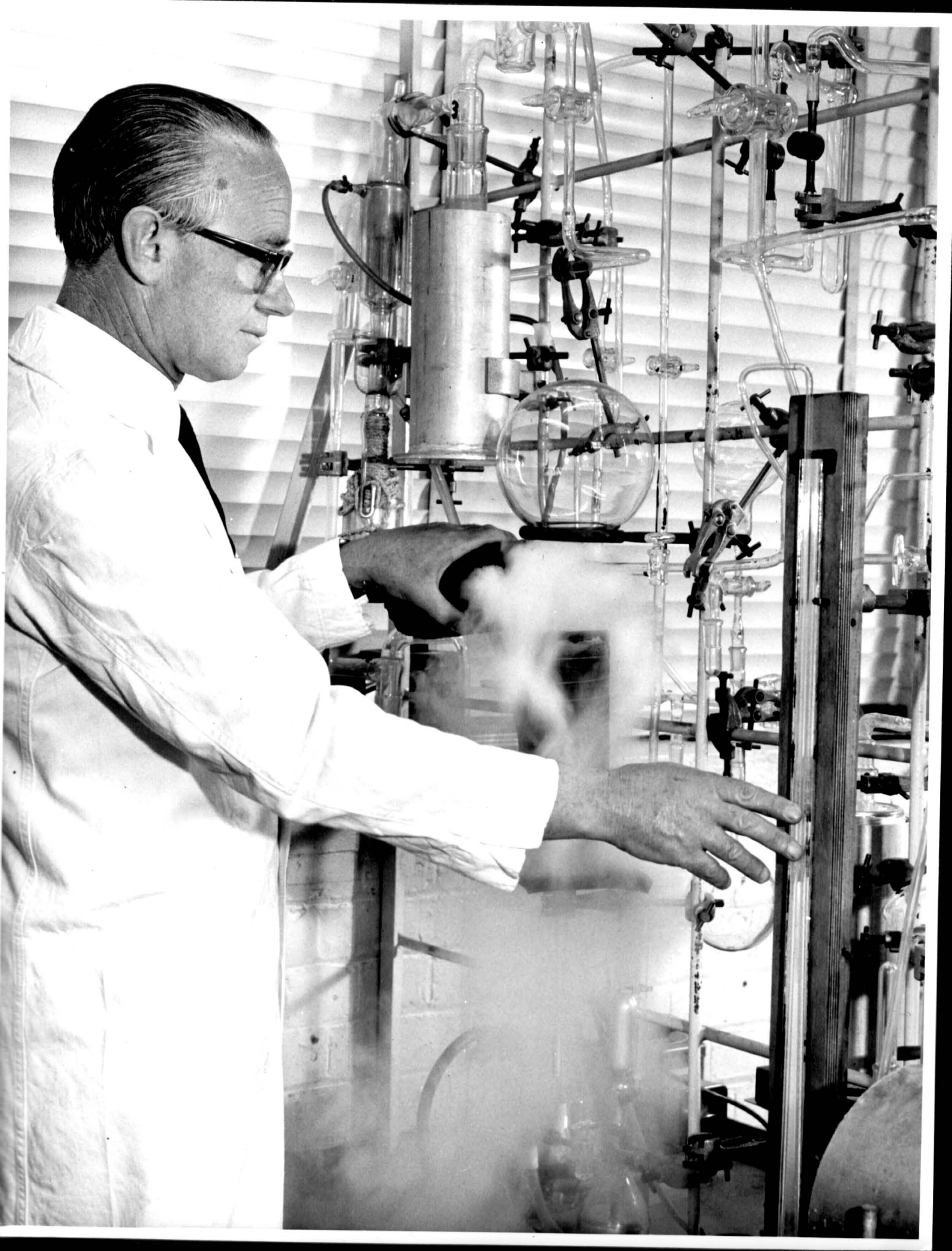

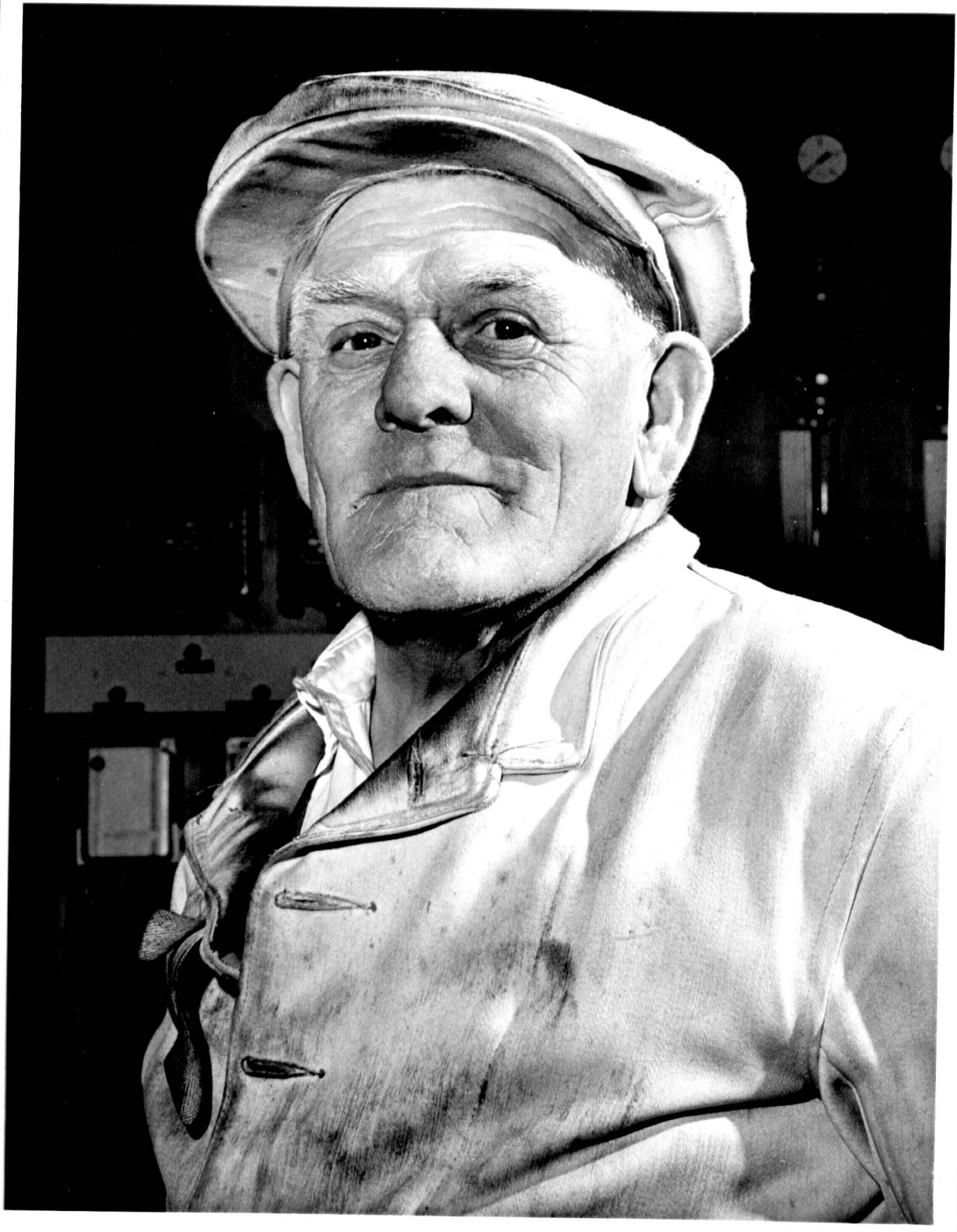

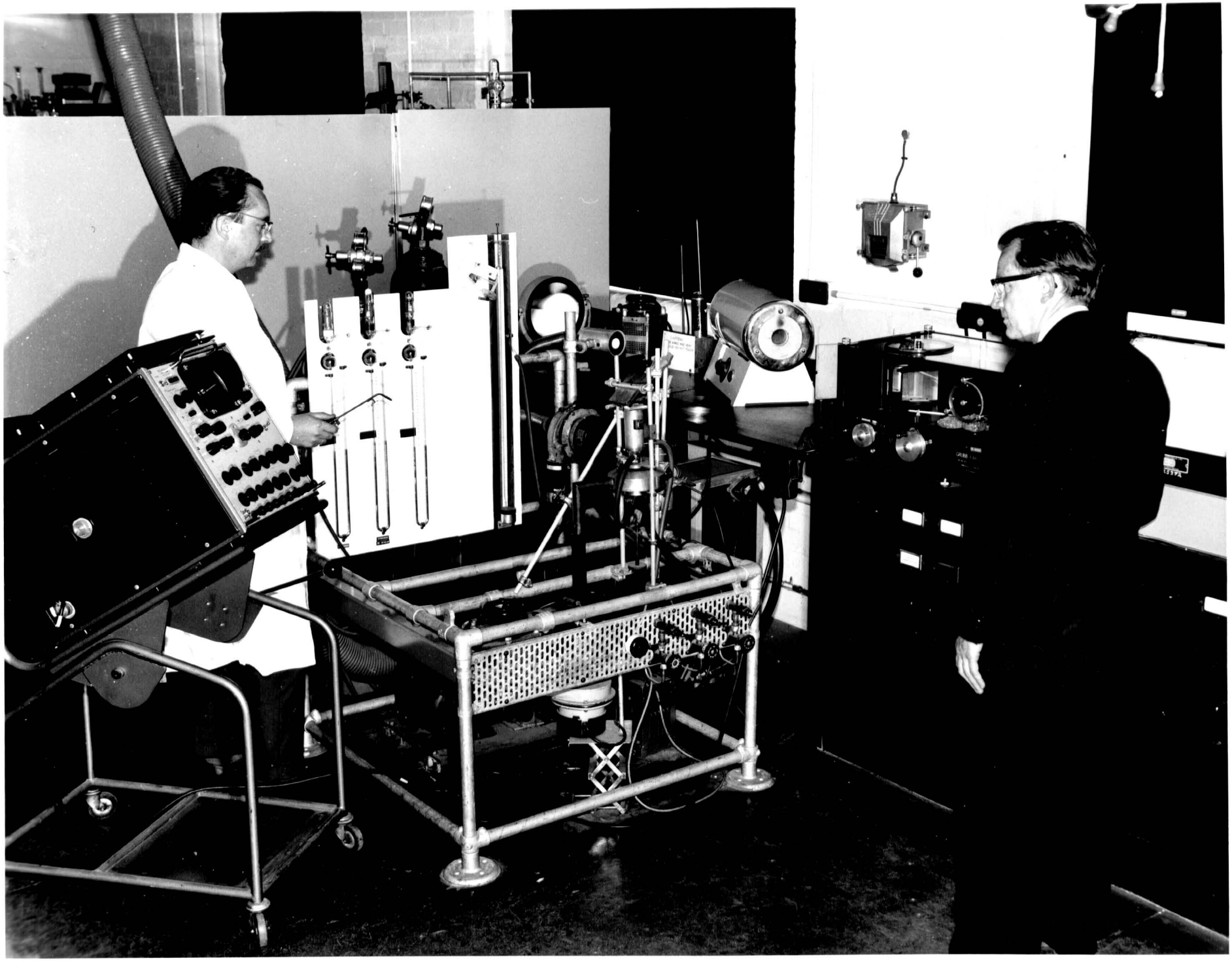

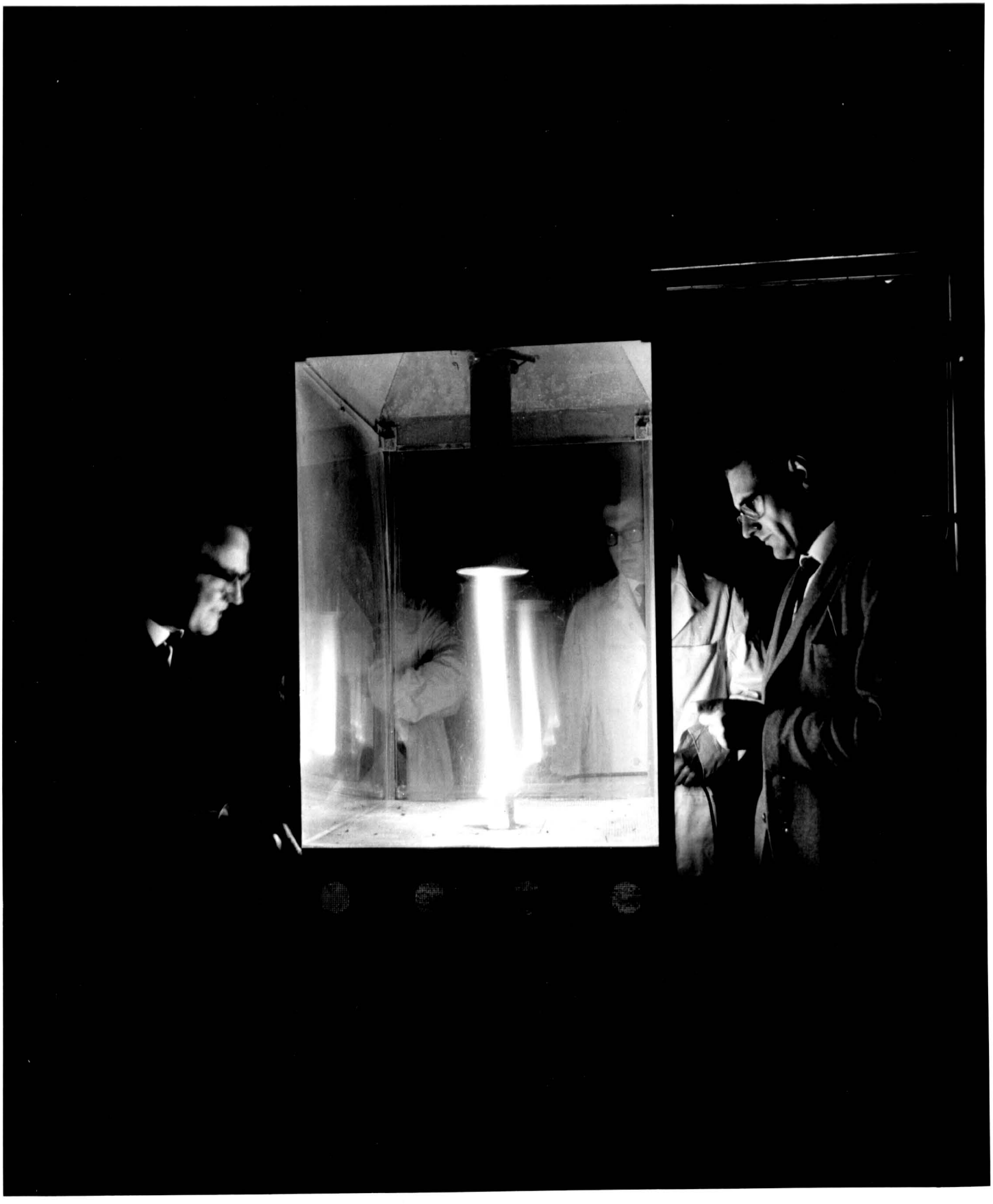


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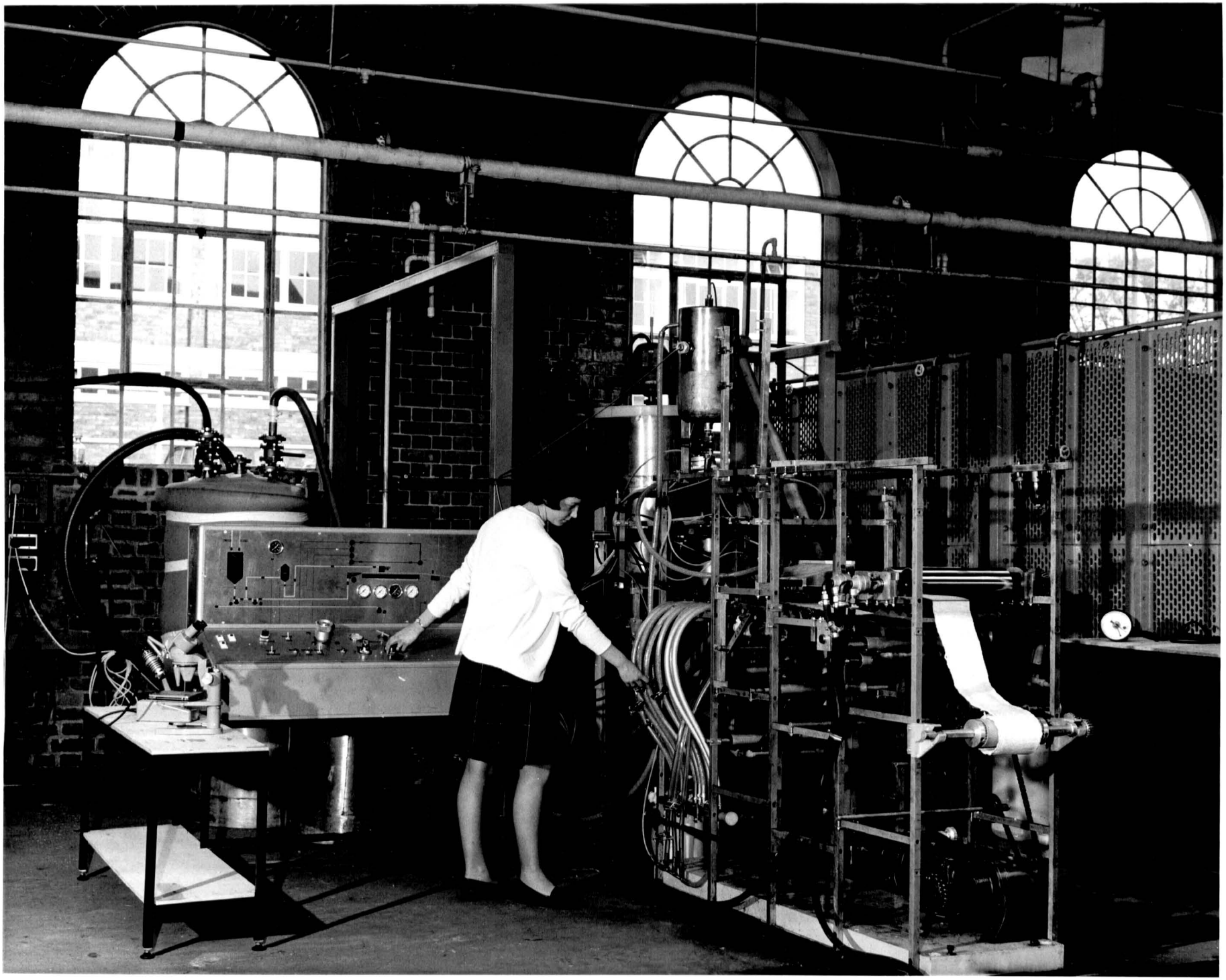

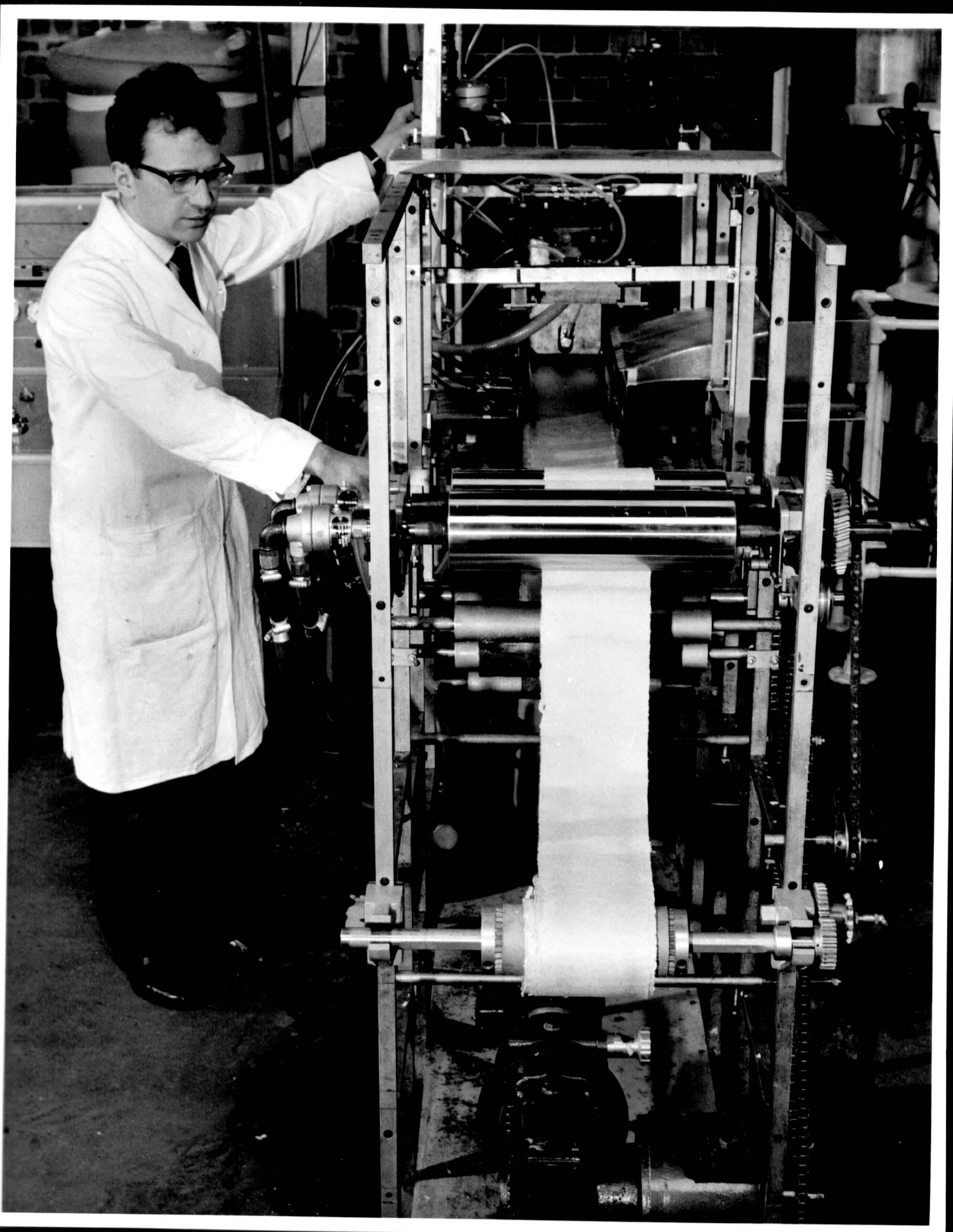


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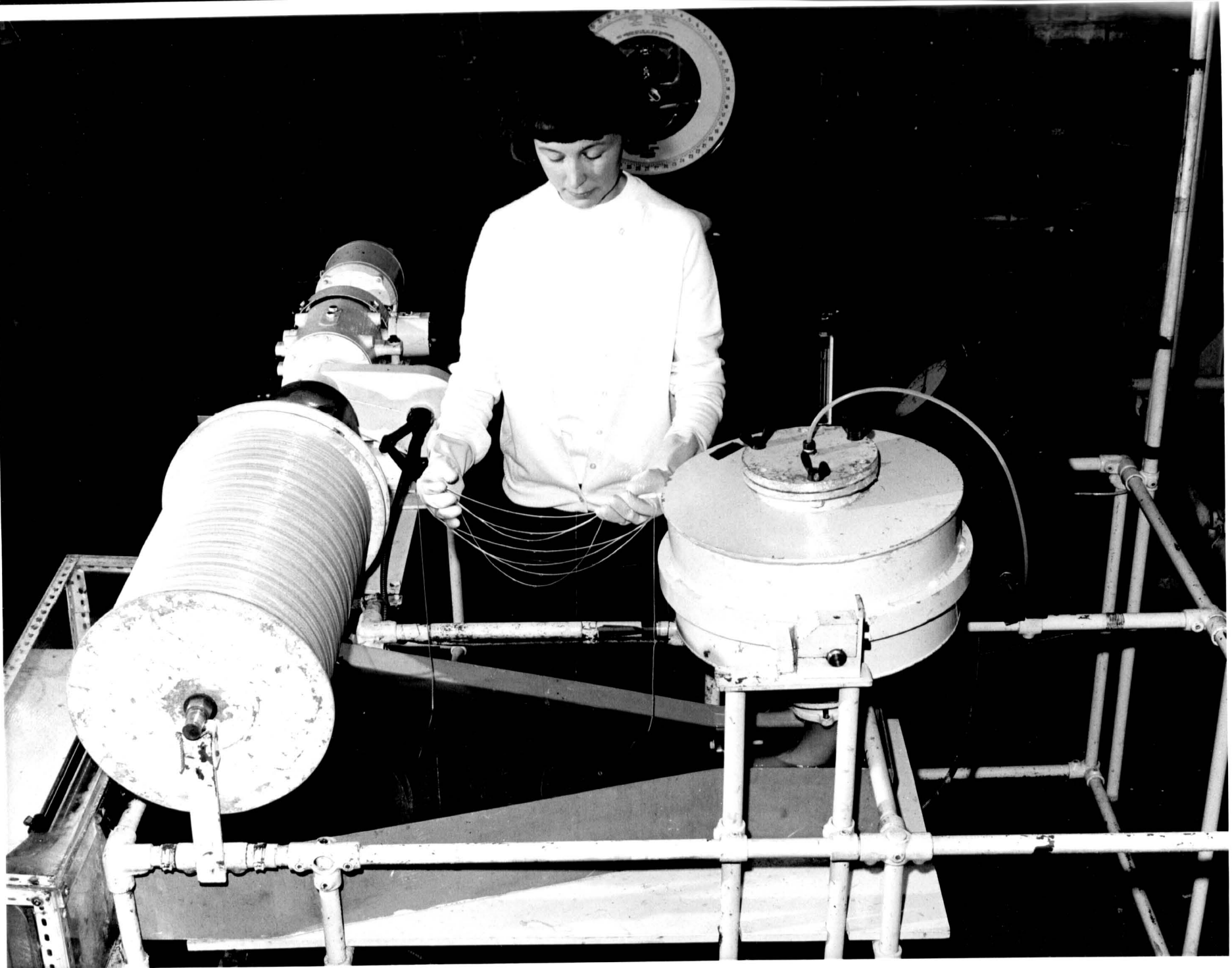


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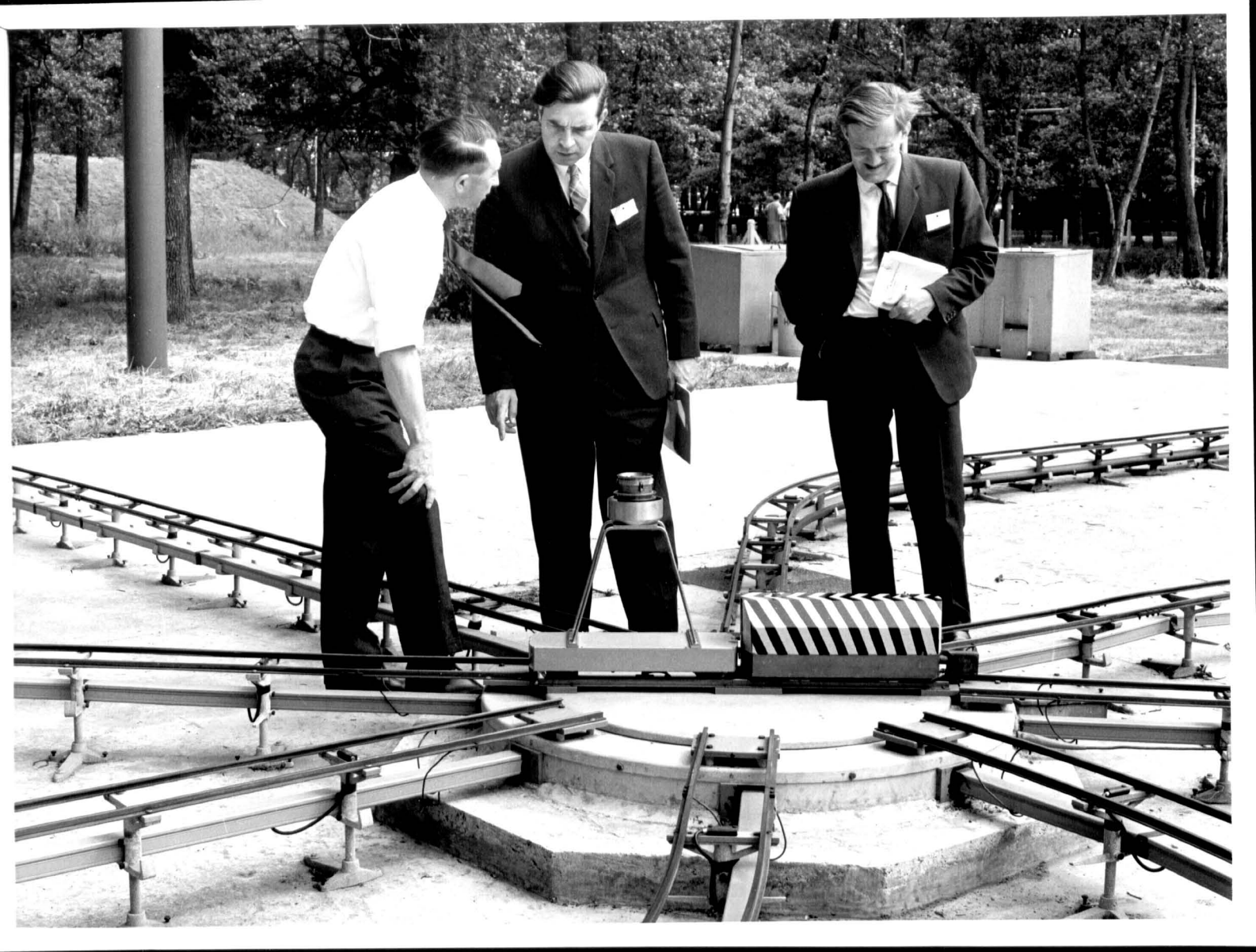

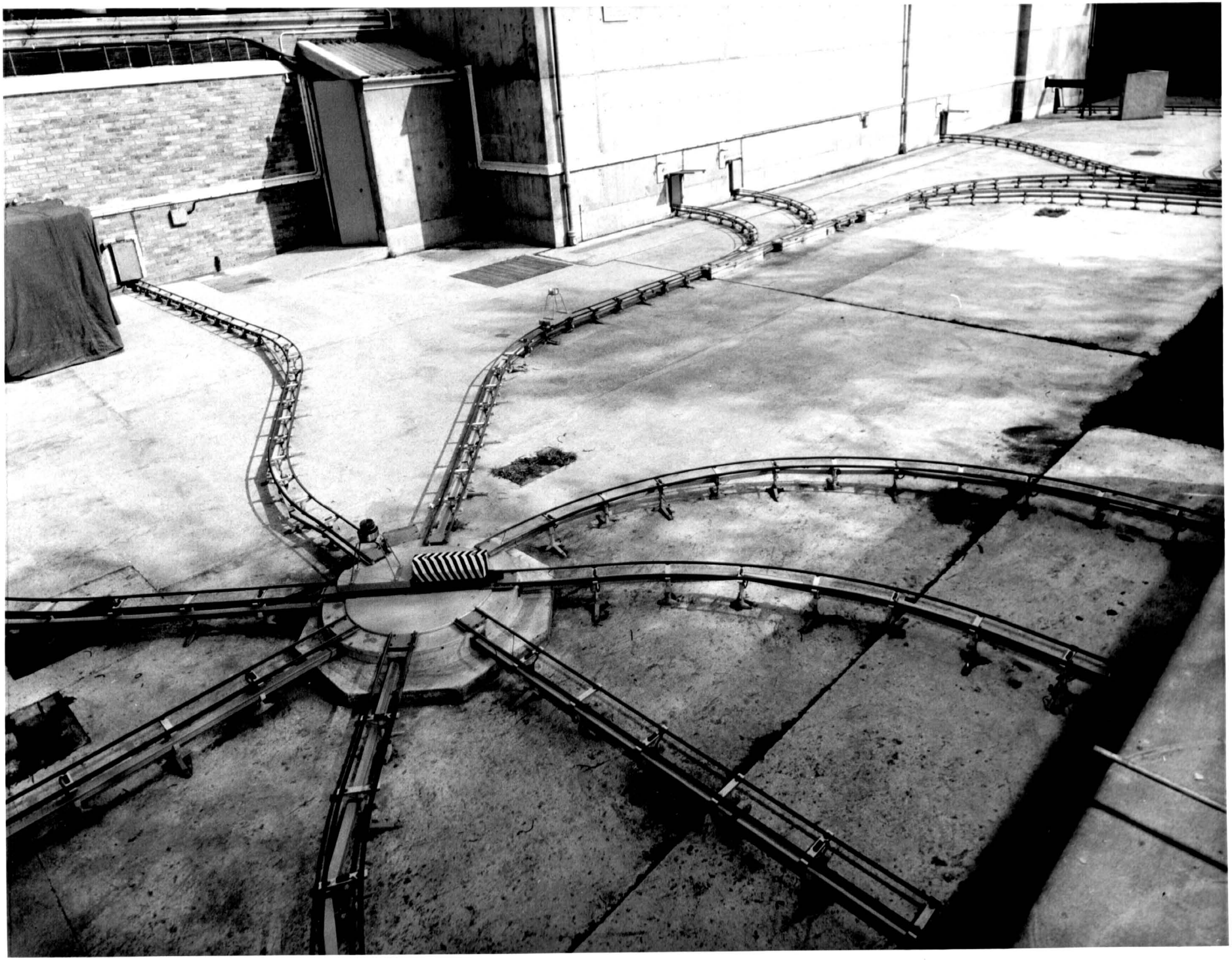

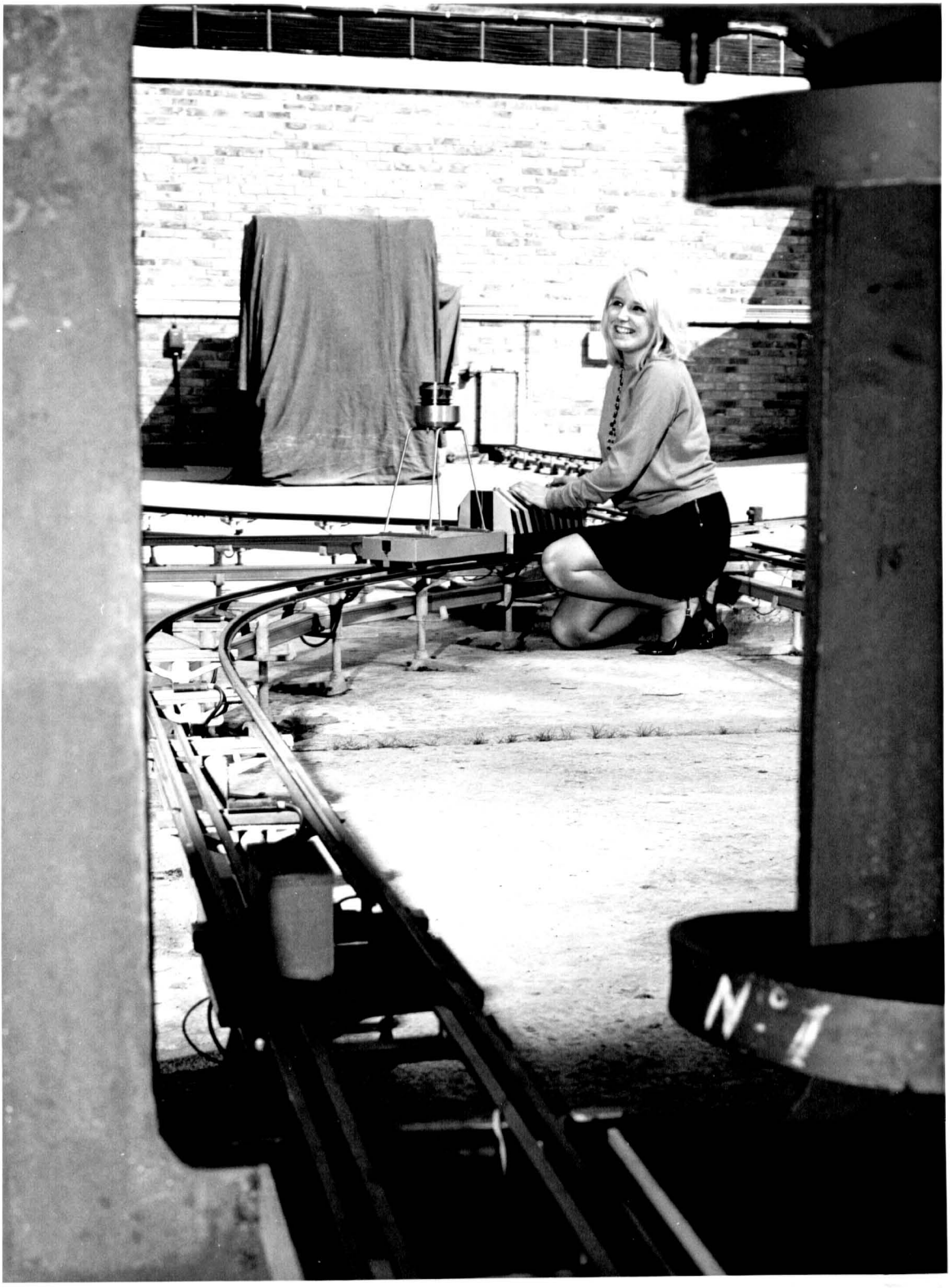
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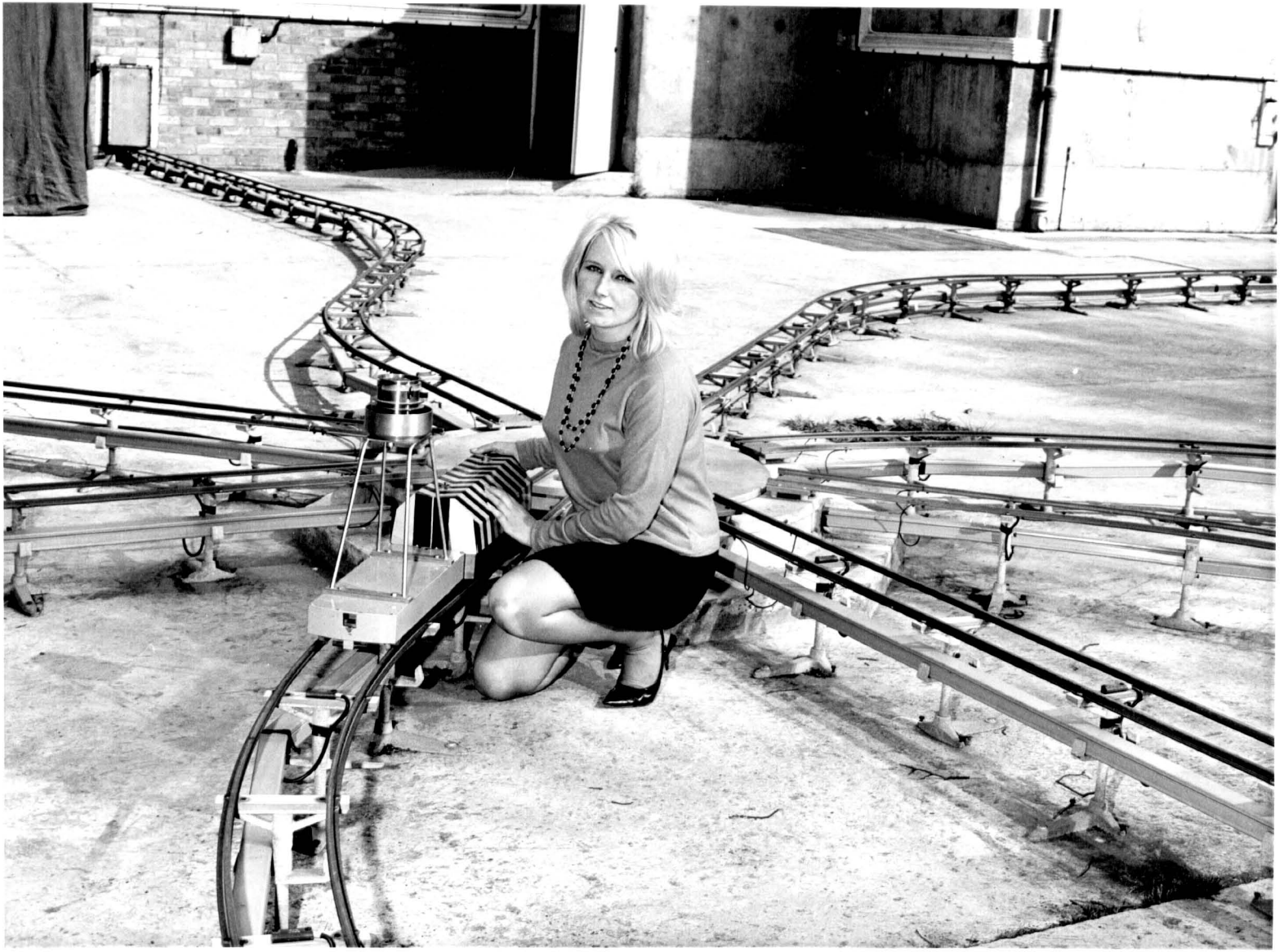


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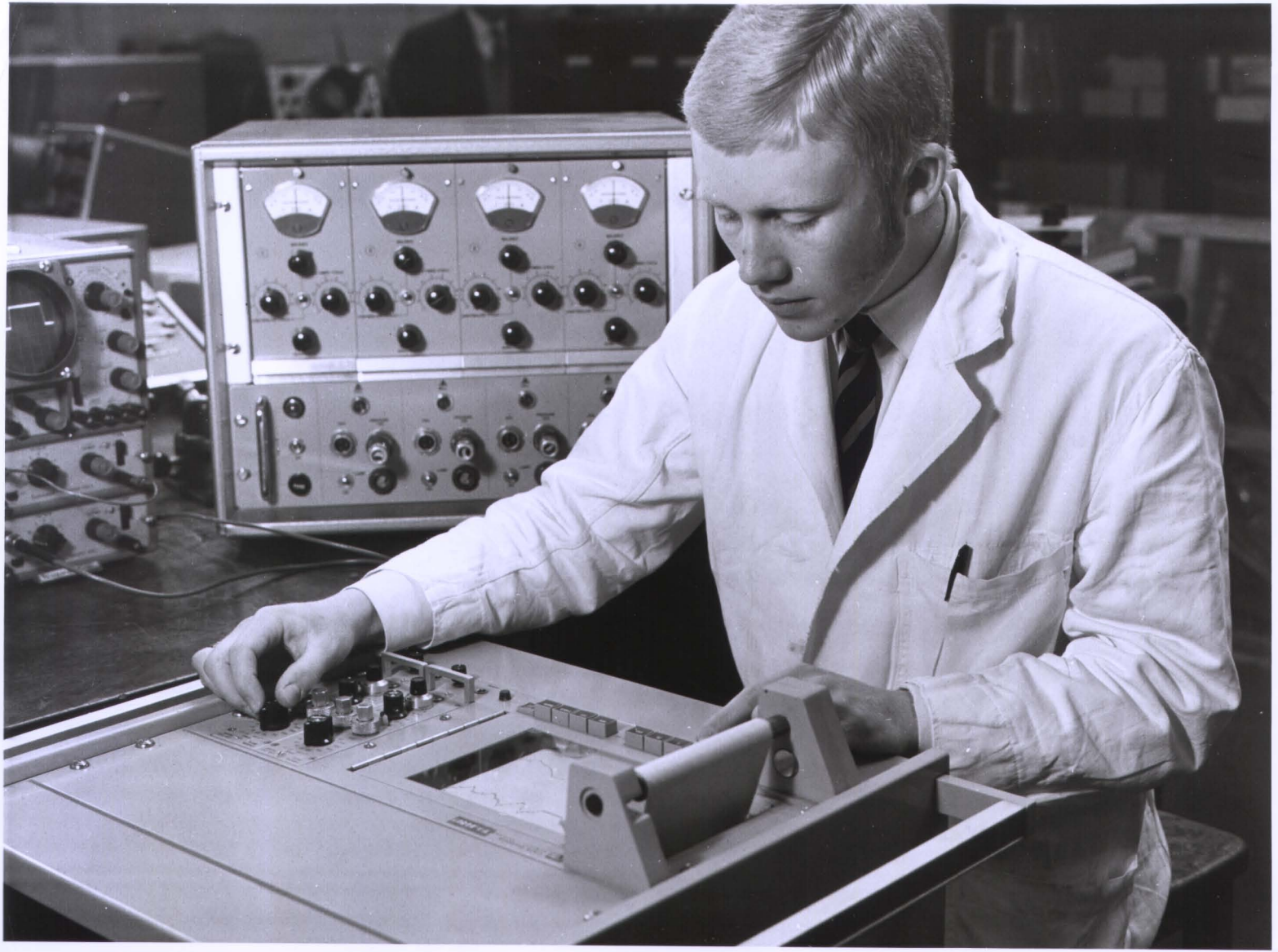

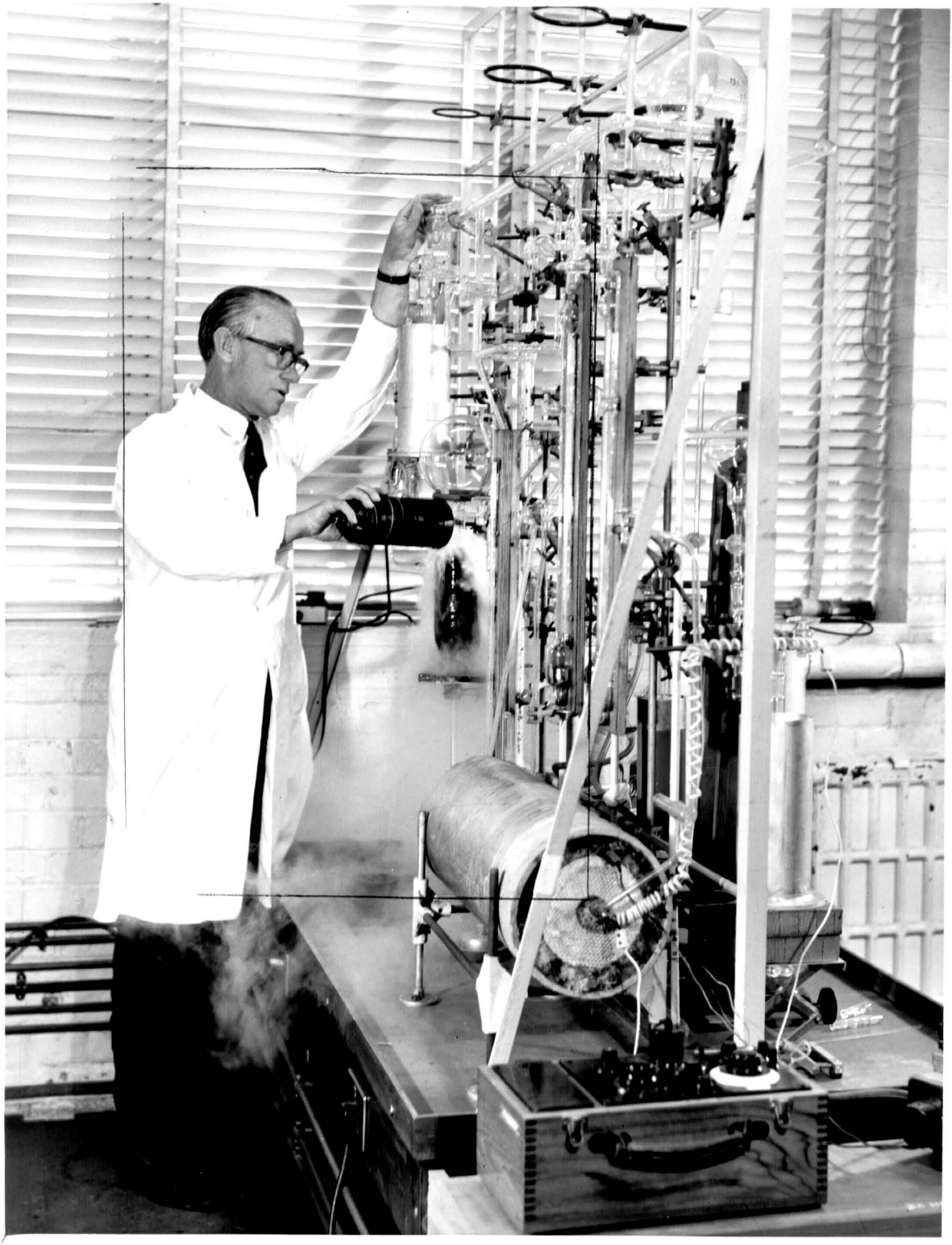

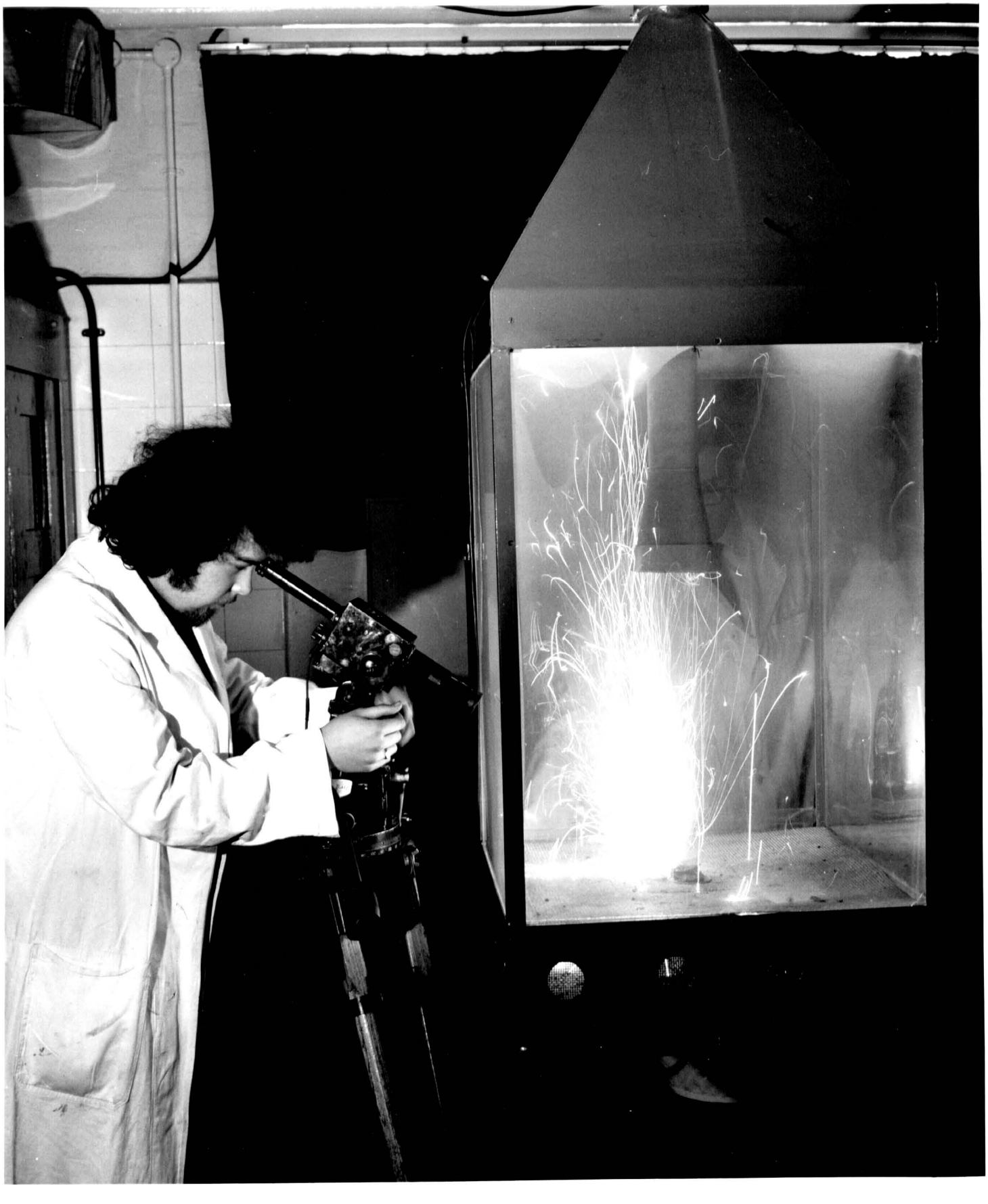

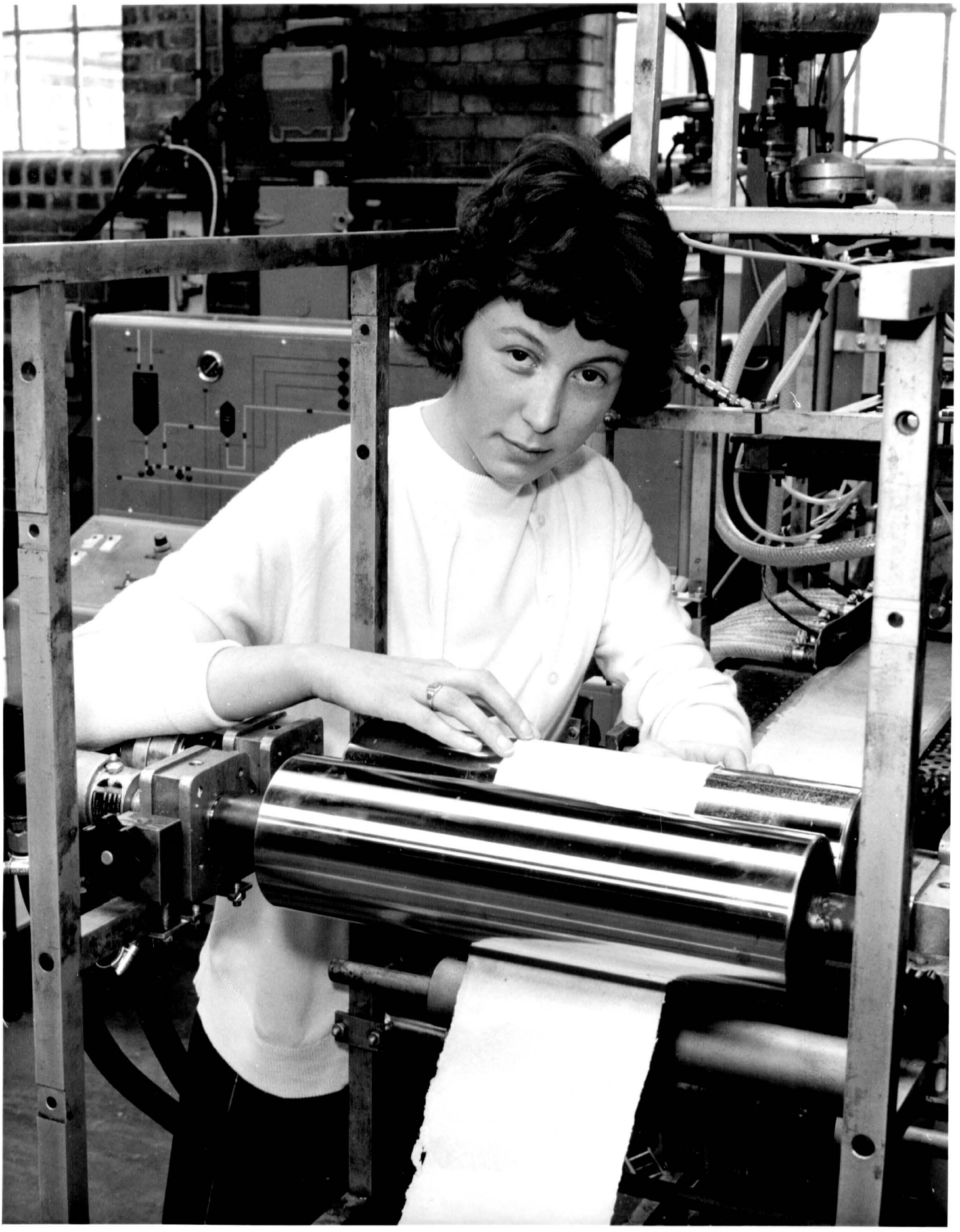

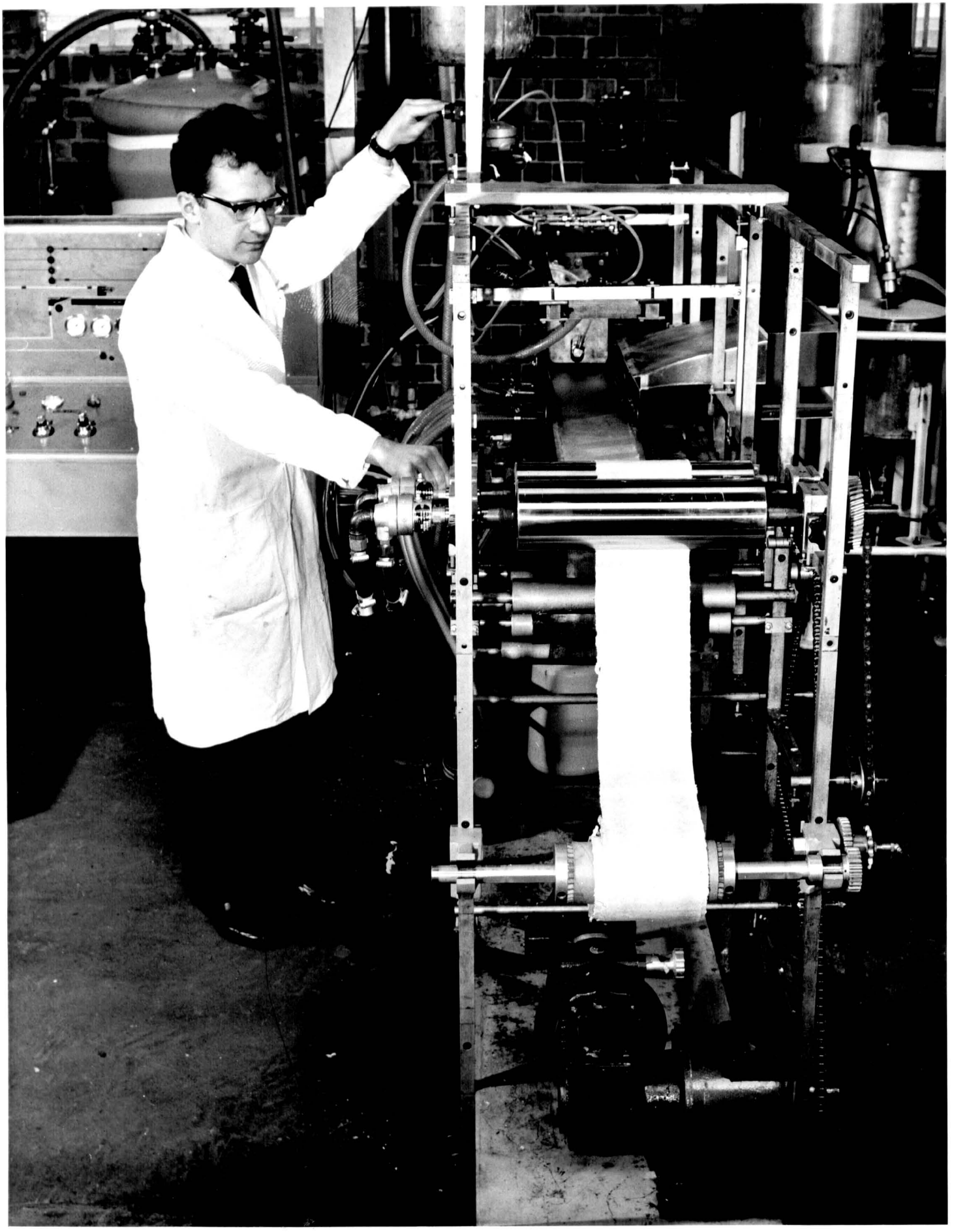

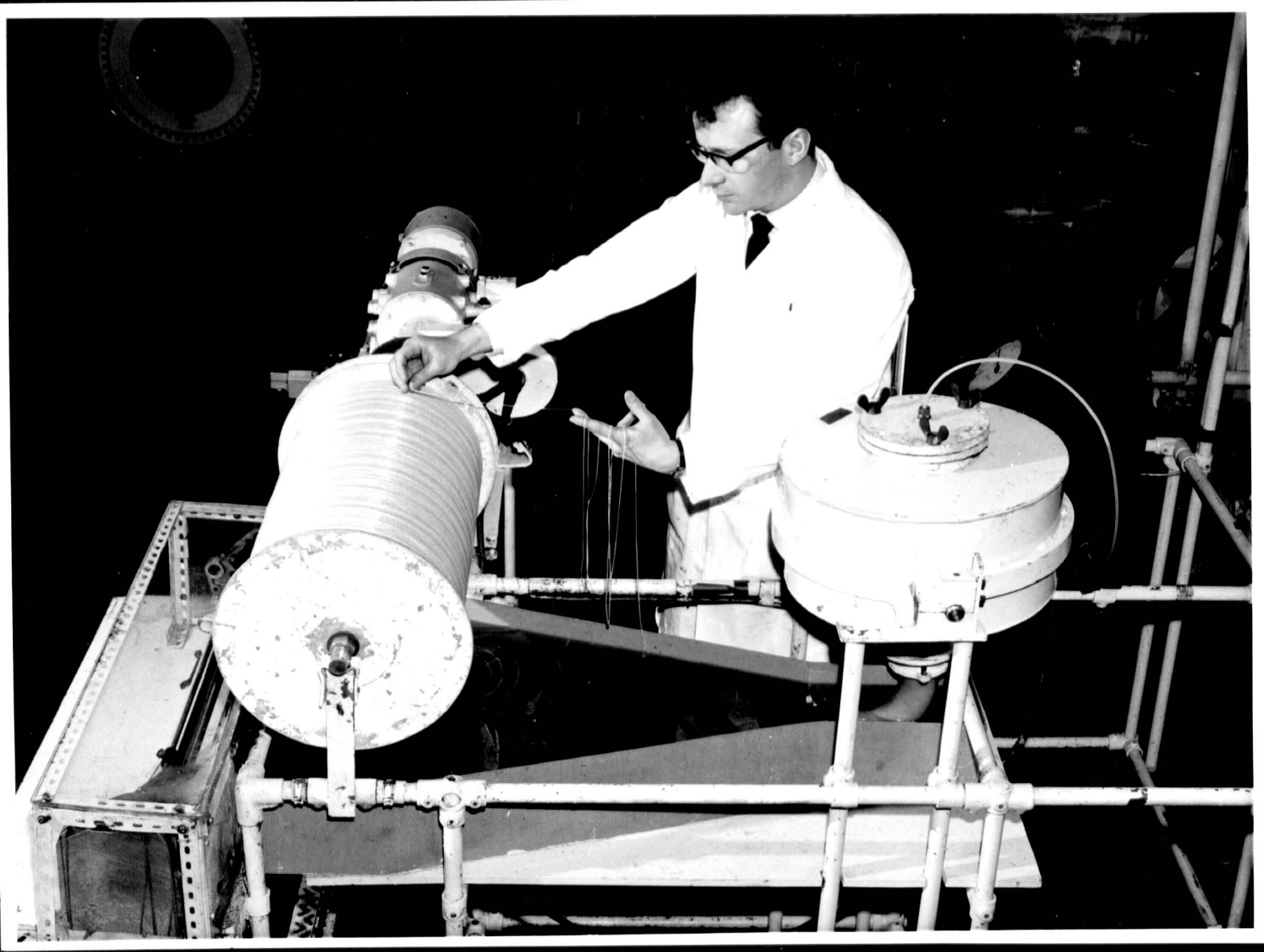


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