UNIVERSITY OF STRATHCLYDE

THE ELECTRONIC IMAGING OF BAIRD TELEVISION

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In fulfilment of the requirements for the degree of
Doctor of Philosophy (Part-Time)

April 2000

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Declaration

This dissertation is submitted in fulfilment of the requirements for the degree of Doctor of Philosophy (Part-Time) in the Department of Information Science, Strathclyde Business School.

I declare that in accordance with University Regulation 20.1.20, this dissertation embodies the results of my own work and that it has been composed by myself. Following normal academic conventions, I have made due acknowledgement to the work of others.

Signature: Dougl Brown

Date: 18/8/00

ABSTRACT

The work of this research identifies the electronic imaging developments of the Baird Television company during the decade from 1933 -1943. John Logie Baird was the pacemaker for the development of the infant television, founded the first British and German television company, and became the catalyst for further development by the wider industry. It will be shown that the engineers and scientists guided and promoted by the Baird Company became eminent in the television industry, and made significant contributions to the evolution of modern television and imaging systems.

It is often stated that Dr Vladimir A. Zworykin of 'Westinghouse' and later of the Radio Corporation of America (RCA) invented the iconoscope television camera, but it is seldom acknowledged that Philo Taylor Farnsworth demonstrated the first working electronic television camera, the image dissector. This innovative device made possible military night vision apparatus, image intensifiers, image converter tubes, the first scanning electron microscopes and image tubes for astronomy. A portable television camera with an imaging stage based on this device was used on the Apollo 11 mission in July 1969 to relay television pictures from the surface of the Moon. [1]

Contrary to the popular belief that Baird was limited to mechanical expertise, Baird Television produced advanced electronic vacuum devices from as early as 1934. It will be shown that Baird Television manufactured a derivative of the Farnsworth image dissector known as the Baird electron camera, and later produced Baird iconoscope tubes and cameras.

1 Farnsworth, E. G. : Distant Vision: Romance and Discovery on an Invisible Frontier. Salt Lake City, Utah. Pemberlykent. 1990. pp. 327-328.

This research will show that Dr Sommer, a physicist at Baird Television, invented the most sensitive photocathode material available anywhere just before the Second World War. This major contribution later enabled the success of the RCA image orthicon, and subsequently electronic colour television. It will be shown that Baird Television had the expertise to produce and demonstrate a single-stage, direct-view, image converter tube in 1936. From 1937 the Baird Company asserted a leading position by demonstrating projection cathode-ray tubes designed to bring large-screen television to the cinema. Cinema Television was formed by Isidore Ostrer as a subsidiary of Gaumont British in 1937 which then held most of the stock of Baird Television, in effect it was Baird Television.

Under a scheme sanctioned by the Court on the 17 December 1940 the undertakings and assets of Baird Television were acquired by Cinema Television to become a subsidiary of Gaumont British, 'Cinema Television Ltd (Incorporating Baird Television). [2] The take over included some of the key technical people from the old Baird Company but they were quite unaware of any change. Although effectively the Baird Company officially ceased trading after it went into receivership in November 1939, the closed files on the Baird Television Company at the Public Records Office, London, [3] show that it legally remained in existence until the completion of the winding up of the first Baird Company, Television Ltd. This had been voluntarily wound up on 9 September 1930, and although deemed dissolved, was not finalised until 28 February 1942, by which time all sundry patents and assets were transferred to Baird Television Ltd. Hence the

[2] Register of Defunct Companies. London. Macmillan Publishers Ltd under license for International Stock Exchange. 1990.

[3] Television Ltd. Closed records of the company. London: Kew. Public Records Office. Call number 206588.

reason for Cinema Television carrying the title (Incorporating Baird Television) during the war years. Although the name 'Baird Company' is used by the work of this research and its sources to describe the war activities of Cinema Television from 1940, the name is used only in this loose sense.

The personal diaries and memoirs of G. A. R. Tomes, a former Baird Television engineer, have supported the work of this research. These important sources assist in clarifying the Baird Company's electronic imaging contributions in the field of electronic camera tubes, projection tubes, photocells and radar tubes as part of the national effort during the Second World War. The 'Tomes diaries' were cross validated by original Baird Television documents, photographs, notebooks and memoirs supplied by the late Dr Szegho another former Baird employee.

This research has located original Baird hardware including a cold cathode-ray tube (circa 1933) incorporating a Szegho-cathode configuration, Baird Company photo-cells, a Baird demonstration paddle-wheel television cathode-ray tube and a Skiatron radar tube. This research is supported with Baird company photographs (circa 1939 -1940) illustrating key Baird technologies, Baird products and the sophisticated apparatus of the Baird facilities.

The above, together with Baird brochures, company documents and patent applications assist in presenting, for the first time ever, a balanced account of the electronic imaging technology of Baird Television.

Acknowledgements

This research would not have been possible without the support and encouragement from my wife Susan and our daughter Louise. I am also very grateful to the following people: Gilbert Tomes who supplied first-hand knowledge of the Baird Company in the form of personal diaries which are in preparation for future publication. I would also like to thank the Baird family for releasing copies of John Logie Baird's personal diaries from 1940 to 1946.

I am particularly indebted to the late Dr Constantin Stephen Szegho (1905-1995) who kindly supplied a large quantity of physical Baird source material and invited me to interview him at his home in Chicago in 1991. Thanks also to: Dave McKay (General Manager, JVC); Dr A. H. Sommer, (Veteran Baird Company physicist (1936-1939) for first hand information about J. L. Baird, Baird Television, EMI and RCA; Forbes Gibb (Information Science, University of Strathclyde) Professor Simon Fraser and Dr Peter Waddell (Mechanical Engineering, University of Strathclyde) for reading, appraising and steering this work.

Finally I would like to mention Charles Brown, Elisabeth Szegho, Robert and Jill Allan, Jimmy Logan, Ray Herbert, Professor Tom Maver, Ann Morrow, Helen Thomson (Lena Martell), John Cran, Jan Leman, Michael Bennett-Levy, Samuel Kaplan, Adolph Schmidt, Colin McCallum, Kenneth McDonald, Tom McArthur and the 'Baird Foundation' for their interest and continued support.

The Electronic Imaging of Baird Television

CONTENTS

New Research Criteria

Prior television research carried out by this author [1] in fulfilment for the degree of Master of Philosophy, entitled, "The Contributions of John Logie Baird to Television and Related Technologies," April 1997, assessed the work of J. L. Baird from the realisation of low definition mechanical television to the development of higher definition, colour and three dimensional television in the mid nineteen forties. The purpose of this new and distinctly different sphere of research is to establish the electronic work carried out by the Baird Television Company in contrast to the separate research conducted by J. L. Baird. This work is based on recently acquired Baird company sources including internal company documents and a set of professional photographs commissioned by Baird Television circa 1939, plus newly discovered examples of early television apparatus. The work of this research will also assess the expertise and technology of Baird's industry with the assistance of diaries and memoirs from late and surviving former employees of the Baird Company.

A substantial quantity of evidence has been located which indicates that the Baird Company made a significant contribution to advanced electronic imaging research from as early as 1934. There is no complete or published account by the scientists and engineers who pioneered this leading-edge work, many of whom have since died in relative obscurity. It is therefore the purpose of this research to produce an authentic and verifiable account of the electronic imaging work of Baird Television.

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1. Brown, D. The Contribution of John Logie Baird to Television and Related Technologies. MPhil. Thesis. Glasgow . Department of Information Science. University of Strathclyde. 1997.

This research has located three main contributors. In the USA: Dr Sommer and the late Dr Szegho, both electronic television pioneers of particular merit in the development of vacuum physics at Baird Television. The third contributor from England, Gilbert Tomes, kept daily diary entries of electronic work at Baird Television. Further to this, material from the British Patent Office, items of published work by Sommer and Szegho, letters, and Baird source material will be presented and supported by other sources. These together with photographs, news scrap books and other items, formerly the property of the Baird Company, will assist in building up a substantial account describing the electronic imaging of Baird Television 1933 -1943. In the event of information conflicting, sources were examined in detail and arguments presented to analyse and establish the correct order of events. Where difficulty was encountered conflicting information was disregarded unless verified by a further source.

The late Dr Szegho who was enthusiastic in producing audio recordings of his memoirs for this research made available to the author large quantities of original Baird documents, photographs and hardware. As a leading designer of cathode-ray tubes, Szegho's work was initially pivotal to the development of the first Baird cathode-ray tubes. His work extended to the development of cathode-ray tubes for projecting television images on large theatre screens prior to the Second World War.

Dr Sommer, who is now living in a Massachusetts retirement village, kindly replied to the author's many searching questions over a two year period, during which time Sommer described his role in developing specialised photosensitive surfaces for photocells and camera tubes.

Sommer described how he later applied his work at Baird Television to improving the television camera tubes of Marconi-EMI and RCA.

The following section describes briefly the author's motivation in carrying out this research and the methodology applied in gathering together information from these new sources.

Methodology

The author's motivation to trace the history of television began in the late nineteen fifties as a boy of nine years of age determined to discover how pictures appeared on a television screen. Simplistic answers from relatives such as being told that the pictures came down from the aerial by travelling through wires to the set were not very helpful. An uncle, and radio engineer, Alexander Brown offered assistance by demonstrating a television picture on a small green radar screen. There was no cabinet covering this home-made set just a metal frame illuminated by the orange glow from the many amplifying valves. In 1950, in the absence of a television transmitter in Scotland, the elder Brown had been one of the first enthusiasts in Glasgow to receive 405-line television from the BBC transmitter at Sutton-Coldfield in Birmingham, which had opened in December 1949. The author, although not fully appreciative of the process of television, was satisfied that the 'magic in the box' could be explained by science and technology. Alexander Brown introduced the author to the work of John Logie Baird and electro mechanical television by producing a crude working model.

Later the author began a career in electronics in the Department of Electrical Engineering at Glasgow University. At college he was given the opportunity to study television and video as a specialised subject. One very important lesson learned from his late uncle was: "it is easier to understand the future of technology - if you can relate to its past".

During the decade from 1974 to 1984, the author practised as an electronics engineer specialising in the design of environmental control systems and as a quality assurance engineer supporting the semiconductor industry. On joining the staff of the University of Strathclyde in 1985, the author's knowledge and interest in television was called upon in support of the 'John Logie Baird Foundation'. This was a university group involving industrialists who were interested in pursuing a project to raise the profile of the late pioneer of television and Alumni of Strathclyde University.

In 1987, Dr Peter Waddell a senior lecturer in the Mechanical Engineering Department of Strathclyde University, and a leading authority on John Logie Baird, was introduced to the author. Waddell was interested that the author had retrieved 30-line television images from a 78 RPM record (circa 1928) for display on a cathode-ray tube. Waddell called upon the system to be used as a working exhibit in the, "Jam, Socks and Television" exhibition celebrating the life and work of John Logie Baird at the Collins Gallery, University of Strathclyde. This took place in 1988/89 and the exhibition successfully toured British museums and galleries for a further eighteen months.

A public presentation given by Waddell on the history of Baird to the people of Helensburgh encouraged the author to research Baird Company patents and relevant technical journals. A quote from an article in 'Television and Short-Wave World' dated August 1936, which described Baird Company work also defined the starting point for the work of this research: "It is interesting to note that the Baird engineers had evolved a method of making the electron image visible." [1]

1 Editor. "Television and Short-Wave World." London. Bernard Jones Publications. August 1936.

The significance of the above quote which had been overlooked by most television historians for over sixty years, was recognised as an indication that Baird Television may have developed an image convertor tube. This is a device which few engineers could claim to have produced as early as 1936.

Patent records at the Mitchell Library in Glasgow linked the name of Dr Szegho to the image convertor work at the Baird Company laboratories in 1936. Other names located during this primary search included Dr Sommer, Dr Samson, T. M. C. Lance, G. A. R. Tomes and V. A. Jones.

The device identified as an 'image convertor' was contained in an evacuated cylindrical glass envelope, had a photosensitive coating at one end and a fluorescent screen at the other. An optical image projected on the photosensitive coating was converted to an electron equivalent inside the tube, and then by means of electrical fields this was converted to an optical image on a display screen. The image which appeared on the fluorescent screen resembled a high resolution monochrome television picture. Devices of this type were used during the second world war to convert infrared or invisible light to visible light, therefore enabling military personnel to effectively see in virtual darkness.

A simple analogy to illustrate the function of an image tube is to consider a cylindrical bar of lettered rock. Letters in the confection are extruded along the length to produce a few readable words when viewed at one of the ends. The letters which appear inverted at the other end relate to the applied image, the pattern of the extruded letters along the length of the cylinder are analogous to electrons travelling along the image tube, and the readable letters are analogous to a converted visible image on the screen.

Rank Cintel, formerly Cinema Television and originally Baird Television, (now Cintel International) led the author to contact former employees: Herbert, Jones and Lance. Both Lance and Jones indicated that Dr Szegho had worked on the image convertor tube in 1936.

Herbert, who communicates with surviving former Baird employees by producing a regular Baird Newsletter, supplied the author with addresses for Dr Szegho and Dr Sommer in the USA. Szegho confirmed that he had made an image tube at Baird Television in 1936. The author later interviewed Szegho at his home in Chicago in 1991 and continued to correspond until Szegho's demise in 1995.

Dr Sommer also responded to the authors letters in support of the work of this research. G. A. R. Tomes, a former Baird employee who had also worked with Szegho and Sommer, contacted the author through a connection with the late Dr Szegho's widow. Tomes supplied his personal diaries describing imaging work at Baird Television and an interview was held between the author and Tomes at his home in England during the Summer of 1999. The author also visited the burned-out site of the Baird Laboratories at the Crystal Palace. At Bromley Public Library a video recording of a lecture given in Bromley Town Hall by former Baird employees was located and viewed.

Chart 1a describes the flow of methodology 1991 - 1994 showing the origins of this research. Chart 1b describes the further developments 1995 - 1998 which culminated in this research project.

Chart 1a
Origins and Developments of Research
The Electronic Imaging of Baird Television

Methodology
1991-1994

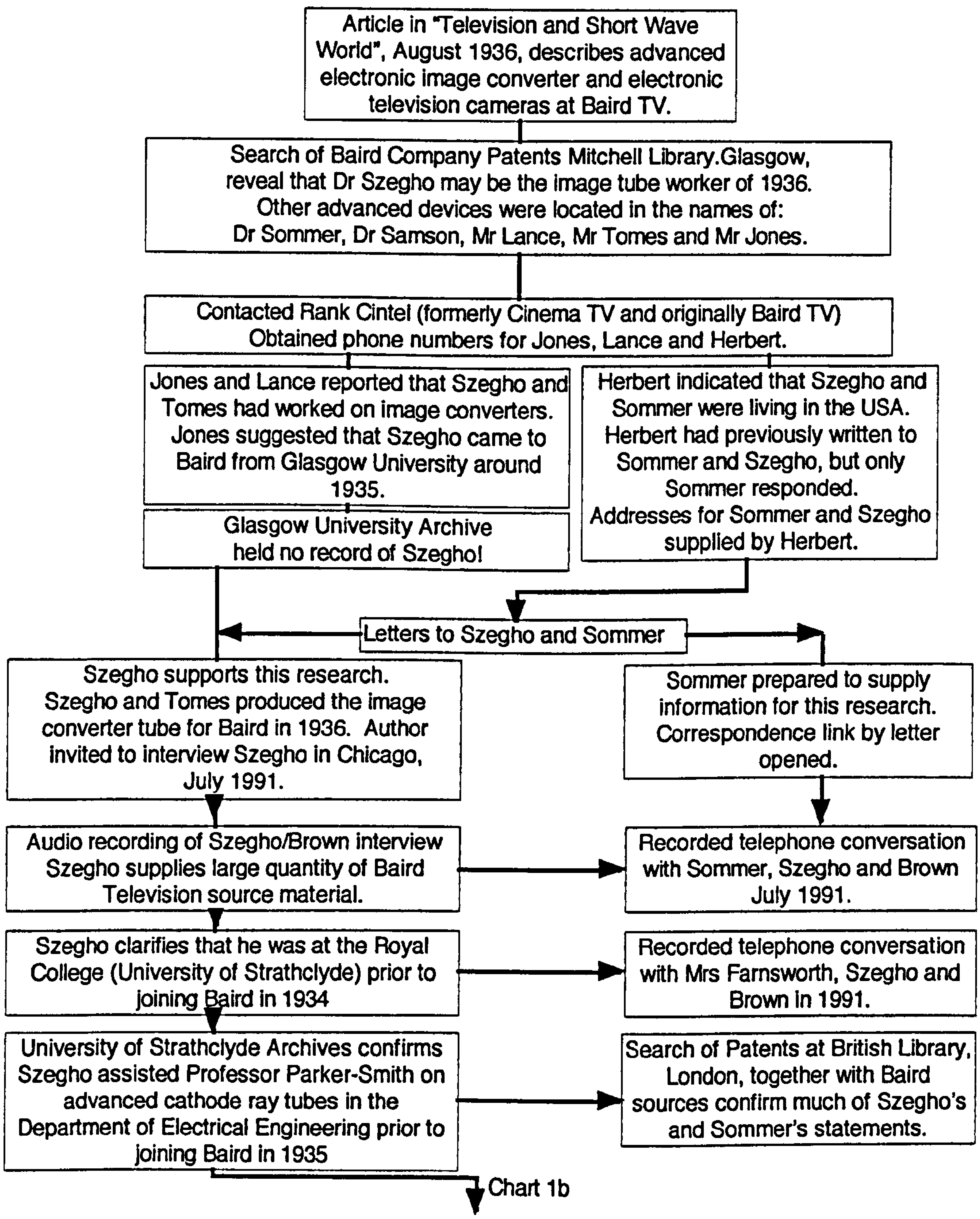
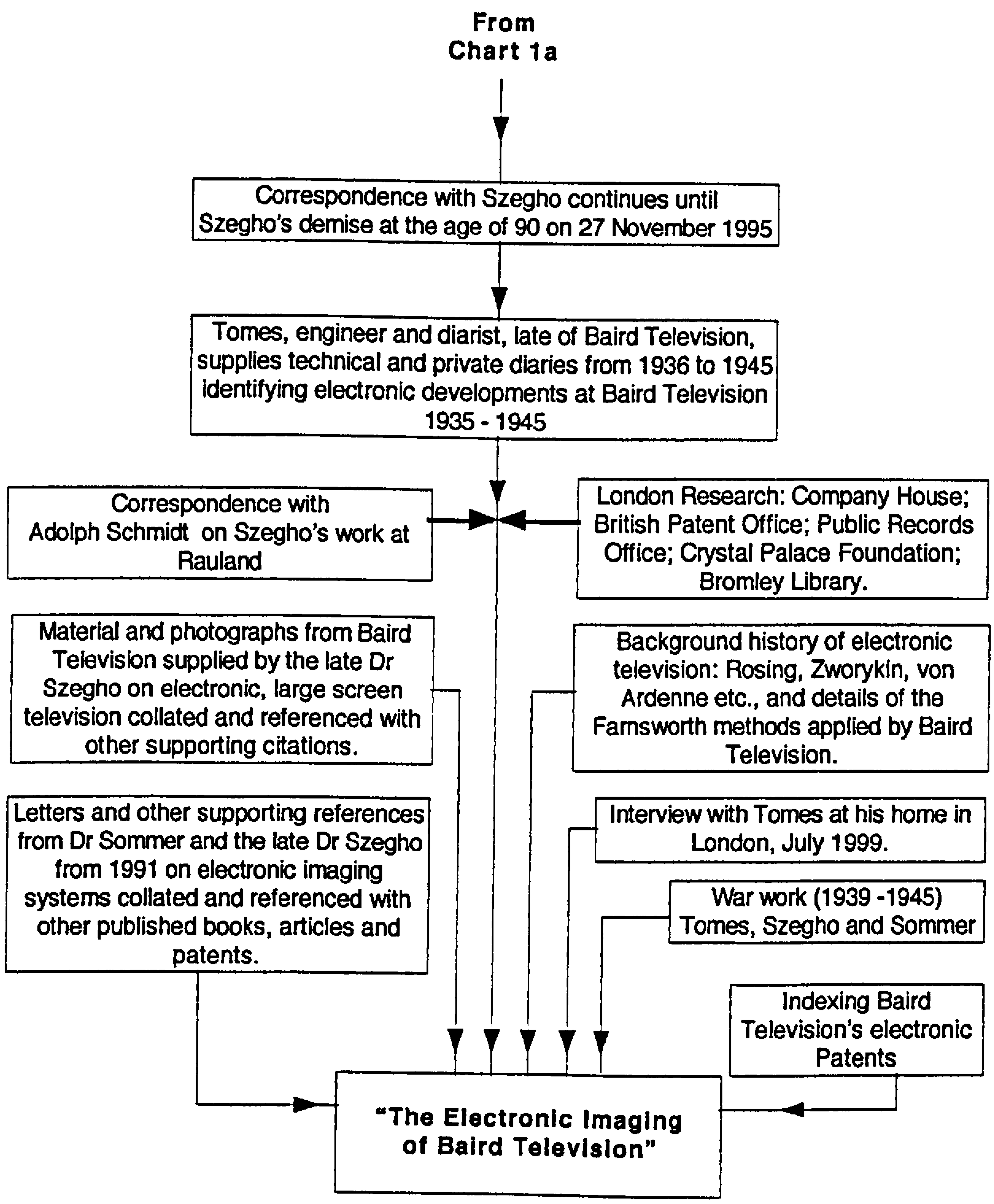


Chart 1b
Developments of Research

The Electronic Imaging of Baird Television

Methodology
1995 - 1999



Source and Literature Review

Introduction

Introduction

Despite many John Logie Baird biographies, patents and articles, there has never been a properly researched and collated study of the electronic imaging work of the Baird Television Company. This literature and source review will show that there is a dearth of information in the biographical work on John Logie Baird with relation to the advanced electronic technology adopted by the company which he formed, and will also describe the sources critical to this research.

Over the years biographers have dealt adequately with the early nineteen twenties achievements of John Logie Baird leading up to the advent of modern electronic television. Some of those authors have recorded the advanced colour television work which was personally accomplished by J. L. Baird from his private laboratories adjoining his home at 3 Crescent Wood Road in Sydenham. However, it should be clarified that this particular sphere of Baird's work, although partly relating to high resolution electronic imaging, is quite separate from the electronic imaging work of the Baird Company (taken over by Cinema Television in 1939). The Second World War, mobilisation of staff to the Armed Services, diversification of the company to secret war work and the imposition of the Official Secrets Act, followed in 1946 by Baird's death, may all have contributed to this void in the Baird Company's technical history.

This review is a critical analysis of a wide range of primary material, both published and unpublished. The various sections include: Baird biographies; relevant articles by independent television historians including

Abramson and Burns, and sources relating to the work of Philo T. Farnsworth whose technology was pivotal to Baird Television.

This review will clearly indicate whether the sources were co-patentees, workers, friends, independent historians or biographers, etc., and will also relate to the critical sources: Szegho, Tomes and Sommer.

Section 1

Baird Biographies

1931: H. J. Barton-Chapple (Baird Engineer) **Sydney Moseley** (Independent Biographer)

The first important book describing the work of John Logie Baird was published in 1931 and written jointly by Baird television engineer H. J. Barton-Chapple and Baird's co-director and biographer Sydney Moseley. Entitled, 'Television Today and Tomorrow ' [1] this was a technical television reference book designed to enlighten and encourage the informed radio enthusiast and home constructor. Concepts are presented to the reader in a reasonably easy to follow language to enable the construction and operation of home 'Televisors'. Reference is given to methods of scanning and synchronism together with advice on solving typical problems which may be encountered. Other aspects of Baird's early inventions are detailed including Noctovision, the apparatus for seeing in the dark using infra red rays, and a section is given to Phonovision, a system of video-disc recording and playback. In general this covers most of John Logie Baird's electro-mechanical television from 1927 until 1930. The methods discussed in depth are of no particular significance to the all-electronic television work of the Baird Company.

This book was encouraged by J. L. Baird who almost certainly recognised that it was a means of furthering the popularity of the infant television in the potential market place. The Baird Television Company produced ready made Televisors and a kit of parts for the more technically competent.

1933: R. F. Tiltman (Independent Writer and also editor of 'Television' the first magazine dedicated to Television)

By the time this book was published, John Logie Baird had become a household name and a personality in the field of television. Baird had achieved valuable public recognition in March 1925 when commissioned by Gordon Selfridge to demonstrate shadowgraph television for a three week period at the famous Selfridge store in Oxford Street. A surge of worldwide publicity followed in 1926 when Baird demonstrated the first ever 'real' television at 22 Frith Street to members of the Royal Institution. Since that historic event Baird continued to receive much acclaim from other futuristic demonstrations including: 'Noctovision' a means of seeing by infra-red radiation; 'Phonovision' the first video disc recording; experimental colour television; Three dimensional television; and the first transatlantic television broadcast in 1928. This was the setting in which Tiltman wrote 'Baird of Television'. [2]

In the Foreword by Lord Angus Kennedy, the Vice President of the Television Society, Baird is described as a "romantic hero" and "inventive genius" who despite poverty and ill health had the perseverance to achieve what nearly everyone else regarded as impossible. This work describes Baird's early life from his birth in Helensburgh to the breakthrough of working television in 1925. Poetically, Baird is caricatured as a half-crazed inventor, starving in a garret, penniless and living in the most abject poverty. Tiltman asserted that the name of Baird had become: " as indissolubly linked for all time with television as that of Marconi with wireless."

Written in advance of the electronic imaging at Baird Television, this book became an important source relating to J. L. Baird's early life.

Although Baird's accomplishments from 1926 until 1932 are well documented, Tiltman wrote:

> "I have purposely avoided going into the technicalities regarding his apparatus and many developments. This book is not the correct place for these, and I can advise those interested to read *Television Today and Tomorrow,* Moseley and Chapple (Pitman), or *Practical Television* by Larner (Benn), and the monthly magazine *Television.*"

By no coincidence, the magazine 'Television', which may be described as a vehicle for Baird's television, was at that time edited by Tiltman.

1947: Egon Larsen (Independent Writer)

Published in the year following Baird's premature death, Egon Larsen dedicated a chapter of his book, "Inventors' Scrapbook", [3] to Baird the pioneer of television. Larsen presented concise details of 30 line television and gave a good account of John Logie Baird's 600 line, high definition colour television work in the nineteen forties. There is no mention of the all-electronic television developments at Baird Television from 1934.

1952: Sydney Moseley (Independent Biographer)

Sydney Moseley wrote this tribute to J. L. Baird in a sincere attempt to put Baird's achievements into context. 'John Baird: The Romance and Tragedy of the Inventor of Television', [4] was published in post war Britain, when people were encouraged to look forward and not back through the dark war years. This was the dawn of a new era where television, apparently invented by Marconi-EMI, was to be radiated to the nation through the broadcasting monopoly of the BBC. This was television without any credit to the late J. L. Baird.

Moseley described the many struggles during Baird's campaign for supremacy in television broadcasting. He revealed that unknown to Baird he had secretly acquired and owned the failing Baird Television Company for a short period in 1931 before negotiating the sale to Gaumont British.

In 1951, during the research for Moseley's book, a manuscript comprising J. L. Baird's autobiographical notes were located at the offices of Scophony/Baird Company (formerly John Logie Baird Limited).
Mr L. F. Odell, the company's managing director gave Sydney Moseley access to them for inclusion in his book. The manuscript, 'Sermons Socks and Television' later published in 1988 as 'Sermons Soap and Television' by the Royal Television Society [5] is reviewed later in this section.

Baird, who considered Moseley to be one of his closest friends, had been disappointed when Moseley decided to resign as a director of Baird Television in 1933. Prior to the outbreak of the Second World War, Moseley went to America where he believed that he would best serve the British war effort by informing the American people of the urgent need for their help in Europe. Moseley, therefore could not comment on the electronic imaging work of the Baird Television Company which began about the time of his departure.

1959: Thornton H. Bridgewater (Former Baird Engineer)

John Logie Baird was a distinguished graduate from the Royal College of Technology in Glasgow which is now the University of Strathclyde. A Memorial Fund was set up by the college in the mid nineteen fifties which received a good response. A memorial plaque was erected in the Electrical Engineering Department and a fund established for a medal and a prize to be awarded in the final year Electrical Engineering course. This also included a biennial lecture, 'The Baird Memorial Lecture', to be based on television and related fields. The first lecture 'Baird and Television' was given by former Baird Engineer, Thornton H. Bridgewater, MIEE on 17 March, 1959. [6]

Bridgewater spoke of Baird's superhuman determination in his endeavours to realise television, citing qualities of perseverance, tenacity, enthusiasm, courage and faith. In his opinion Baird's greatest achievement was the accomplishment of true television in 1926, given that he was ill, poor and inexperienced in the art of electronics.

The lecture gave no hint that Baird had also developed a high resolution colour television system of 600 lines, or that he had constructed the world's first working colour cathode ray tube, the Telechrome! It is not surprising therefore, that by restricting this lecture to technology circa 1927, that the electronic work of the Baird Television Company was not included.

1973: Margaret Baird (Wife of J. L. Baird)

In the early nineteen seventies, as the memory of the late John Logie Baird was beginning to fade into obscurity, his widow, Margaret Baird wrote an updated biography entitled, 'Television Baird.' [7] Relying to a very large extent on the (then) unpublished memoirs of J. L. Baird, 'Sermons Soap and Television,' Margaret Baird introduced the family element and the human touch to the Baird story. It must be emphasised that although details are given of Baird's television methods (mostly from Baird's own words) this is not a technical book. The electronic colour television work which Baird carried out during the Second World War is described, but there is no reference to the all-electronic imaging of the Baird Television Company.

1976: Maurice Exwood (Independent Writer)

In 1976, Maurice Exwood wrote a 'History of Technology' Monograph for the Institution of Electronic and Radio Engineers, entitled
'50 Years of Television.' [8] Exwood, who restricted his monograph to Baird company business history from 1926 until 1929, is critical of inaccuracies and the lack of exact chronology to be found in most Baird biographies. He is direct in condemning the methods practised by Baird Television in transactions with the Postmaster General, the Royal Institution, and the British Broadcasting Corporation. As an example: some members of the Royal Institution accused Baird and his associates of using the Institution's name to promote Baird Television schemes. The problem emerged from an article by Baird in June 1928: [9]

"I gave a demonstration of Noctovision to the Royal Institution ...."

Exwood explained that the reference to the 'Royal Institution' infuriated

A. A. Campbell Swinton, member and former manager of the Royal Institution who wrote to Sir William Bragg, Fullerton Professor of Chemistry and member of the Royal Institution:

> "..... The seriousness of these statements is that they are being used on the Stock Exchange to fleece the public."

Sir William Bragg then wrote to Baird in a more parliamentary language:

> "..... It is quite true that you were kind enough to invite members of the Royal Institution, but no such demonstration was given at, or to, the Royal Institution."

Baird immediately agreed and had a correction printed in the letters page of the July 1928 issue of 'Television.' However, Exwood believed that the publicity had tarnished the reputation of Baird and Baird Television. Although Exwood blames Baird Television's first business manager and co-director, Captain Hutchinson, who seemed prepared to put Baird on the map at all costs, he indicated that John Logie Baird should not be admonished of all blame in the methods applied to promoting his schemes.

Exwood also suggested that Baird's services may not have been called upon by the Government during the Second World War possibly because his name had remained tainted in high circles. Despite this, he concluded that undoubtedly J. L. Baird was a great inventor who should be remembered as a 'great Briton'.

1978: Michael Hallett (Independent Writer)

In the series of books 'Pioneers of Science and Discovery', Michael Hallett wrote, 'John Logie Baird and Television'. [10] This work begins with an introduction covering the history of television from 1873 and concludes with the death of Baird in 1946. The work is well presented in relating the early life of Baird and the breakthrough in television but becomes noticeably flawed towards the end by failing to recognise Farnsworth's contributions. J. L. Baird is well treated but there are serious inaccuracies, one example being that the 'Baird's Telechrome' picture tube is described as a colour television camera tube. Unintentionally, by appearing to be thorough, this book has helped to perpetuate the argument that the Baird Company used outdated mechanical technology and were unable to compete in the field of electronic television.

1985: Geoff Hutchinson (Independent Writer)

In 1985, Geoff Hutchinson produced a brief history of John Logie Baird entitled, ' The Pioneer of Television: Baird'. [11] Very similar in content to the previous biographies this work concentrates on early achievements and gives credit to Baird's 600 line colour and three dimensional television work. No mention is given to Farnsworth and the Baird Electron Camera.

1986: Waddell and McArthur (Independent Writers)

In 1986, Waddell and McArthur published the controversial book entitled, 'The Secret Life of John Logie Baird'. [12] This book, regarded by many as the first technically competent study of Baird, identified new details of Baird's otherwise secret life and raised a number of questions. As a direct result of this work almost every major British encyclopaedia now indicates that John Logie Baird is the inventor of radar, military night vision and fibre optics. Waddell and McArthur accurately document that Baird experimentally operated a version of Farnsworth's electronic camera but limited their research in this field.

1988: John Logie Baird (Autobiographer)

The basis for all later Baird biographies published after Tiltman, the unfinished autobiography of John Logie Baird entitled, 'Sermons Socks and Television', [13] was published by the Royal Television Society in 1988 as 'Sermons Soap and Television'. This was published as a tribute in remembrance of John Logie Baird who was instrumental in establishing the Television Society in 1927.

The original memoirs were dictated by J. L. Baird to a hired secretary in the summer of 1941, when he was 52 years of age and recovering in a nursing home from a heart attack. No one knows why Baird did not complete his autobiography but it is likely that on returning home he simply concentrated on more compelling projects. This may explain why the notes do not include details of the electronic work of Baird Television, Farnsworth and the Baird Electron camera. The memoirs were discovered in 1951 on the premises of 'Scophony/Baird Ltd', (formerly 'John Logie Baird Ltd') the company which Baird founded in 1945 with the assistance of his close friend the film star Jack Buchanan. While the autobiography brings one closer to Baird and his opinions, a criticism is that he is generally poor in specifying dates. A carbon copy of the original manuscript is currently in the possession of the Baird family in Canada.

1990: John Logie Baird (Autobiographer)

The second edition of 'Sermons Soap and Television', [14] claims to carry a more full and original text, including a foreword by the President of the Television Society, Paul Fox, CBE and an introduction by J. L. Baird's son, Dr Malcolm Baird. On reviewing this book it was discovered that while the original text is virtually the same as the first edition, there are corrections and notes included which clarify the original memoirs.

1990: Waddell and McArthur (Independent Writers)

A updated version of Waddell and McArthur's book entitled, 'Vision Warrior', [15] was published by Orkney Press and appeared in 1990. This book included some new facts discovered about Baird's secret life and was reviewed in the House of Commons on 10 May 1990. The following motion [16] was signed by 65 MP's, of all parties including; John McFall, George Robertson, George Younger, Jim Sillars, George Foulkes and Donald Dewar:

> "That this house recognises the outstanding contributions of John Logie Baird, that lad o' pairts from Helensburgh whom history will record as being the person who invented television and radar technology; applauds the efforts of the University of Strathclyde to establish a permanent John Logie Baird Visitor and Research Centre and suggests that in addition a permanent memorial to Baird's genius is established in his home town and that some form of recognition be given to his wife and surviving family in gratitude for the life and talents of this man, who was a Jules Verne with a difference - A visionary who made his dreams real."

'Vision Warrior' concentrates on the theme of Baird's secret life and does not cover the electronic imaging of the Baird Company or describe with any detail the Farnsworth/Baird license.

1996: Ray Herbert (Former Baird Engineer)

'Seeing by Wireless', [17] published by former Baird Engineer, Ray Herbert first appeared in 1996. Using first hand knowledge and with assistance from other former employees of the Baird Company, Herbert comes close to presenting the history of the electronic work of the Baird Television Company. J. L. Baird and his television achievements are concisely covered in this 27 page illustrated booklet. The electronic imaging work of Baird Television is, however, limited to only a few paragraphs and illustrations.

Analysis: This biography review has shown that Baird had written and intended to publish his autobiography 'Sermon's Soap and Television' which most likely would have replaced Moseley's (1952) biography. From 1953 there was no further biographical detail on J. L. Baird or his pioneering work,until Margaret Baird (1973) restored public interest. Three small publications followed; Exwood (1976), Hallett (1978) and Hutchinson (1985). Lacking in originality, all of the biographies mentioned have relied substantially on the work of 'Moseley and Barton-Chapple' (1931), Tiltman (1933) and to some extent on Baird's autobiographical notes (1941). Original research on Baird was carried out by Waddell and McArthur (1986) who published the controversial, 'Secret Life of Baird.' This resulted in a surge of interest in the press followed by the publication of Baird's, memoirs, 'Sermons Soap and Television,' by the Royal Television Society (1988). Waddell and McArthur published 'Vision Warrior' (1990) which resulted in a motion to honour Baird posthumously being signed by 50 M.P.'s from all parties. The most recent original research is the work of Herbert (1996) and Brown (1997). The pull-out chart (Chart 2a) illustrates the chronology of the

Baird biographies from 1931 to 1997.

With the exception of, Brown, Waddell & McArthur and Herbert's work, the Baird biographies have lacked originality and despite the new research carried out by these authors, little emphasis has been placed on the electronic imaging work of the Baird Television Company.

Chart 2b is a calendar of the events and achievements of John Logie Baird and the Baird Television Company 1923 -1946. The chart indicates the joint and separate work of J. L. Baird in red, while in contrast some of the highlights of the isolated work of Baird Television are shown in black.

Chart 2a

Baird Biographies

1931-1997

Calendar of Baird Biographies

1930 -1939	1940 -1949	1950 -1959	1960 -1969	1970 -1979	1980 -1989	1990 -1999
1930	1940	1950	1960	1970	1980	1990 **Sermons Soap and Television:** 147 pages John Logie Baird. 2nd. Ed **Vision Warrior:** 310 pages Peter Waddell & Tom McArthur
1931 **Television Today and Tomorrow** Moseley and Barton-Chapple 163 pages	1941	1951	1961	1971	1981	1991
1932	1942	1952 **John Baird:The Romance and Tragedy of the Pioneer of Television** Sydney Moseley: 256 pages	1962	1972	1982	1992
1933 **Baird of Television** Ronald F Tiltman 213 pages	1943	1953	1963	1973 **Television Baird** Margaret Baird: 160 pages	1983	1993
1934	1944	1954	1964	1974	1984	1994
1935	1945	1955	1965	1975	1985 **The Pioneer of Television** Geoff Hutchinson: 32 pages	1995
1936	1946	1956	1966	1976 **John Logie Baird: 50 Years of Television** Maurice Exwood : 29 pages	1986 **The Secret Life of John Logie Baird** Peter Waddell and Tom McArthur: 272 pages	1996 **Seeing by Wireless** Ray Herbert: 27 pages
1937	1947 **Inventors' Scrapbook** Egon Larsen: Section on Baird: 6 pages	1957	1967	1977	1987	1997 **The Contributions of John Logie Baird to Television and Related Technologies** Douglas Brown: 236 pages
1938	1948	1958	1968	1978 **John Logie Baird and Television** Michael Hallett: 86 pages	1988 **Sermons, Soap and Television** John Logie Baird 1st Edition:147 pages	1998
1939	1949	1959 **Baird and Television** John Logie Baird Memorial Lecture. Thornton H Bridgewater 15 pages	1969	1979	1989	1999

Chart 2b

Chronology of Events

J. L. Baird and Baird Television Ltd

1922 - 1946

Calendar of events and achievements of John Logie Baird and the Baird Television Company 1922-1946

1920	1925 **1 Jan.:**Patent 253,957:Fibre Optics. **20 Jan:** Patent 269,258: Flying-Spot. **March:** Crude Shadowgraph TV demonstrated at Selfridges, London. **11 June:** 'Television Ltd' registered. **2 Oct:** Realisation of real television. **21October:** Patent 270,222 Image sharpening **16 December:** Wilfred Day resigns as Partner and Director of Television Ltd. Replaced by Hutchinson and Broadrip.	1930 **4 Oct:** Baird Development TV Company amalgamated with Baird International TV Company to form Baird Television Ltd.	1935 Dr Samson hired to develop the Baird electronic camera tube based on Farnsworth's Image Dissector patents. **15July:**Tomes hired to work under Szegho on cathode ray tubes.	1940 Baird Television Ltd in receivership. **17 December:** Baird TV liquidated and J.L. Baird leaves Company. Gaumont British continue Baird TV as: Cinema Television (Incorporating Baird Television). Company name abbreviated to CinTel. Captain Moon takes control of War work in Rotunda.	1945 J.L.Baird: Unwell but determined to continue, forms a new company with partner and film star Jack Buchanan: John Logie Baird Ltd Dr Sommer hired by EMI to develop photo surfaces for electronic television cameras.
1921	1926 **21 Dec:**Patent 292,185: (RADAR). 'Object detection by radio location.' **26 January:** Television demonstrated to 40 members of the Royal Society, 22 Frith Street, Soho, London. **28 August:** Colour and 3D television. **15 October:** Patent 288,882:Infrared 'Noctovision' television. **Also:** Patent 289,104: Phonovision. (Video disc recording)	1931 **31 March:** Simultaneous sight and sound TV from Brookmans Park. Televising the Derby.	1936 **1 Jan:** Dr Sommer hired to develop photocells and photosurfaces. **5 March:** Szegho,Tomes and Sommer construct and activate an image converter tube. **1 Oct:**High definition television trials Baird/EMI from Alexandra Palace. **30 Nov:**Crystal Palace Fire. **December:** J.L.Baird demonstrates 120 line monochrome TV on a 6 x 8 ft cinema screen.	1941 **April:** J.L.Baird 600 line colour television using Sommer's panchromatic photocell. Szegho sent to Baird Corp. USA to develop projection cathode ray tubes. **1 Nov:** J.L.Baird becomes Consulting Technical Adviser to Cable and Wireless. **18 Dec:**Demonstration of colour stereoscopic television without special glasses.	1946 **14 June:** J.L.Baird died peacefully in his sleep.
1922 **HASTINGS** Pioneering television work begins at 21 Linton Crescent. Work transferred to 8 Queens Arcade.	1927 **26 Jan:** Patent 292,632 'Magnetic recording discs.' **10 March:** Patent 297,014 Improved Radar concept. **27 April:**Baird Development Co. registered. **24 May:**Television from London to Glasgow.	1932 Baird Television Ltd acquired by Gaumont British.	1937 **4 February:** Baird Television's 240 line system fails to be accepted by the BBC and EMI gains BBC television contract. **December:** J.L.Baird demonstrates private colour television project to the press. Szegho and Tomes give Cinema Television demo's to Gaumont British. Gaumont British form a separate company named Cinema Television.	1942 Cinema Television Acquired by J. Arthur Rank and renamed RANK CinTel. J.L.Baird: Interlaces 5 times to produce 500 line 3D colour pictures. J.L.Baird: Demonstrates 1000 line, 3D, colour television. Production of VCR140 Radar tubes. 25 July: J.L.Baird's Telechrome tube. Baird USA acquired by Rauland Corp. Szegho hired by Rauland to head their Cathode Ray Tube Division.	1947
1923 **27 June:** Transmitting by television crude shadowgraph images of a Maltese cross.	1928 **8 February:** TV from Coulsdon UK to Hartsdale, New York. **5 June:** Patent 321,389 'Colour TV.' **26June:** Baird International TV registered. **3 July:**Colour TV to the Brit. Assoc. **27 July:** Baird Inc and Baird TV Corp. formed in USA. **10 October:** Patent 324,049 'Videodisc player.'	1933 Moseley quits Baird Television.	1938 **4 February:** J.L.Baird. 120 line colour television on a 12 x 9 ft screen to an unsuspecting audience of three thousand at the Dominion Theatre, London. **22 February:** Baird travels to speak at World Convention of Radio Engineers in Sydney, Australia.	1943 Hankey Committee set-up by Government to review the requirements for Post War television. J.L.Baird: Gives evidence to Hankey Committee promoting 1000 line, 3D colour television.	1948
1924 **22 Aug:** Moves to premises at 22 Frith Street, Soho, London. **5 April:** Baird writes to Wilfred E Day. **14 April:** Baird/Day partnership.	1929 **11 June:** Fernseh AG, Berlin. Formed in equal partnership with Baird Television, Zeiss Ikon, Loewe Radio and Bosch. **30 September:**First Official Baird television transmissions from the BBC.	1934 **8 June:** Dr Szegho was hired as Teaching Assistant by Professor Parker Smith of the Royal Technical College, Glasgow, Scotland **September:** Szegho hired by Baird Television, in advance of Farnsworth. **October:** Farnsworth arrives and licenses Baird Television to use of all of his British patent. Szegho establishes a vacuum plant and C.R.T. research section.	1939 **July 20:** Patent 532,259 Sommer. Panchromatic photo surface. **21 August:** War in Europe. **13 Nov:** Baird Television filed for bankruptcy. Cinema TV/Gaumont takes total control of assets. Staff reduced to 34 Cinema TV producing photocells for Gaumont's projectors and producing one iconoscope television camera/day. Cinema Television: Large screen 405 line Boon-Danahar fight to paying audiences in London cinemas.	1944 Cinema TV win contract to build VCR 97 Radar tubes. **18 August:** J.L.Baird demonstrates to the London press the first all electronic colour television system using a new colour cathode ray tube: Telechrome.	1949

J L Baird Highlights are shown in red. Events related to the Baird Company are shown in black.

Section 2

Technical Magazine Articles, Journal Articles and Conference Papers

Television by Electron Image Scanning (October 1934)
Philo Farnsworth: (Article: Journal of the Franklin Institute)

Farnsworth's technology had a profound influence on Baird Television's decision to adopt high vacuum electronic television picture and camera tube design and production. This article describes the television camera and cathode-ray picture tube technology which Farnsworth developed and named the Image Dissector and the Oscillite respectively. This source [18] contains the first complete technical text on electronic television to be written by Farnsworth. [19] He describes electron multipliers and the principles of electron scanning techniques all of which were licensed to the Baird Company. In 1936 the content of this article was repeated by George Eckhardt in a book entitled, Electronic Television. [20]

Modifications of the cold-cathode Braun Tube (January 1935)
Dr Szegho: (Paper: Journal of the Royal Technical College)

The paper [21] deals with investigations into the use of metal discharge tubes to permit continuous working at higher currents and voltages than can be used with the usual sealed-glass type. A new type of self renewing cathode is described.

This paper indicates the importance of Szegho's cathode ray tube expertise to the history of Strathclyde University and highlights Baird Television's interest in Szegho.

A Cathode-Ray Oscillograph Equipment embodying a High-Voltage, Gas-Filled, Sealed-Glass Oscillograph Tube (June 1935): Parker Smith, Szegho, and Bradshaw: (Conference Paper, IEE Journal)

In this paper [22] a description is given of a high recording speed oscillograph equipment embodying a new development in cathode ray tube oscillography. This paper indicates the importance of Szegho's cathode ray tube expertise and highlights Baird Television's interest in hiring him.

Development of Theatre Television in England (21 October 1947): A. G. D. West: (Conference Paper, SMPE Convention New York / Journal of SMPE - August, 1948)

The Director of Cinema Television A. G. D. West gave this review [23] of the progress of theatre television in Great Britain, both before and after the war, and gave credit to John Logie Baird as the initiator of the concept. The design and performance of equipment, developed by Baird Television, later Cinema Television, is described. West also indicated that there were proposals for a theatre television service in England, first in London , and then throughout the country.

Excellent material based on the projection cathode ray tube work of Szegho and Tomes of Baird Television.

The First Demonstration of Television (1975) R. W. Burns: (Journal Article: Electronics and Power)

In 1975, Professor Burns, head of the Department of Electrical Engineering at Trent Polytechnic, Nottingham, published an article in Electronics and Power, entitled, 'The First Demonstration of Television'. [24] Burns clarified that in the late 19th and early 20th century a huge volume of engineers and scientists of many nationalities were undertaking to solve the problems of seeing by electricity. He indicates that despite this worldwide competition it was John Logie Baird who solved the problem, albeit with little money, poor facilities, no research and development knowledge in electrical engineering. Burns analyses the key scientific developments which form the background to television history. Burns centres this article on the Baird Televisor and describes the ingenious methods applied to overcome the poor transient response of the selenium photosensitive cell.

This is an excellent piece of research on the early work of John Logie Baird which is well referenced and analysed. The work of R. W. Burns is of the highest academic standard.

Birth of the London Television Station (7-9 July 1978) R. W. Burns (Conference Paper read before IEE.)

Burns continued his research into John Logie Baird and in July 1978 read a paper before the 6th IEE weekend meeting on the history of electrical engineering, University of Nottingham, entitled, "Birth of the London

Television Station". [25] This paper describes the work of Baird and Marconi-EMI at Alexandra Palace during the television system trials of 1936 -1937. Line standards are described and details given of tests carried out independently by Westrom, of the US Signal Corps, and Engstrom, of RCA in 1933 to evaluate the relative merits of pictures containing from 60 to 480 lines of resolution. There is also a discussion on the interlaced scanning of Marconi-EMI and the progressive scanning adopted by Baird Television. I have no hesitation in citing this work in support of the thesis.

J. L. Baird: success and failure (1979): R. W. Burns: (Journal Article : Proceedings of the IEE.)

Burns wrote an excellent analysis on the success and failure of J. L. Baird [26], for the Proceedings of the IEE published on 9 September 1979. Covering the historical background and the early developments of Baird's television, Burns is critical of the methods of Captain Hutchinson, Baird's first co director and publicity manager. Burns looked at the difficulties encountered in the commercial beginnings of Baird's company and indicates a number of serious errors of judgment by the Baird board of directors. In summing up Burns points out that:

> "Of all the various factors which determined the fortunes of Baird Television Ltd one of the most important was the failure of the company to reach an agreement with the Marconi Wireless Telegraphy Company in 1932. Two years later the Chelmsford Concern combined forces with EMI to form Marconi-EMI Television Company Ltd."

This work has been extensively referenced and is well presented.

The History of Television for Public Showing in Cinemas in the United Kingdom. (December 1985): R. W. Burns: (Journal Article: Proceedings of the IEE.)

Of particular significance to the work of this research, Burns produced this excellent publication for the Proceedings of the IEE. [27]
As with the previous work of Burns this is well documented and researched. However, new material supplied by the late Dr Szegho for inclusion in this thesis will make a significant contribution to knowledge in this specialised field of television technology.

Seeing by Electricity. (17 October 1985): R. W. Burns: (Journal Article: Proceedings of the IEE.)

In an article entitled "Seeing by Electricity", [28] Burns produced a compilation covering much of his previous research into the history of television. He investigates the early use of the cathode ray tube leading up to Zworykin's Iconoscope and McGee (et al) with their Emitron tube. The history of Baird and television is discussed from his early beginnings to the later years of Baird's life and work with cathode ray tubes.

An excellent compilation of his previous papers and articles on Baird and the history of television.

'Television' (The first television magazine in the World.)

Articles covering some of Baird Television's electronic imaging were published between 1934 and 1941. Reproductions of the magazine articles from 'Television', trade journals and other sources to be cited are in the possession of the author.

Section 3

Television History Books

1950: Heit: Practical Television Engineering

This book [29] includes a section on the cinema projection television work of Szegho at Cinema Television (incorporating Baird Television) UK and Baird Incorporated and the Rauland Corporation USA.

1987: Abramson: The History of Television, 1880 to 1941

This work [30] which is thoroughly researched and well referenced is supported by material from various sources including, publications, patents and a selection of material related by the following list of television pioneers:

Manfred von Ardenne, Alda Bedford, D. C. Birkinshaw,
Tony Bridgewater, Arch Brolly, Mrs. Philo Farnsworth, Lesly E. Flory,
Harley lams, Ray Kell, Thomas M. C. Lance, Harry Lubcke,
Hans G. Lubszynski, Joseph D. McGee, Robert Morris,
George Morton, Albert F. Murray, Albert Rose, Solomon Sagall,
Otto Schade, Kenjiro Takayanagi, Arthur Vance, E. C. L. White,
W. D. Wright, Vladimir Zworykin.

Abramson conducts his survey, which begins with a chapter on the archaeology and history of television from 1671 to 1879 with academic precision. This excellent historical text book has become a useful reference, the main feature of which is Abramson's chronology.

This book is a reliable source of factual information supplying dates, inventors and a wide range of information from which modern television researchers, intending to expand on specialised areas, may base their work.

1990: Callick: Metres to Microwaves: British development of active components for radar systems 1937 to 1944

Callick's research into the history of radar and its component parts [31] identifies some of the items which Cinema Television (Incorporating Baird Television) manufactured for the war effort.

1991: Keller: The Cathode Ray Tube: Technology, History, and Applications

This book [32] which traces the evolutionary developments of the cathode-ray tube from the earliest of experiments describes some of the tubes manufactured by Baird Television and is an invaluable aid to the work of this research.

1998: Burns: Television: an International history of the formative years

The most complete work produced by Burns on the history of television is entitled , 'Television: an international history of the formative years'. [33] The history of imaging is traced back to the earliest years of speculation from 1877 to 1922 in the first part of this three section work. The second section identifies the era of low definition television from 1926 to 1934. This section also covers the large screen era 1930 to 1935, but does not include the cathode ray projection tubes developed at Baird Television. The concluding section identifies the era of prewar and high definition television from 1934 to 1939.

Published by the IEE, this book describes the work of the many engineers and scientists throughout the world who have contributed to the development of television. It sets the context of the first demonstration of television by providing the reader with a knowledge of contemporary 1926 technology. This is a very useful reference book, which although helpful in supporting this thesis, does not specialise on the work of John Logie Baird or the electronic imaging of Baird Television circa 1933 to 1942.

1990: Farnsworth: Distant Vision: Romance and Discovery on an Invisible Frontier

In 1990, Elma Farnsworth the widow of the American inventor of electronic television, Philo T. Farnsworth produced a biography entitled, 'Distant Vision: Romance and Discovery on an Invisible Frontier'. [34]

After the death of her husband in 1971, Mrs Farnsworth decided to become a historian, to 'set the record straight'. This manuscript traces the life of Philo T. Farnsworth from early beginnings to his realisation of electronic television on 7 September, 1927. This work describes the bitter rivalry which existed between Farnsworth, with his image dissector camera, and Zworykin of the Radio Corporation of America with his iconoscope television camera. A chapter describes the license agreement with Baird Television, however, it suffers from a limited chronology. While some of the factual accounts supplied are important to support the work of this research, other sources are relied upon for key dates.

Section 4

Theses

Philo Farnsworth: The Quiet Contributor to Television

Stephen F. Hofer (1977)

The work of Philo T. Farnsworth made a significant contribution to the development of electronic television at Baird Television Ltd. In his PhD thesis [35] Hofer examines the personal, technical, and legal aspects of Farnsworth's work.

This well balanced and organised thesis contains a bank of useful information relating, in particular, to the patent infringement contest between Zworykin of RCA and Farnsworth, and their respective television camera tube inventions. Details of rulings and dates are documented providing an extremely useful source.

The Contribution of John Logie Baird to Television and Related Technologies: Douglas Brown (1997)

In 1997 the author presented a thesis [36] for the award of 'Master of Philosophy' from the Department of Information Science, University of Strathclyde. The aim of the research was to make a study of the life and work of John Logie Baird and to analyse the expectations, successes and failures of this man of vision. The research analyses specific phases of his work, and includes a condensed biography from Baird's earliest days in Helensburgh to his realisation of television in London on the 2 October

1925. The work also researches the circumstances surrounding the legacy which has dishonoured the public name of John Logie Baird. There is an analysis of published material to determine Baird's contribution to the evolution of the television industry, including his role in the inauguration of the first television company and the first public television service. The work of this research concludes with an in-depth study to identify Baird's contributions to modern colour television.

The above thesis indicated that separate research was required to identify the electronic imaging work of the Baird Television Company.

Section 5

Diaries

The Diaries of Gilbert Tomes (1934-1945)

Gilbert Tomes contacted the author of this research in January 1998 after corresponding with the widow of the late Dr Szegho in the USA. On learning from Mrs Szegho, that I had completed my masters degree on Baird in 1997, and was now embarking on a PhD project by researching the electronic work of the Baird Television Company, Tomes indicated that he had first hand knowledge of the period in question. Tomes kept a record of his working life at Baird Television in the form of personal diaries and laboratory notes. These are valuable sources which can be supported by publications and cross verification with other sources. The diaries, currently being prepared by Tomes for private publication [37] from original diary entries and notes, also contain valuable photographic evidence of Baird Television Limited. Tomes holds the negatives of photographic sources, possesses hardware in the form of Baird photocells and other artifacts. Tomes has a clear recollection of the events which took place at Baird Television and is able to supply supporting data which enables his contribution to be of particular merit to this research.

John Logie Baird Diaries 1940 - 1946

Photocopies of John Logie Baird's diaries, [38] were kindly supplied by the Baird family. These diaries, which contain mostly the names of projects, colleagues and telephone numbers are cryptic, there are few entries which record events or ideas in plain language. See (Figure i).

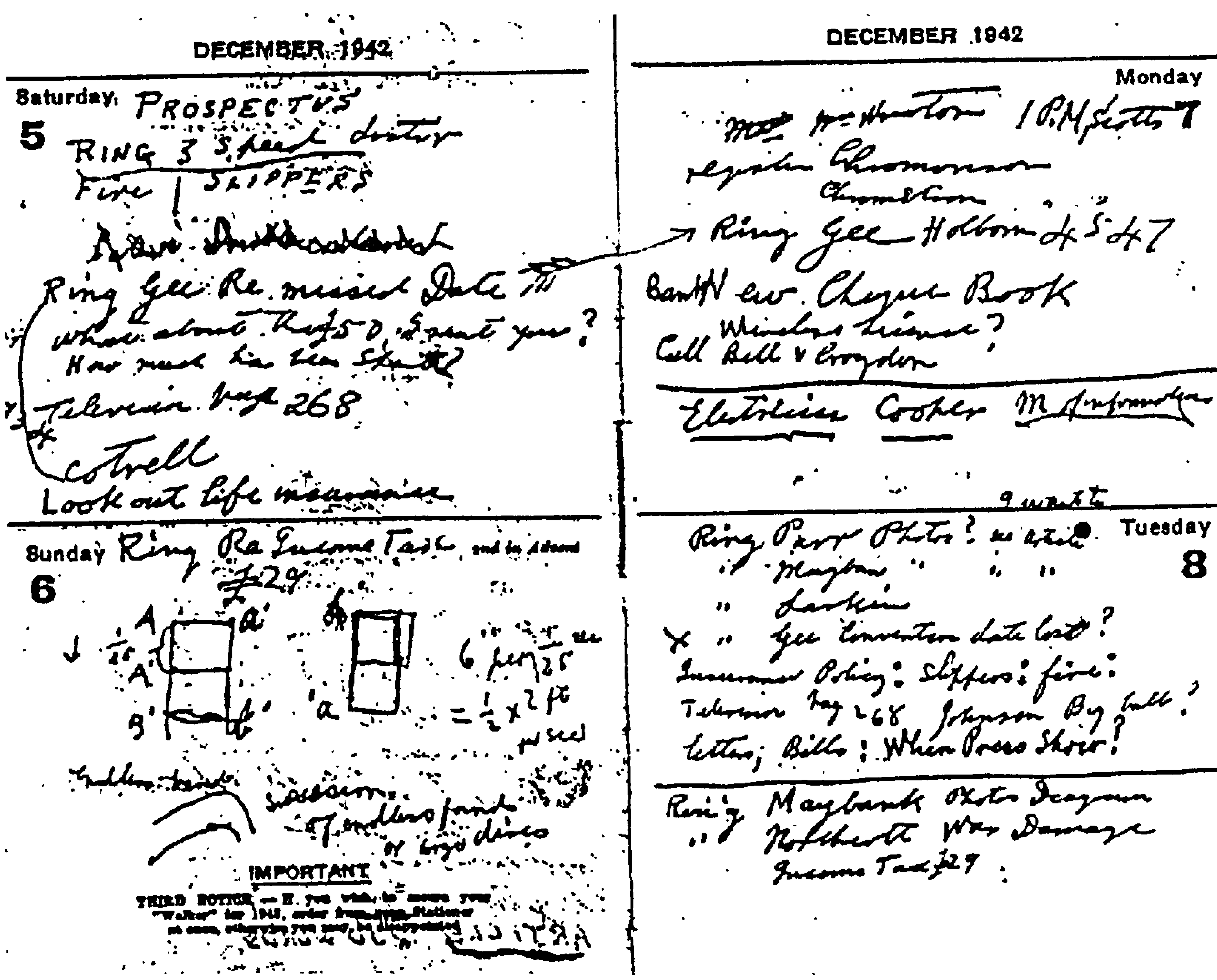

DECEMBER 1942
Saturday 5
PROSPECTUS
RING
SLIPPERS
Sunday 6
IMPORTANT
DECEMBER 1942
Monday 7
Cheque Book
Tuesday 8

Figure i: Typical entries in J. L. Baird's Diary

Despite this the Baird diaries are considered significant to the work of this research and may be used as a cross reference source.

Section 6

Marketing Material

A small number of original and reproduction Baird marketing brochures, advertisements and data sheets are in the possession of the author. These include in original condition the 1938 -1939 electronic television brochures describing Baird television receivers. This collection also includes a quantity of Cinema Television brochures and specification sheets for post war video and test apparatus. Reproductions of company literature appear as required in the appendices of this thesis.

Section 7

Interviews, Letters and Unpublished Sources

In the search for material relating to the history of Baird Television, the author interviewed the late Dr Constantin Stephen Szegho at his home in Chicago, Illinois in the USA during the summer of 1991.

Dr Szegho (Audio Recording)

Szegho's first contribution to electron physics was an improved high performance 'sealed-off' cathode-ray tube which he produced for his doctorate at the Institute of Technology, Aachen in Germany. Unlike contemporary tubes these devices did not require to be continually evacuated by pumps throughout their operating life. Professor Parker Smith from the Royal Technical College (Strathclyde University) purchased a unit and invited Szegho to continue his work in Scotland. In 1934 Szegho and Parker Smith read a joint paper before the IEE in London where the apparatus was seen by J. L. Baird. Szegho was immediately hired as head of a proposed cathode-ray tube department to be established at Baird Television in London.

It will be shown that during his time with Baird Television, Szegho took out many patents for television tubes and electronic camera tubes, pioneered image convertor tubes, incendiary bomb detectors, worked on developing radar tubes and produced one of the first monoscope tube test card devices for electronic television.

The late Dr Szegho supplied published work and other documents for inclusion in this research which are now in the possession of the author.

1. Baird Company brochures (circa 1934 -1954).
2. Cold cathode ray tube, circa 1934, incorporating a Szegho-cathode configuration.
3. Paper by Szegho, Parker Smith and Bradshaw, Metering Section of the IEE London. 1934.
5. Baird Company photo-cells (circa 1935 -1936).
6. Baird Television Ltd brochures.
7. Private collection of 70 photographs of the Baird Factory circa 1939.
8. Extracts from Dr C. S. Szegho's unpublished memoirs.
9. Letters between Dr Szegho and the author from 1990 to 1995.
10. The minutes of the board meetings and records of the Baird Television Corporation, USA.
11. Records from the Rauland Corporation, reports dated 1940 -1951.
12. Draft copy of the Deed of Sale of Rauland to Zenith 1942.

Dr Sommer (Former Employee of Baird Television Ltd)

A number of letters between the author and Dr Sommer, a short audio recording together with other papers, and lists of publications are in the possession of the author.

Being of Jewish descent Dr Alfred H. Sommer was forced to escape from Germany to England in 1935. In a letter to his friend Gilbert Tomes, dated 15 October, 1994 [39] Sommer summarised the events. The following is an extract:

"I had a good Friend at the Phys.Chem. Institute in Berlin where I got my PhD in 1934. Brauer who was a Post-doctoral and totally anti-Nazi helped me to get a job in a small Berlin Company ....

.... that is how I learned to make gas-filled phototubes for sound-reproduction in portable projectors. My friend (Brauer) and I had a common acquaintance, Krahwinkel, who headed the Post Office Research Laboratory that developed television. In his Laboratory was, George Weiss, who invented the grid-type secondary multiplier. Krahwinkel was committed to show mechanical television to Hitler at the Berlin Radio Show in September 1934, and he asked the large German AEG to make multiplier phototubes for his system. They did not manage, so Krahwinkel, who knew about my work, came to me and promised to get me an introduction to the Baird Company via his friend, the Director of Fernseh AG if I supplied six usable tubes by August 1935. I, and my anti-Nazi assistant, worked day and night through a very hot summer and were successful. All concerned kept their promises and, after many difficulties I managed to get a visitor's visa to visit Captain West at the Crystal Palace in October 1935. He was very nice and offered me a job...............

.... I started work on 1 January 1936. I still feel that I owe my life to at least four wonderful people who helped me to get the job."

Section 8

Patents

The work of this research has identified and sorted into chronological order the 328 British patents issued to the engineers and scientists of the Baird Television Company from 14 July 1930 to 1 July 1940. These are contained in Appendix 5 and do not include patents naming John Logie Baird as the inventor or co-inventor. A separate listing in Appendix 6 details in chronological order the 175 British patents granted to John Logie Baird from 26 July 1923 to 10 April 1945.

Section 9

Review Conclusions

This review has critically identified the prior work of Baird biographers and has shown that there is a dearth of material relating to the electronic imaging of the Baird Television Company 1933 -1942 (later Cinema Television). The analysis of other published work relating either directly, or indirectly, to the work of Baird Television has resulted in the conclusion that this era of Baird Television's advanced imaging technology has never been properly documented.

The evidence supplied by former Baird employees, Szegho, Sommer and Tomes is critical to the work of this research and assists significantly to knowledge relating to the electronic imaging of Baird Television. Despite problems which are normally associated with age, each of the above was able to provide a coherent testimony. In only a few instances has verification been necessary by cross referencing of the three sources and other material evidence. In each case their contributions, which may be in the form of oral, written, photographic or published material, are pivotal to the work of this research.

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Introduction

Television, the instantaneous medium which enables events to be viewed as they occur, regardless of distance, is one of the most significant technological achievements of the twentieth century. It has probably made as great an impact on society as the advent of the family motor car, the telephone and radio. Television is not a unique technology but one which required the convergence of developments in other sciences including: photography; photo electricity; the telephone; radio and the cathode-ray tube. The notion of television easily predates its inception, but its inauguration was delayed until 1926, when John Logie Baird brought together the minimum requirements. Baird demonstrated to a skeptical public that recognisable images could be sent and recovered across a distance of space. Although modern television must claim no single inventor, Baird was a visionary and a pacemaker for the television industry over a span of two decades from 1926 until his premature death in 1946. Separate research by Abramson [1] and Burns [2] have produced balanced accounts of the history of television during its formative years. Both authors, outstanding in the field of television history, give credit to the creative work of John Logie Baird.

Abramson stated: [3]

> "On January 26,1926, Baird gave a demonstration of his television apparatus to some 40 members of the Royal Institution at his laboratory in Frith Street, Soho. This was the first public demonstration of true television ever witnessed."

Burns wrote: [4]

> "However for more than 45 years success eluded the early inventors.

Then on 26 January, 1926, Baird demonstrated for the first time anywhere a rudimentary form of television."

John Logie Baird's television company, established in 1925, experienced many transformations to survive the effects of a world depression and the results of severe competition. The original firm named TELEVISION was followed in 1927 by THE BAIRD DEVELOPMENT COMPANY which in 1928 formed BAIRD INTERNATIONAL TELEVISION. Baird International was responsible for establishing BAIRD INCORPORATED, New York in 1928, and the Berlin based FERNSEH AG, (translated: Television Ltd) in 1929. Baird Development was amalgamated with Baird International in 1930 to form BAIRD TELEVISION. The Gaumont British Company acquired Baird Television in 1932 and separately formed CINEMA TELEVISION in 1937 to accommodate J. L. Baird's concept of theatre television. In reality the work of Cinema Television was carried out by Baird Television staff in Baird Television premises. When Baird Television went into receivership in November 1939 the company continued to trade under the name of Cinema Television (Incorporating Baird Television). In 1942, J. Arthur Rank acquired the Gaumont British parent company and in 1958, following the creation of the Rank Organisation in 1955, Cinema Television became Rank Cintel Limited. In September 1996 Cintel was acquired by the Schroder Venture Group [5] and in March 1997 Cintel became subject to a management led buy out. This was driven by Jack Brittain-Managing Director of Cintel and Adrian Rees-Managing Director of Brimar for the 3i group. [6] Cintel is currently trading under the name CINTEL INTERNATIONAL.

In 1942, Baird's New York based company "Baird Incorporated" was acquired by the Rauland Corporation which secured a reciprocal patent arrangement with Rank Cintel. The Rauland Tube Division was later acquired by the Zenith Corporation and moved to Chicago, [7] where it ceased trading in 1999.

The demand to improve television resolution in the early nineteen thirties motivated the development of electronic scanning methods which embraced the work of many inventors; Rosing, Dieckmann, Campbell Swinton, von Ardenne, Zworykin, Farnsworth and others. This research focuses on the outcomes resulting from measures taken by Baird Television and her American sister company in response to those challenges.

The first chapter profiles the significant contributors to Baird's electronic imaging and includes an introductory section describing the mechanical scanning concepts of Paul Nipkow. There is an analysis of the contemporary television research carried out by Rosing, Dieckmann, Campbell-Swinton, von Ardenne, Zworykin, Farnsworth and Szegho. It is also shown that in 1934 a significant contribution was made by the Department of Electrical Engineering at the Royal Technical College in Glasgow, now the University of Strathclyde.

The second chapter describes in detail the principles behind the electronic television technology of Farnsworth and Zworykin with the main differences highlighted. This chapter sets the scene for the adoption of electronic television by Baird Television Ltd under the direction of Captain A. G. D. West.

The third chapter describes the television developments in Britain from 1933 by Baird Television and EMI. A 'pull-out' plan of the Baird facilities at the Crystal Palace illustrates the working environment. The technology implemented by Baird Television relating to the Baird-Farnsworth link is also detailed. A 'pull-out' technology transfer chart shows the inter-company relationships in television research which affected Baird Television leading up to 1934. Another 'pull-out' chart describes the Baird Company staff structure and departmental groupings. A description is given of the Baird cathode-ray tube facility which was developed for the production of high quality electronic television receivers, and an introduction is given to the development of the image dissector known as the Baird electron camera.

The fourth chapter introduces the Baird and Marconi-EMI trials conducted by the BBC at the Alexandra Palace. There is a description of the implications of the devastating fire which razed the Crystal Palace and the Baird Television facility to the ground. Despite the suggestion [8] that the Baird electron camera perished in the Crystal Palace fire of 30 November, 1936, it will be shown that such an assembly remained in place at the Alexandra Palace until the end of the system trials in 1937. A section analyses 'television system resolution' by comparing the Baird and Marconi-EMI specifications. The case is presented and evidence cited that the definition attainable from Baird's 240-line sequential system was slightly higher than that of the 405-line interlaced system.

The fifth chapter, supported with evidence from recently located Baird material deals with stages in the development of cinema television. The case is presented that J. L. Baird and Szegho of Baird Television were separately leading, but in different aspects of large screen projection television.

The sixth chapter looks at Baird Television during the Second World War and commences with a description of the breakthrough in the sensitive photosurfaces made by Dr Sommer at the Sydenham factory. A description is given of the development of the Baird iconoscope cameras by Dr Samson. A section covers Szegho's employment in the US in 1940 with the American Baird Company, which in 1942 was acquired by the Rauland Corporation. Szegho's contributions to the war effort while working for Rauland are described. A brief description is given of telecine work, and another section describes a secret project involving the British, Russian and French Air Ministry. Cinema Television, Sydenham are shown to be the main contractor for the manufacture of the Skiatron radar tube and the chapter is concluded with a description of the highly secret war work carried out in the Rotunda.

The seventh chapter analyses the achievements of Baird Television/Cinema Television personnel and reflects upon John Logie Baird's individual achievements. It will be shown that many of the engineers and scientists who worked for Baird Television went on to become eminent in the industry.

The work is concluded with a glossary, appendices and a complete listing of the British patents of J. L. Baird and his associates at Baird Television.

References: Introduction

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CHAPTER 1

The Renaissance of Television

Frontispiece: John Logie Baird
1888 - 1946

List of Illustrations Chapter 1

Section 1.1

Progressive Image Scanning

Figure 1.1: Paul Nipkow

The process of converting an image into a continuously variable electrical signal, to be sent and received by wire, was first described by Paul Nipkow (Figure 1.1) in his visual telegraph patent of 1884 [1] This very advanced document revealed a method by which an image could be systematically scanned into elemental points by means of a rotating perforated disc. It is interesting to note that although this patent became the master plan for a myriad of television experimenters, it appears that Nipkow never built and tested the device. This was probably due to the fact that Nipkow recognised that most of the technology required to demonstrate the idea was not available. His theory would not be made practical for another forty two years. On 2 October 1925, John Logie Baird successfully used the Nipkow scanner with modifications of his own design to dissect and reconstruct the image of a human face. [2]

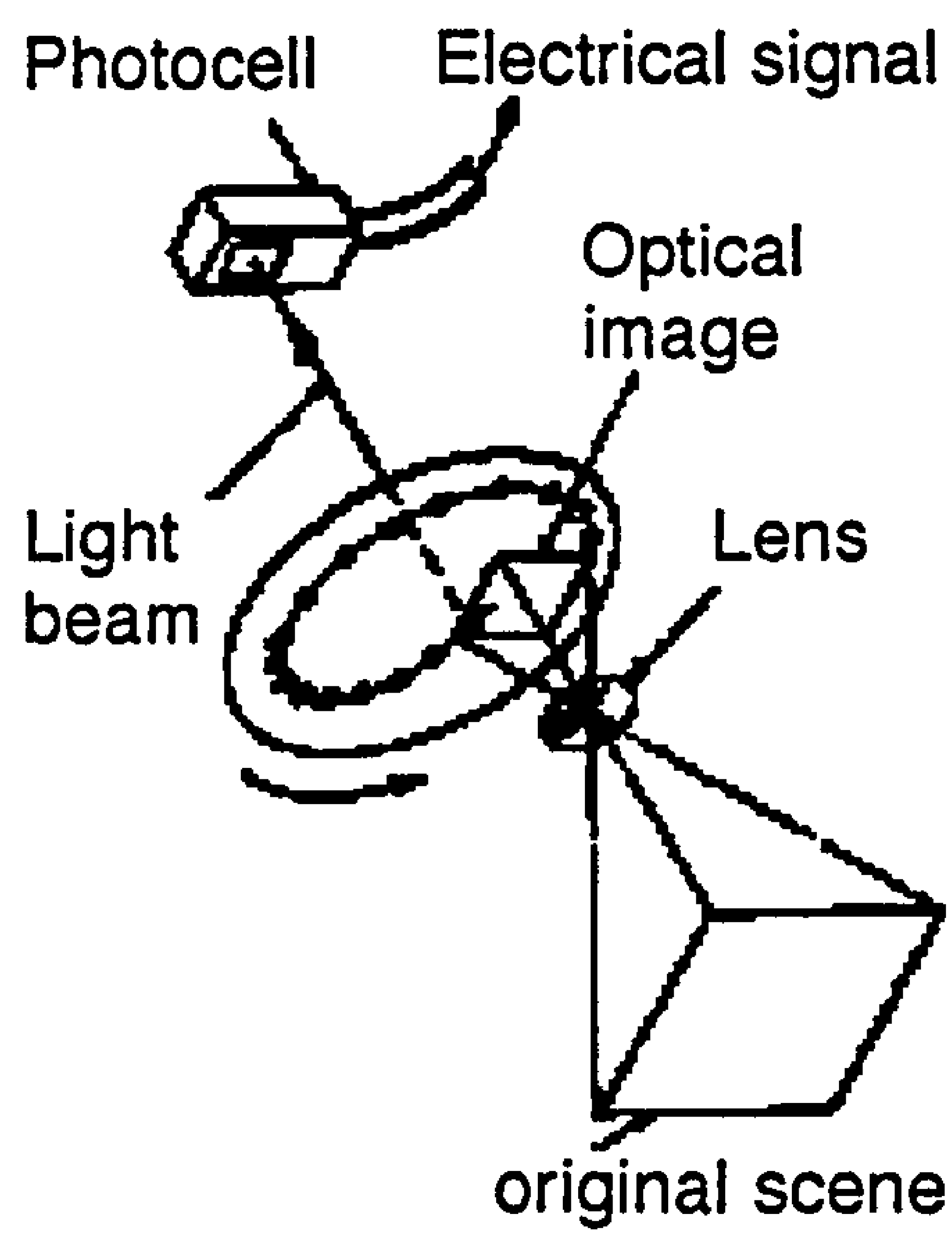


Figure 1.2: The Nipkow Scanning Disc

The concept of progressive mechanical scanning is best described with reference to Figure 1.2. Light focused from the original scene reaches the surface of the rotating scanner by means of a lens. At any given time one of a series of apertures describing a spiral around the disc, allows light from the scene to reach a photocell. The purpose of the photocell is to produce an equivalent level of electrical current to represent each element of the scanned picture. Consider the case of a spiral of thirty equally spaced apertures around the disc: The vertical distance between the apertures represents the height of a scene. As the disc turns the innermost aperture will describe a series of pin points of light in the form of an arc (almost a straight vertical line) onto a photocell. The next aperture of the spiral scans another vertical line of the image but this time slightly to the right. Each aperture in turn will individually scan an arc of the image until the entire picture area, from bottom to top and left to right has been coarsely scanned. With every cycle of rotation of the disc one complete frame of a thirty line image is produced and converted to a serial electrical signal by the photocell. The speed of rotation is selected to enable, by persistence of vision, the human retina to retain a complete picture or frame when viewed through the scanner. John Logie Baird set the speed of rotation to seven hundred and fifty revolutions per minute giving a picture frequency of twelve and a half frames per second:

$$\frac{750}{60}\text{ RPM} = 12.5 \text{ revolutions per second}$$

$$\text{Therefore: frame period} = \frac{1}{12.5} = 0.08 \text{ seconds}$$

During this frame period the photocell can register a continuous electrical vision signal in the range from 12.5 Hz to approximately 13,000 Hz. This is equivalent to the typical response available from replaying a good quality music cassette. Clearly this was quite an achievement by J.L.Baird in the mid to late nineteen twenties using the available valve technology. The highest frequency of the Baird's vision signal is calculated from the speed of disc rotation, the number of apertures in the spiral and the detail required per line. Baird set the height of the image to be seventy changes from black to white during a line which in electrical terms is the equivalent of thirty five square waves occupying the time of one line. Therefore the highest frequency (F_{max}) of the signal obtained from the scanning disc can be calculated as follows:

$$\text{Line period} = \frac{\text{Frame period}}{\text{number of perforations}}$$

$$\text{Therefore: Line period} = \frac{80}{30} \times 10^{-3} = 2.67 \times 10^{-3} \text{ seconds} = 2.67 \text{ ms}$$

$$\text{Pixel period} = \frac{\text{line period}}{\text{number of elements}} \quad \frac{2.67}{35} \times 10^{-3} = 76.29\ \mu s$$

And as frequency is the reciprocal of time. $F_{max} = 13{,}109$ Hz

Figure 1.3: Singer Jane Carr and her televised 30 Line image, November 1932.

The aspect ratio of seven high by three wide was selected by J. L. Baird as the optimum required for head and shoulders images based on the limitations of early valve amplifiers.

At the receiving end, a means was provided to enable the scanning disc to be rotated in perfect synchronism and isochronism (speed and position) with the transmitter. A light source positioned behind the scanner was modulated by the received vision signal to produce the correct brightness for each element of the picture. Persistence of vision (not fully satisfied at a rate of twelve and a half frames per second) rendered an animated and flickering replica of the original scene on the retina when the modulated light was viewed through the scanning disc. Figure 1.3 gives a good indication of the quality achieved from a 30 line Baird televisor in 1932. Note the heavy make-up on the artist's face to compensate for the severe loss of resolution caused by bandwidth restrictions imposed by medium wave band radio where a single channel must not exceed 8KHz. The problem results from the loss of the smallest picture detail (highest resolution) which exists in the television signal between 8KHz and 13KHz.

These narrow channels are a requisite of broadcasting on the medium waveband (200 to 500 metres) which has a total band width of 900KHz. In comparison, a modern 625 line television transmission extends from above 500 metres down to below 50 metres and occupies a total bandwidth of 6MHz in an allocated 8MHz channel space. Modern wideband television is made practicable by the use of ultra shortwave, microwave (and cable network) broadcasting.

Despite the encouraging results achieved, Baird and others were aware of the inherent limitations of mechanical scanners, such as problems of rotational inertia and poor sensitivity. This led Zworykin and Farnsworth to consider alternative systems utilising methods employing electronic scanning. Zworykin would take a new and independently different approach for his electronic camera, but Farnsworth's approach was to produce an inertia-free, electronic analogue of the Nipkow disc.

Section 1.2

Electronic Images

This research identifies the expertise demonstrated by John Logie Baird and his companies in the development of electronic imaging systems. Prior to this J. L. Baird had shown versatility and competence in both mechanical and electrical engineering in the process of developing mechanically scanned television. The earliest of Baird's television methods involved electronic devices such as thermionic amplifiers, filters and wave-shaping circuits. Earlier research [3] indicated that Baird's first television pictures were obtained by combining the flying spot scanner with an advanced electronic image enhancing circuit of his own design. J. L. Baird had discovered that he could achieve greatly improved sensitivity by reversing the location of the photocell and the light source. Instead of floodlighting the subject, and trying to amplify the reflected light, which was below the useful sensitivity of selenium, he scanned the subject with an intense spot of light and collected the larger levels of reflected light with selenium. He also applied electronic image enhancing circuits known today by the industry as 'aperture control' circuits which are widely used in video recorders to sharpen the otherwise soft pictures produced. It is also a tribute to J. L. Baird that the flying spot scanning technique, perfected by Cinema Television (incorporating Baird Television), was adopted by the modern television industry as the standard method for transferring film to video media.

The desire for higher definition television in the early nineteen thirties brought about a renaissance in the art of television, leading Baird and others to originate and develop higher resolution electronic image scanners. While initially Baird Television had meagre resources to carry out the high vacuum work required, the results obtained by other workers in this field were more than challenging. The directors of Baird Television considered electronic television to be a genuine threat to the success of their company and in 1934 they took the following actions:

1. Began negotiations to obtain a license to manufacture and develop the electronic apparatus demonstrated by the American television pioneer Philo Farnsworth.
2. Identified experts in the field of electron vacuum physics to work on cathode-ray tube, photocells and electronic camera research.
3. Planned to develop and manufacture a range of all-electronic cathode-ray tube television receivers .

To achieve this Baird Television employed the technology of Philo Taylor Farnsworth and hired three specialists, Dr Alfred H. Sommer (photo sensitive surfaces and photo tube design), Dr Kurt A. Samson (electronic camera tube design) and Dr Constantin S. Szegho (cathode-ray tube design).

To place Baird and his company's involvement with electronic scanning and cathode-ray tubes into context the following sections review the contemporary work in electronic television leading up to this period.

Section 1.3

Blueprint of a System

Figure 1.4: Philo T. Farnsworth

Philo Taylor Farnsworth (Figure 1.4) was born in the United States of America on 19 August, 1906, near Beaver, Utah. As a six years old he first became fascinated by the telephone and gramophone in his home. When his father told him they were created from the minds of clever people he came to the conclusion that inventors were truly special people. He hoped that one day he would become an inventor. [4]

In 1919 the Farnsworth family moved to a ranch near Rigby, Idaho. Elma G. Farnsworth wrote in her memoirs of her late husband: [5]

> "Philo was overjoyed to find the ranch powered by a Delco power system. Of equal or greater importance to him was the stack of radio, popular science, and semi-technical magazines he found in the attic of his new home, left by the former owner who had installed the power system."

The magazines encouraged Farnsworth to learn more about science and invention but his father and uncle were not impressed with the reliability of the electricity generator. When the maintenance costs could no longer be sustained and the generator failed after a recent repair Philo offered to help. He explaining to his father that he had watched the service engineer on several occasions and was sure that he could repair it. Lewis, his father had a great deal of confidence in his son's ability and after consideration gave his consent. Philo carefully took the mechanism apart, wiped away heavy oil deposits and accurately reassembled the generator.

Elma Farnsworth wrote: [6]

> "He had a very interested audience as he stood back and, with an outward show of confidence, pushed the 'on' button. An audible sigh of relief was heard as the generator came to life and ran like new. Uncle Albert slapped Philo on the shoulder and pronounced him officially the 'engineer in charge of the generator.' When his father hugged him and said, 'Good work, son,' the pride swelling within him almost burst his buttons."

Proud of his new status Farnsworth began to experiment with electricity. One of his first successful projects was the repair of a burned-out electric motor which he connected to the mechanical crank of their washing machine. He also installed lights in the barn to help with the practicality of early morning and late evening chores. These incidents describe the first of many interesting parallels between the lives of Farnsworth and J. L. Baird, who at the age of thirteen constructed an electricity generator and installed lights at his home in Helensburgh, Scotland. [7]

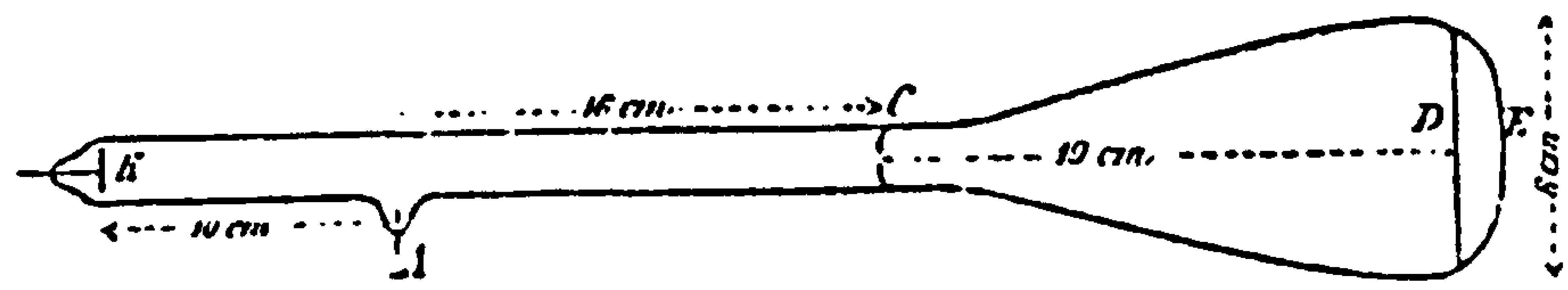


Figure 1.5: Diagram of the Braun CRT 1897

Farnsworth read about the possibilities of sending pictures by means of radio waves using Paul Nipkow's concept of rotating discs with a spiral of holes. [8] He clearly recognised the need to dissect an image into a consecutive signal but he thought that the mechanical aspects of scanning were clumsy and inadequate. In 1921, the Farnsworth family moved to a farm in Bybee four miles from Rigby, Idaho. In his continuous quest for knowledge Farnsworth learned about Albert Einstein's famous 'Theory of Relativity'. He also read about the first cathode-ray tube known as the 'Braun Tube' (Figure 1.5) named after the inventor in 1897: Karl Ferdinand Braun. [9]

There is a level of myth attached to most important inventions and in Farnsworth's case it has been recorded [10] that he was ploughing a field in a consecutive pattern when the idea of electronic television scanning suddenly became obvious. He theorised that perhaps the transmitting and receiving discs as suggested by Nipkow could be replaced by electrons moving in a vacuum. Farnsworth was not, however, the first to consider using cathode rays to achieve the scanning and reproduction of an image. David and Marshall Fisher wrote: [11]

"The story about electronic scanning coming to Farnsworth in a flash of insight must, however be taken with a grain or two of salt. Campbell Swinton had published his ideas thirteen years previously, and the concept of scanning was inherent in all work done with the Nipkow disk, with which Philo was familiar."

Vladimir Zworykin working with Boris Rosing in Russia and Max Dieckmann in Germany had previously carried out experiments with cathode-ray tubes as image receivers, [12] but it was A. A. Campbell Swinton in Edinburgh, Scotland, who first suggested applying them as image transmitters. On 12 June, 1908, Campbell Swinton prescribed the use of cathode-ray tubes for both image scanner and image receiver in a famous letter to Nature: [13]

"....the problem of obtaining distant electric vision can probably be solved by the employment of two beams of cathode rays (one at the transmitting end and one at the receiver) synchronously deflected by varying fields of two electro magnets placed at right angles to one another...."

Campbell Swinton improved his plan for distant electric vision which he described at the presidential address to the Roentgen Society in 1911. [14] He stated that this was an idea only and that the apparatus had never been constructed. Despite the prior art, Farnsworth would employ unique and ingenious methods to his system for electronic scanning television.

Farnsworth was aware that he required a good education to realise his target but the family were not wealthy and unfortunately in 1919 their circumstances deteriorated.

Elma G. Farnsworth wrote: [15]

"He and his father had worked very hard on their farm, resulting in a very good harvest. However, the great post World War One depression hit and there was no market for their farm products. Unable to make the payments, they lost the farm."

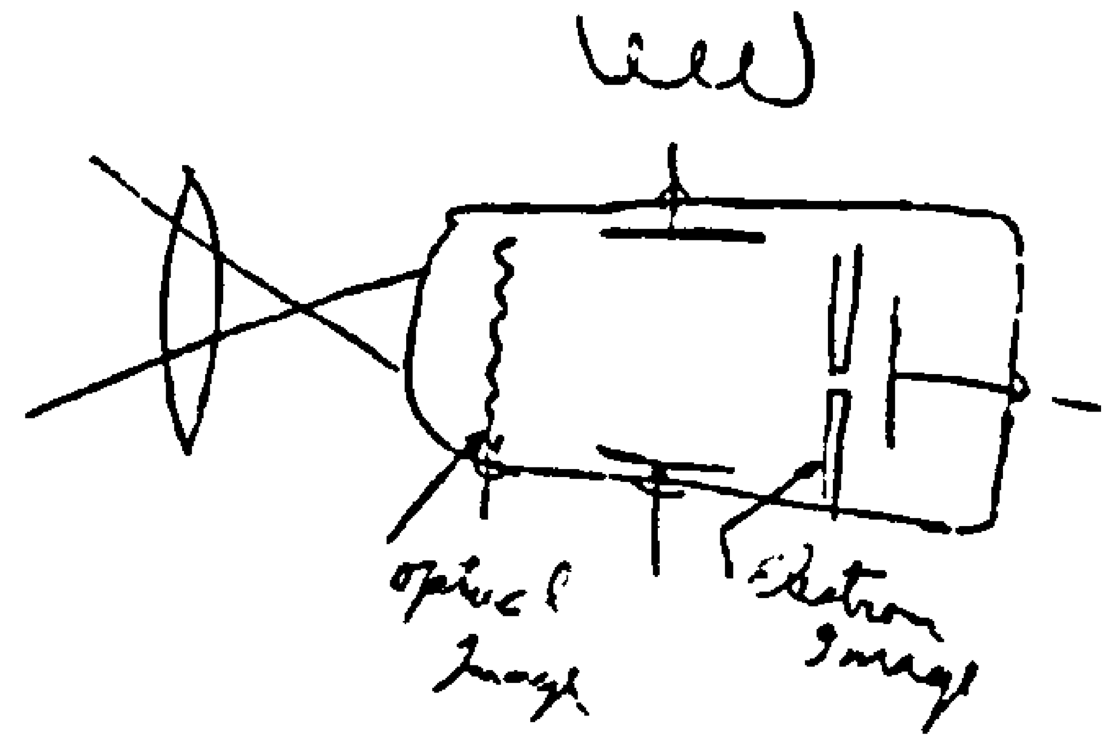


Figure 1.6: Sketch from Farnsworth's notebook

In September, 1921, Farnsworth entered Rigby High School determined to gain sufficient knowledge to realise his ambition to develop a system of electronic television. Farnsworth signed up for maths and science but was refused chemistry. He was told this was "strictly for senior students," however, a compromise was reached which allowed him to sit-in during chemistry lessons. When his chemistry teacher Justin Tolman saw that Farnsworth was capable of the class work he arranged that credits be awarded provided he received extra tuition. It was agreed that Tolman would tutor him after school hours. One afternoon Tolman arrived for the tutorial class to discover Farnsworth at a chalkboard which was covered with diagrams and equations. Farnsworth, feeling the need to discuss his idea with someone he could trust, revealed his theory for an electronic television scanner. To help with the description Farnsworth made a sketch of the device he had conceived. (Figure 1.6.) He then removed the page from his notebook and gave it to Tolman who agreed that the idea did seem to be possible. (See Section 2.3). This drawing was later cited as important evidence in the defence of Farnsworth's system in a legal patent battle with the Radio Corporation of America (RCA).

Soon after the disclosure to Tolman it became necessary for Farnsworth to leave school to work with his father on a leased farm.

Figure 1.7: Elma (Pem) Gardner

Figure 1.8: Cliff Gardner

Although this was a serious academic upheaval Farnsworth and his father produced a good harvest enabling the settlement of outstanding debts.

During 1922 Farnsworth gained an electrician's license after completing a correspondence course with the National Radio Institute. He became a junior railway electrician and used his first wages to attend courses at the University of Utah. In 1923 he became a student at Brigham Young University where due to the hiatus in his education he was enrolled as a special student and allowed to complete his high school credits.

Paul Schatzkin wrote: [16]

> "The Farnsworth family moved into a two family house in Provo. The other half of the house was occupied by the Gardner family. Cliff, the oldest of the two Gardner boys, was nearly the same age as Phil and since the two boys shared a common interest in radio and things electrical, they became close friends."

Other friendships between the neighbours soon developed and Elma (Figure 1.7) Cliff Gardner's sister became engaged to marry Farnsworth. Cliff Gardner (Figure 1.8) and Farnsworth put their minds together to form a

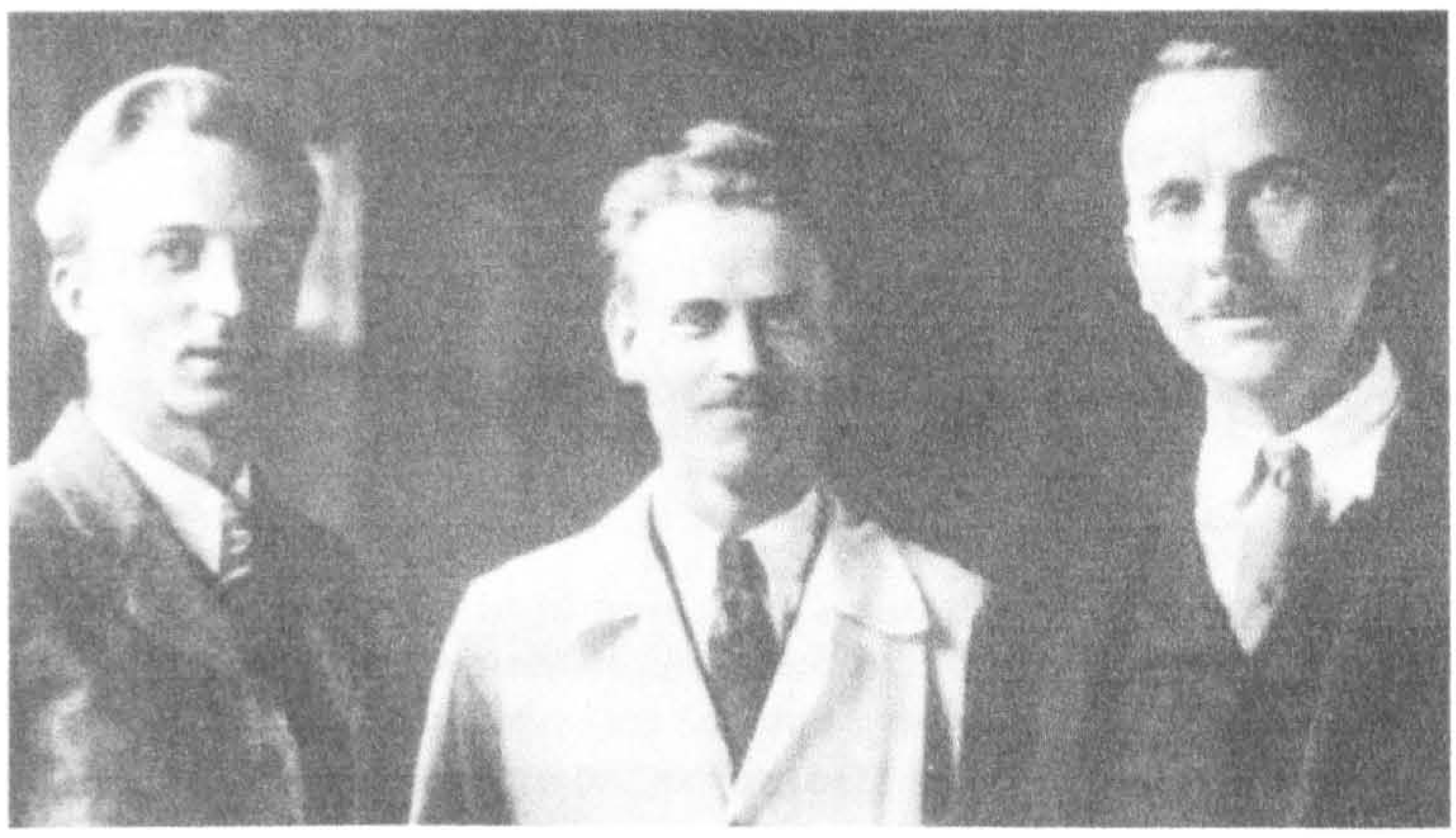


Figure 1.9: Gorrell, Farnsworth and Everson

business but their first venture of installing and repairing radio sets in Salt Lake City failed. Feeling disillusioned, Farnsworth was on the verge of revealing his idea for electronic television to the 'Popular Science' magazine in the hope of receiving a one hundred dollar fee. But he was averted from publishing on the advice of Cliff Gardner who warned him that it would be a mistake he would regret. [17] This was very fortunate as an opportunity for Farnsworth to develop electronic television was already on the horizon.

George Everson and Lesley Gorrell (Figure 1.9) were professional fund raisers who hired Farnsworth and Gardner to help organise a local Community Chest Campaign in Salt Lake City. When they asked him about his plans for the future they listened intently as Farnsworth's ideas for electronic television unfolded. [18]

David E and Marshall J. Fisher wrote: [19]

> "Farnsworth had no money to take out a patent on his ideas and he had the same obsessing fear that stalked Baird: his conception of television seemed so simple, so obvious, that surely someone else would think of it tomorrow. "

Despite a lack of technical knowledge Everson and Gorrell were impressed by Farnsworth's confidence in electronic television and formed a business partnership. Farnsworth owned fifty percent of the venture while the remaining fifty percent was divided equally between Everson and Gorrell. Everson had six thousand dollars of personal savings in an account in San Francisco which he was prepared to risk on Farnsworth's idea. Gorrel, who had little cash to invest at the time promised to cover half the costs and both men agreed that Farnsworth would owe them nothing if the project failed.

On 27 May, 1926, Farnsworth and Elma (Pem) Gardner married and moved to the City of Los Angeles to set up both home and make-shift laboratory at 1339 North Hampshire Street in Hollywood. But, television had already become a fact! Earlier in that year, on 26 January, John Logie Baird in England amidst a plethora of scientific scepticism, surprised the world by demonstrating that electro mechanical methods could render recognisable television images across space. [20]

While Farnsworth would have to concede to second place his strength lay soundly in the direction of electronic scanning. His adversary was not Baird, but a man he had yet to learn about. A man who already had significant experience in the design of electronic television and who was much closer to home.

Section 1.4

Birth of Electronic Television

Figure 1.10: V. K. Zworykin

Vladimir Kosma Zworykin (Figure 1.10) born on 3 June,1889, in Mourom, Russia, 200 miles east of Moscow, would become a significant electronic television pioneer.

David and Marshall Fisher wrote: [21]

> " - his father had a wholesale grain business as well as a steamship line on the Oka River. Vladimir enjoyed an idyllic childhood as a member of Russia's pre-revolutionary upper-class bourgeoisie. He lived in a huge stone mansion and grew up happily diverted by horseback riding, hunting and croquet."

He studied at the St. Petersburg Technological Institute under Professor Boris Rosing (Figure 1.11) who had been trying to transmit pictures. His apparatus consisted of a two polyhedral mirrors' scanner (The Weiler mirror drum scanner later to be used by Baird) and a cathode-ray tube receiver (Figure 1.12). According to Abramson, [22] Rosing's Russian patent of 25 July, 1907, [23] is second in importance to the original Nipkow patent of 1884. [24] Rosing firmly believed that the solution to practical television could be found in the development of cathode-ray tubes.

Figure 1.11: Dr Boris L. Rosing

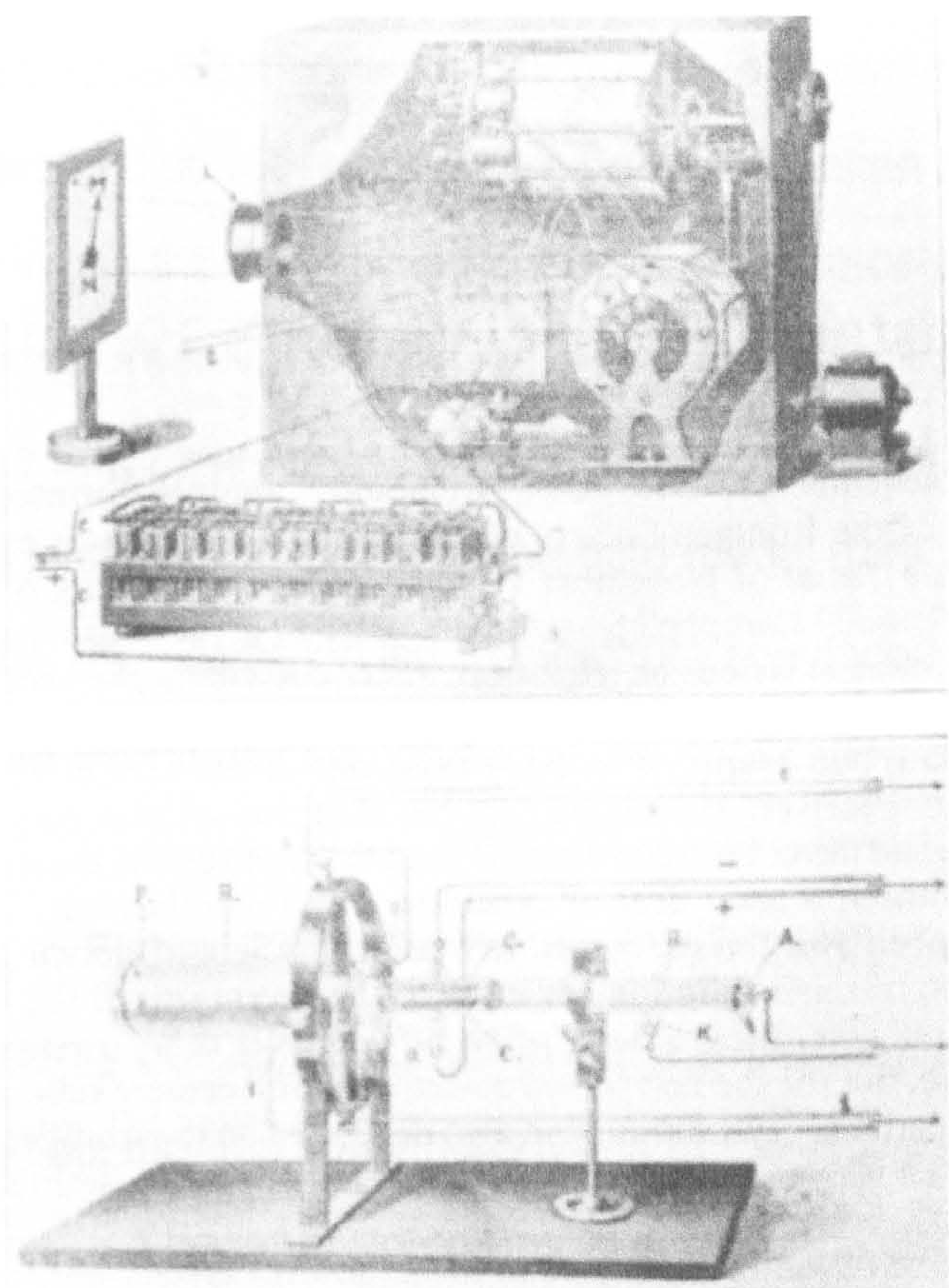


Figure 1.12: Rosing's transmitting (top) and receiving apparatus

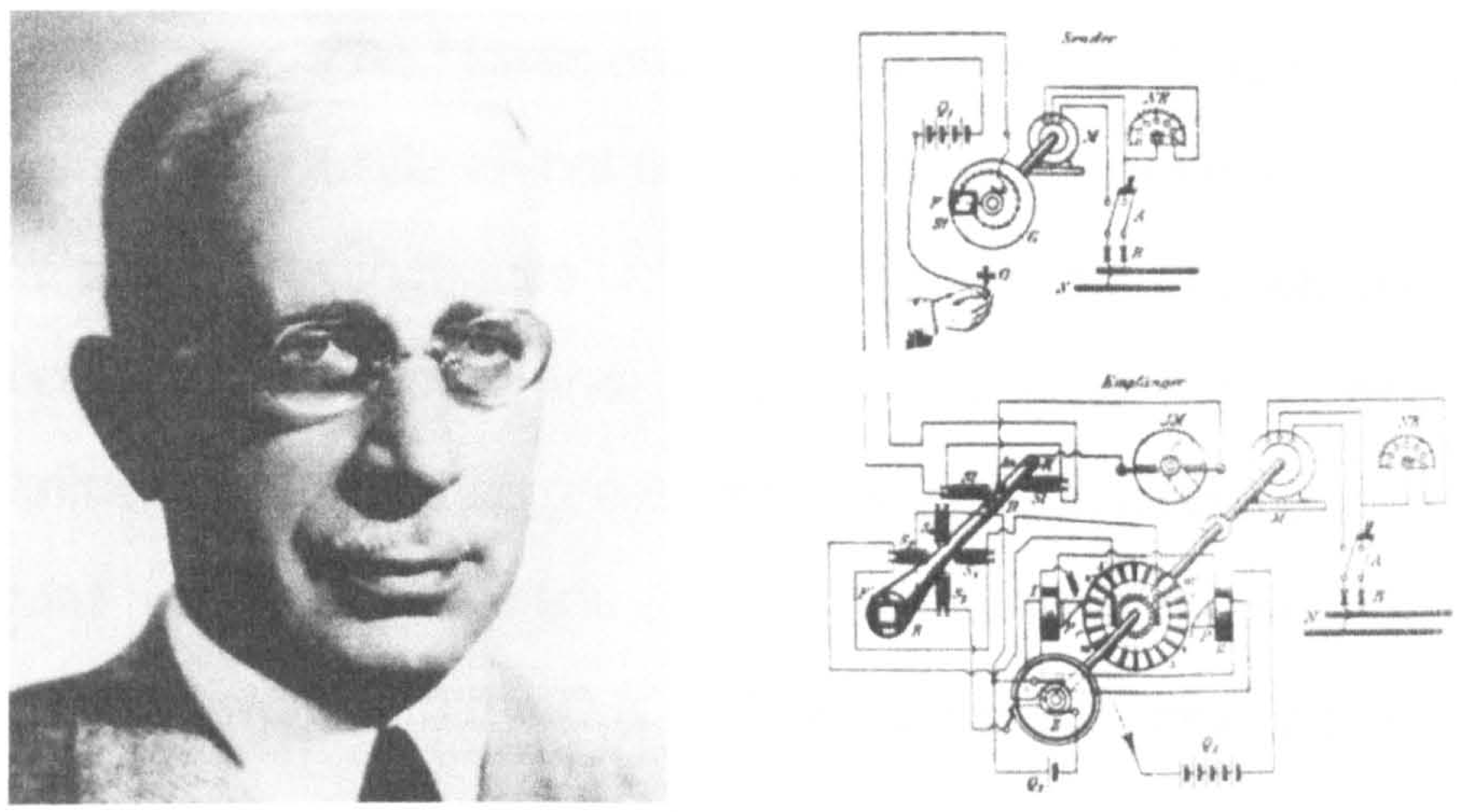


Figure 1.13: Max Dieckmann and his Braun Tube Apparatus 1909

Abramson, [25] also indicated that in 1909, Max Dieckmann of Munich had built and operated apparatus consisting of a unique transmitter (Figure 1.13) using a rotating disc with twenty wire brushes to scan a picture on a metal template. While this system did not involve a photoelectric television transmitter the image receiver comprised a cold cathode Braun cathode-ray tube. By the time that Zworykin received his electrical engineering degree in 1912 Rosing's system was awarded the gold medal from the Russian Technical Society. [26] Zworykin left the Institute convinced that the problem of television would eventually be solved by the application of electronics.

According to Fisher, [27] during the next year Zworykin worked at the prestigious laboratory of Paul Langevin in Paris experimenting with X-rays. He spent the next six months studying physics at the university in Berlin but discovered that he had become an enemy alien with the declaration of war in 1914. He returned hastily to Russia where he was mobilised into the army as a radio engineer and after a further year was posted back to St Petersburg. Zworykin emigrated to the United States of America in 1919.

In 1977, Zworykin stated: [28]

"I was a dreamer. I had ideas and I wanted to work. I found that under the conditions in Russia at that time, work was impossible."

His first job at the Westinghouse Laboratories in Pittsburgh was assembling vacuum tubes on a production line. Gradually he moved on to research photoelectric emission but had great difficulty in interesting the company with his ideas for all-electronic television. After leaving Westinghouse for a year and a half to work with the C & C Development Company of Kansas City he returned to perform television research with more freedom. [29]

On 29 December,1923, Zworykin applied for an electric television system patent. [30] Two concepts which Zworykin evolved helped to make future television practical. He is credited with inventing the iconoscope television camera and the kinescope television picture tube. It is claimed that Zworykin demonstrated a system combining these elements to Westinghouse executives. The transmitted pattern was said to have been a cross projected on the target of the camera tube, and that a similar cross appeared with low contrast and rather poor definition on the screen of a cathode-ray tube. This indicated that his devices were sound but needed much improvement. On the same day that Zworykin applied for his first electric television patent, J. L. Baird applied for a British patent [31] which suggested the adoption of the flying-spot system. [32]

At this time a young Hungarian, later to find his future in television development, was embarking on a university education in Munich. This was Constantin Stephen Szegho, who would study under Dieckmann and develop cathode-ray tubes under the leading electro-physicist in Germany.

Section 1.4

Developing the Cathode-Ray Tube

Figure 1.14: Dr C. S. Szegho

I write this section in the knowledge that the world has recently lost one of the unsung pioneers in the field of television cathode-ray tube development. In 1991, I was fortunate to locate and record an interview with Dr Szegho (pronounced sagoo) which spanned a period of two weeks at his home in Illinois, USA. Correspondence continued until his demise in 1995, through letters and regular 'packages' containing a number of items including unpublished Baird source material. Over the relatively few years that we corresponded, I learned not only more of the history of television, but also of his deep and unreserved concern about world affairs and in particular the plight of his fellow man. The following has been produced from the transcripts of those recorded interviews, documents and other material substantiating his work.

Born on 15 March,1905, in Nagybocsko, Hungary, Constantin

Stephen Szegho (Figure 1.14) was educated at the Cistercian High School, Pecs. He was fascinated by what is today termed as electronics. Szegho's boyhood experiences were in some ways comparable to those of John Logie Baird being punctuated with scientific experiments which began with home made telephones. He repeated the experiments of Volta and others by activating the muscles in frogs legs using a self-built dynamo. When radio broadcasting was still in its earliest stages of development Szegho successfully received wireless waves by means of a primitive radio detector called a coherer. This simply comprised a glass tube containing a globule of mercury between two plugs and which could convert a weak radio signal into an audible sound. This he later improved by using a 'cat's whisker' crystal detector. He also built a device known as a 'Tesla transformer' capable of generating thousands of volts which produced relatively harmless electrical arcs reaching over several inches. One of Szegho's greatest achievements before embarking on a university education in 1923 was the construction of one of the first sensitive regenerative radio receivers in Hungary.

Szegho's father, a company manager, encouraged him to study for a business career but his mother, a social worker, thought that he should become a doctor. With his inclination leaning towards science he felt that he should compromise and study electrical engineering. After a short period at the Institute of Technology in Budapest he entered the Institute of Technology in Munich arriving at the time of the Hitler putsch. This placed him on the Odeonsplatz in 1924 where he had the misfortune of witnessing the Bavarian State Troops opening fire on the marchers led by Field Marshal Ludendorf. After four years of study at the Institute in Munich

Szegho received his degree of electrical engineering.

In 1928 Szegho moved to Aachen in Germany for post-graduate research under Professor Walter Rogowski. Rogowski's speciality was research on and with cathode-ray tubes, and as the foremost electro-physicist in Germany was the editor of a leading journal 'Archive für Eletrotechnik'.

Szegho wrote: [33]

> "These were continuously pumped oscillographs, which are large two metre high instruments designed to register the very fast phenomena of travelling waves. When electricity in a high voltage line encounters a termination of a certain resistance then a wave is reflected back. Instruments are needed to register these events to enable the accurate location of faults on high voltage overhead electrical power lines. "

Szegho worked on the perfection of these instruments with approximately twenty other post graduate students.

Szegho stated: [34]

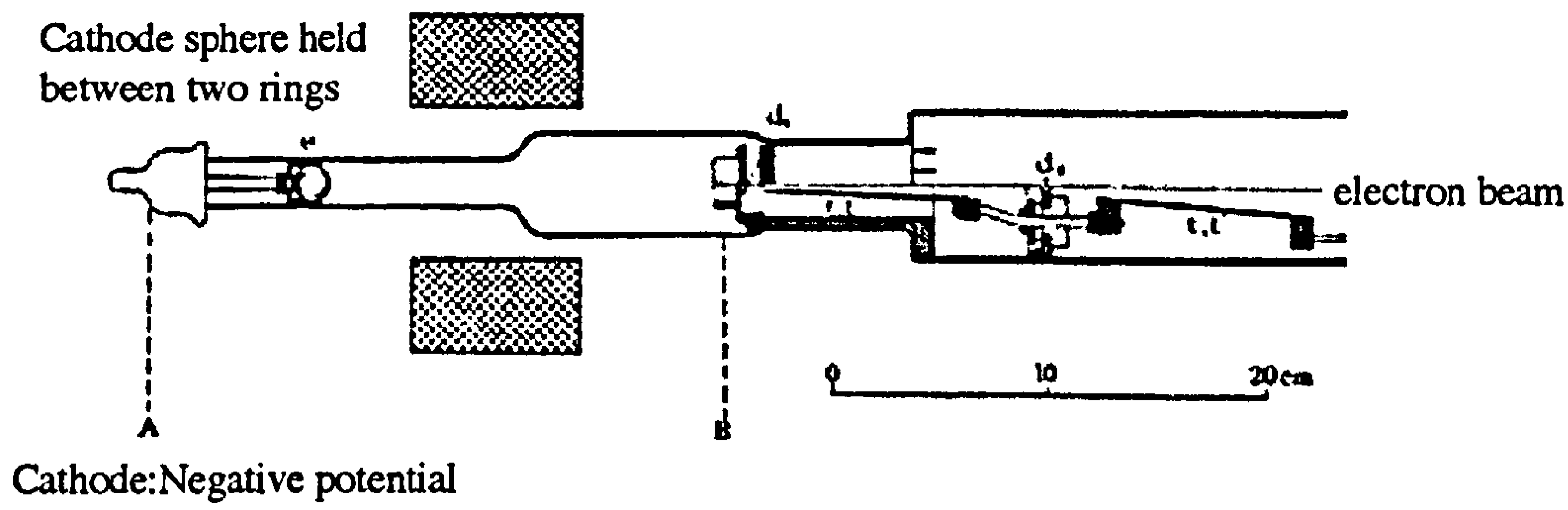
> " Rogowski persuaded me to work on a sealed-off cathode ray oscillograph with a capability similar to the much larger, continuously pumped instruments."

Early fast writing speed cathode-ray tubes operated with a cold cathode and required an extremely high positive accelerating potential from ten to seventy thousand volts at the anode.

Macgregor-Morris and Henley: [35]

> "The recording of transients of duration of the order of less than twenty microseconds cannot be accomplished with low voltage oscillographs because the penetrating power of the electron beam, which depends

By applying a gentle tapping action to the neck of the tube, the sphere rotates between the rings to present a more useful area of cathode.



Section of Szegho's Renewable Cold Cathode Tube.

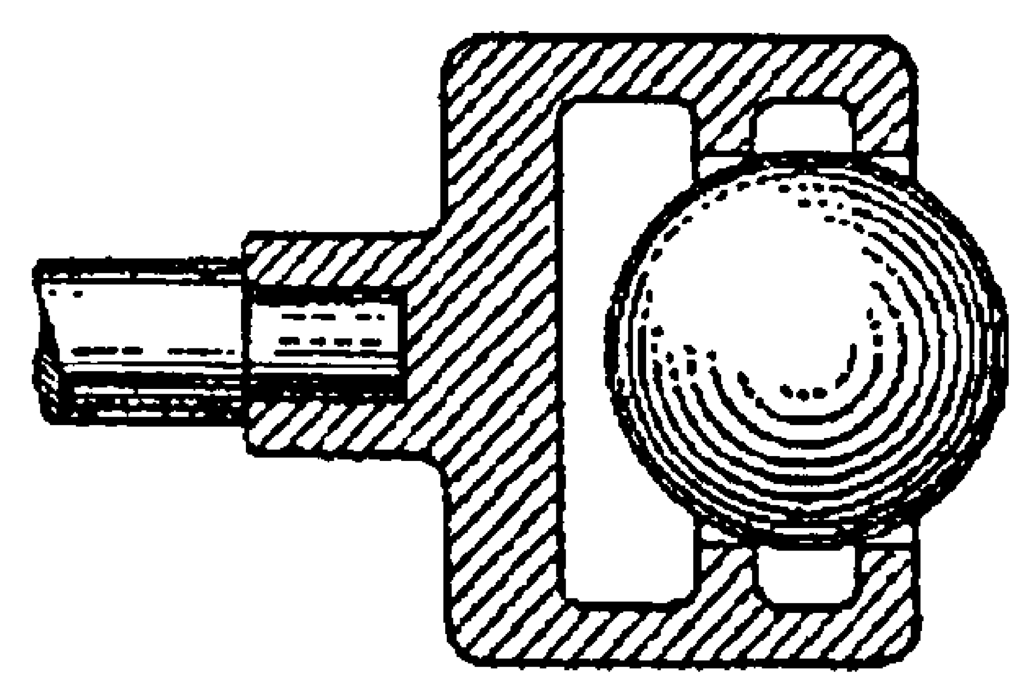


Figure 1.15 Detail of Szegho's Cold Cathode

upon the square of the accelerating voltage, is insufficient to give a measurable trace on a photographic emulsion."

A disadvantage of using such a high accelerating anode potential was the production of a crater in the cathode which after only a few hours of operation restricted the electrons required to produce the beam. Correcting the problem involved the inconvenience of returning the tube to atmospheric pressure and reworking the cathode. As part of Szegho's doctor of engineering thesis he was given the task of solving the problem of the offending crater. Szegho's idea was to redesign the cathode using a one inch diameter aluminium sphere to be retained by friction between two rings (Figure 1.15.) In theory when the beam failed, a fresh surface could be presented to the field by rotation of the sphere within the rings. It was proposed that rotation of the internal sphere would take place by gently tapping the surrounding glass on the neck of the tube. However, his first attempt at rotating the cathode presented a slight problem.

Szegho wrote: [36]

> "The parts inside the tube had, of course, to be completely degreased before evacuating. Then the inevitable happened. After fabrication and some preliminary experiments the above-mentioned crater formed and the electron emission dropped. The time came to tap the neck of the tube to rotate the cathode but the degreasing operation had seized the aluminium sphere against the rings and it would not move."

It seemed to Szegho that his entire PhD was now at risk. Rogowski gave him a useful piece of advice: [37]

> "Absent oneself from the scene if one encounters problems which seem unsolvable at the time and think about them in a removed environment."

The problem of the seized cathode was now the subject matter of Szegho's contemplation removed from the scene. His decision was to apply more than a generous force to the neck of the discharge tube instead of gently tapping it. He returned to the laboratory and applied some very pronounced bangs to the glass! Newton's law of action and reaction worked, the cathode rotated and Szegho's thesis was saved. This novel cathode was recorded as 'Szegho's Cold Cathode' by Macgregor-Morris and Henley in 1926: [38]

> "The cathode has been successfully used by Szegho in a sealed oscillograph with an operating life of over 1000 hours......It is found that if a sphere of 4 cms. diameter is used it has more than 400 useful positions."

After four years in Aachen and graduating as doctor of engineering

Szegho was retained as a Teaching Assistant. Rogowski had plans to exploit commercially Szegho's instrument as a tool for fault locations on high voltage overhead electrical power lines. The system operated by sending electrical travelling waves down faulty power lines and measuring the time taken for the reflected wave to return. This was recorded externally by taking a photograph of the trace which appeared on the oscillograph's internal aluminised fluorescent screen. Successful demonstrations had taken place by sending waves from Aachen into the Tyrol on the overhead lines of the AWE (the electricity generating network of the Rhineland). A company in Cologne, Hochspannungs-Gesellschaft, was commissioned to market the product and build the required high voltage transformers while Dr Hans Rumpff of Bonn constructed the rest of the hardware. [39]

With the rise of Nazi control in Germany, Szegho's position was undermined and terminated by the 'Minister of Instruction' with the remark that, "this post must be filled by a German." Szegho remained without pay at Rogowski's request for a few months to meet their first customer Professor Parker-Smith from the Royal Technical College in Glasgow (University of Strathclyde). Impressed by Szegho's ability, Parker-Smith invited him to work in Glasgow as a Temporary Assistant to support the apparatus (Figure 1.16). Szegho was given a research grant on the 8 June, 1934, by the Royal Technical College.

Szegho stated: [40]

"The Spring in the Scottish Highlands and the Scottish people, after the Nazis, and the friendly atmosphere at the college, were a welcome change. Of course, oscillographs were already made by Cossor and by others that was not new, but I had duplicated the performance of a

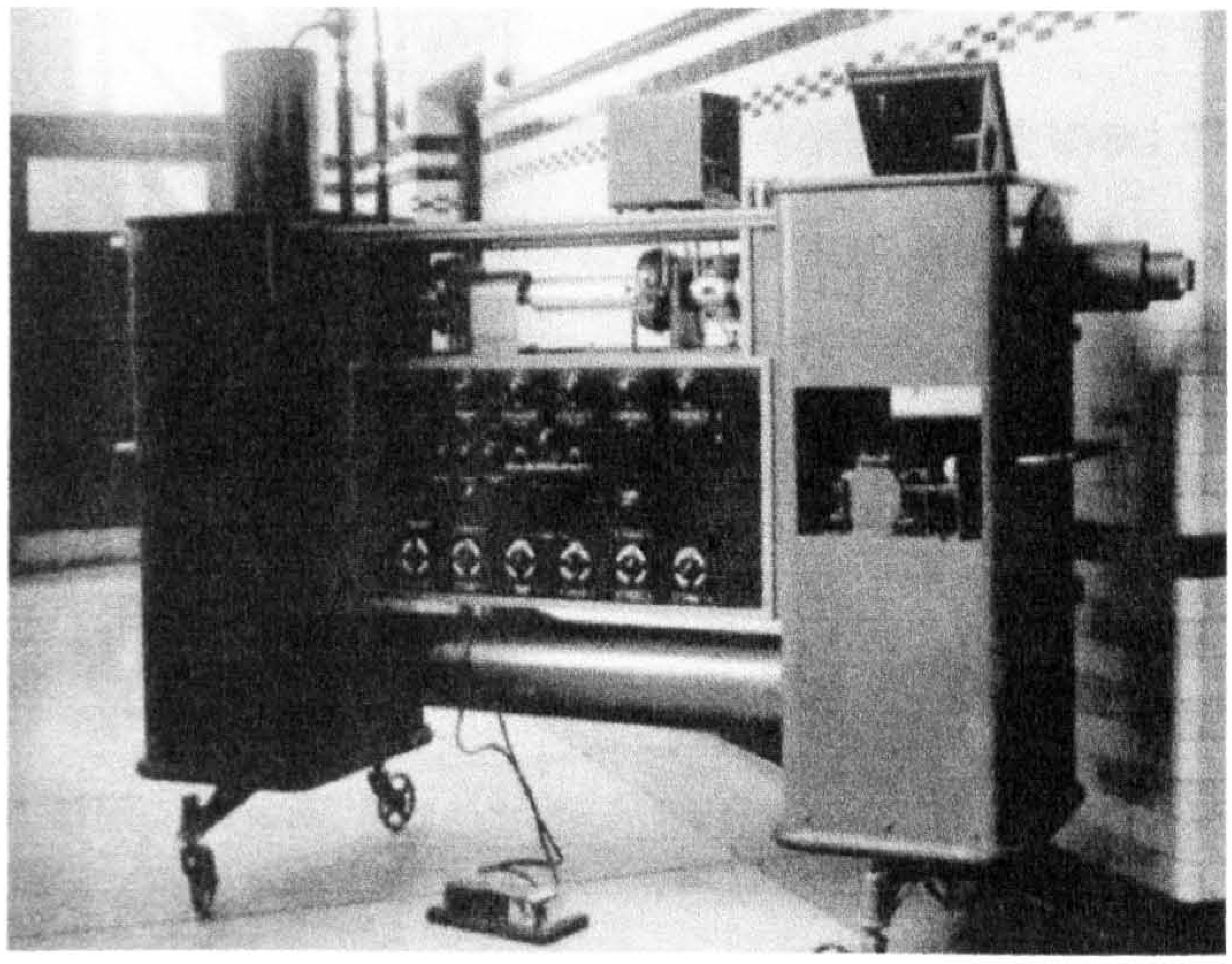


Figure 1.16: Szegho's fast writing speed oscillograph at the Royal Technical College 1934

continuously pumped instrument which permitted registering single traces written in a fraction of a microsecond, using a sealed-off tube."

On completion of his remit on 10 December, 1934, Szegho's temporary engagement with the Royal College was officially recorded: [41]

"Giving valuable instruction in the technique of the new cathode ray oscillograph and also in preparing a paper on this subject to be read at a meeting of the Institution of Electrical Engineers in London."

The outcome of Szegho's work was published in the proceedings of the Glasgow Technical College, [42] and in the above mentioned IEE Journal. [43] Szegho wrote: [44]

"One of the most decisive times of my life was a visit to a German radio exhibition in Berlin. I saw some of the first television pictures on a cathode-ray tube among the exhibits of von Ardenne, Telefunken, and Fernseh AG. I felt that my work, hitherto with a sealed-off cathode-ray tube was sufficiently close to what I saw and made a conscious decision to work in electronic television."

There were two possibilities which Szegho planned to pursue, the first being an arrangement to meet up with Zworykin who was due to arrive in Berlin on a recruitment drive, while the other, through a letter of introduction to the Baird family in Helensburgh, was the Baird Television Company.

The next chapter will introduce the competitive television technology of Farnsworth and Zworykin.

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CHAPTER 2

The First Electronic Television

Figure 2.1: Farnsworth's Dissector-Multiplier Camera October 1934

List of Illustrations **Chapter 2**

Section 2.1

The Race for Electronic Television

Figure 2.2: Crocker-Bishop Research laboratory,
202 Green Street, San Francisco

Baird was the pacemaker with his demonstration of the first working television system on 26 January 1926, [1] however, Zworykin and Farnsworth, in the USA were independently racing to be first with an advanced system of electronic television.

On 27 May, 1926, Philo Farnsworth set up a make-shift laboratory in an apartment at 1339 North Hampshire Street, Los Angeles. Late in the summer of 1926, Farnsworth connected together the various component parts of the electronic circuit and the first image dissector tube. This glass vacuum tube had taken two months of trial and error to produce. Based on Farnsworth's original concept of electronic television, this venture had cost partners, Leslie Gorrell and George Everson, six thousand dollars from personal funds. The partners watched in anticipation along with Farnsworth's wife Elma as the system took shape. Unfortunately, the situation turned to disappointment when it became apparent that in haste, Farnsworth had overlooked one very important specification. The DC generators he used produced a very high surge of power for an instant during start-up. The sensitive apparatus should have remained disconnected or switched off until after this surge had occurred. Inevitably during 'switch-on' a rush of electric current surged through the apparatus instantly destroying the circuit and taking with it the first untested image dissector.

Elma Farnsworth wrote: [2]

> "I knew what a terrible shock this was to him. I could see the thoughts whirling in his head. Was this to be the end of his dream?"

Gorrell and Everson, although disappointed, were not easily dissuaded from the project. But, they decided that more confidence was required before they could convince others to finance the television scheme. It was decided that Farnsworth's ideas should be tested, verified and supported. A patent attorney and an expert from the Californian Institute of Technology were elected to critically interview Farnsworth and appraise the image dissector concept. Farnsworth revealed his scheme in confidence and presented the technical information before this panel of 'experts'. The outcome was positive. Farnsworth had a novel concept which although daring appeared to be technically feasible. With renewed confidence Everson visited the Crocker Bank in San Fransisco with a view to raising the sum of twenty five thousand dollars.

Elma Farnsworth [3]

> "The backing syndicate proposed to put up the money and act as trustees for 60 percent of the venture. Of the remaining 40 percent, Phil was to have 20 percent and George and Les were to divide the other 20 percent."

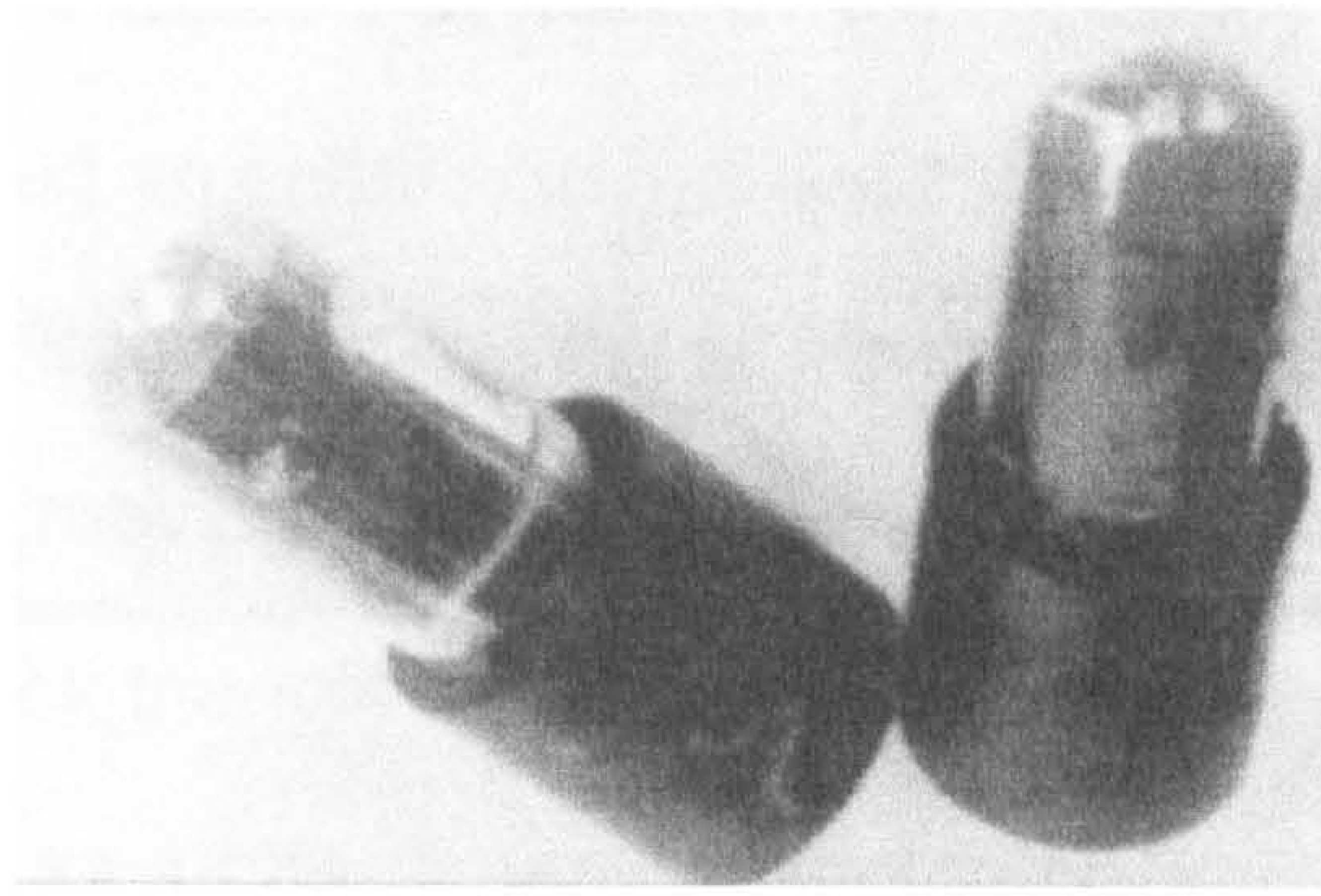
Figure 2.3: Image Dissectors 1927

Farnsworth returned to electronic television on a more realistic scale on 22 September 1926, and established a television research section in the loft of the Crocker-Bishop Research Laboratory (Figure 2.2). Crocker the head of the Crocker Bank had been advised by business partner Roy Bishop (a successful capitalist and engineer) that Farnsworth was a good risk. Cliff Gardner, Farnsworth's former business partner and brother-in-law was called upon to work on the precision glass envelope for the image dissector tube. Elma Farnsworth assisted with secretarial work and helped with technical draughtings. Bill Cummings, a professional glass technologist from the University of California, assisted them with the image dissector flask and trained Gardner in the art of glass blowing.

On 7 December 1927, Farnsworth applied for his first television patent [4] entitled 'Television System.'

Based on an entry in Farnsworth's notebook dated 7 September 1927, Abramson wrote: [5]

> "It is claimed that on 7 September, 1927, he was able to transmit an 'image' from one of his early camera tubes. It was no more than a moving blob of light that was reproduced on a receiving tube, but it proved his new system would work."

Abramson [6] indicated that the Farnsworth family had never accepted that Zworykin operated an electronic camera tube at an earlier date. The image dissector tube shown on the left of Figure 2.3 was used for the above demonstration. The 'moving blob' is described by Everson [7] and Hofer [8] as the image of a black triangle from a transparency. Elma Farnsworth described the image as a one-dimensional moving line. [9] During a year of refinements to the design the image quality significantly improved [10] according to the report from a press demonstration on September, 1928. Burns wrote: [11]

> "The demonstration consisted of the transmission of silhouettes and films but not of television in which the light is reflected from an object was used ..... The received images were displayed on a cathode-ray tube screen and were 1.25 x 1.5 inches in size. They had to be viewed preferably in a darkened room because of their faint brightness."

Farnsworth was not unique with the dissector concept. (Section 2.3 gives a technical description of the image dissector.) The earliest disclosure is a German patent applied for on 5 April, 1925 by Dieckmann and Hell. [12] Figure 2.4, illustrates this device showing two sets of magnets for deflection. Hell indicated that they had built the tube but could not make it function. [13] This was issued on 3 Oct. 1927, ten months after Farnsworth's US patent application of 7 January, 1927. [14] A British patent [15] for an electron image camera tube describing a similar process, was applied for on 22 June, 1928, by Roberts. However, there is no indication that Roberts was any more successful than Dieckmann and Hell. Therefore, the first 'working' image dissector is attributed to Philo Farnsworth.

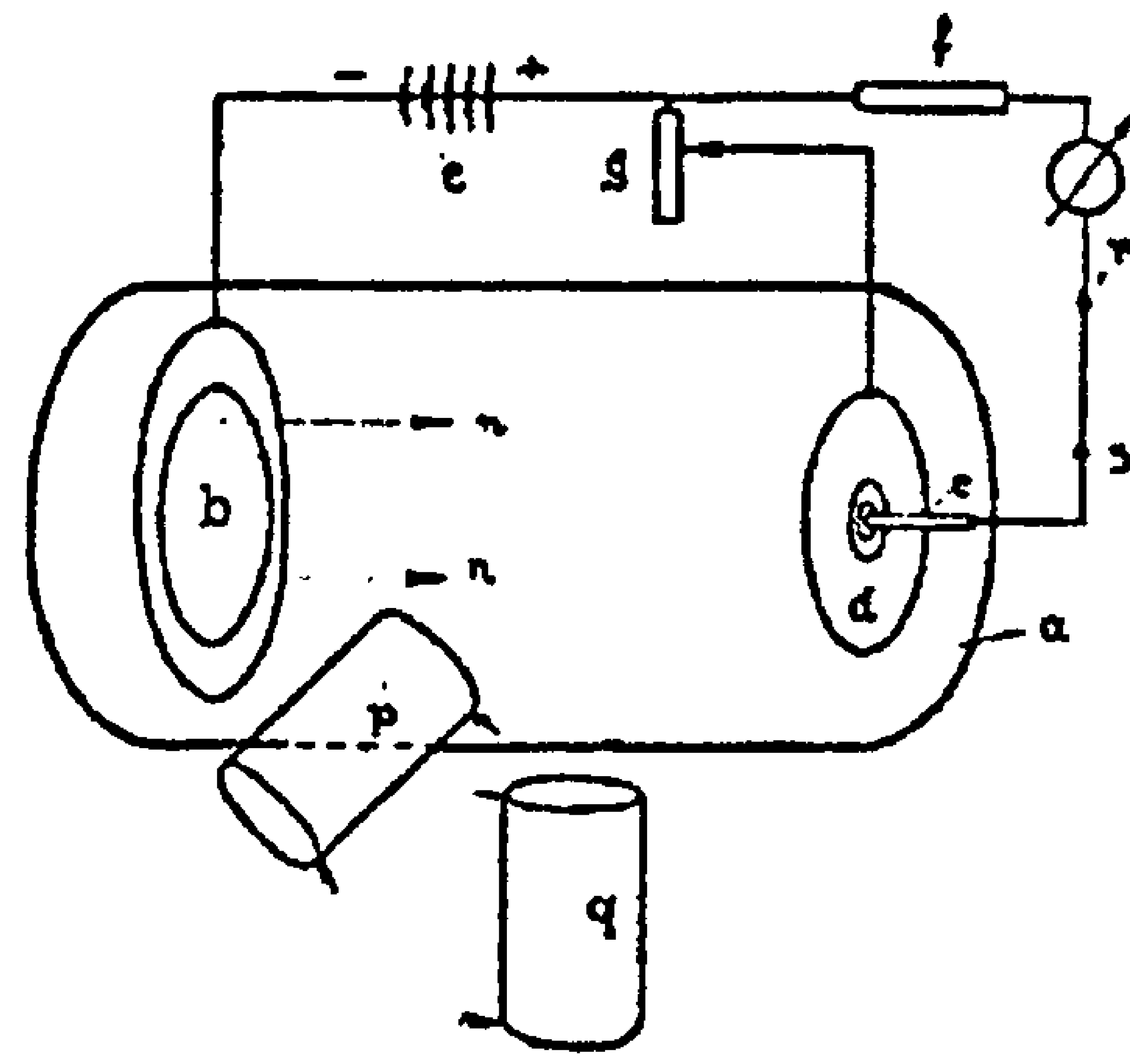

Figure 2.4: Max Dieckmann and Rudolf Hell's similar patent 5 April 1925

While it appears that Farnsworth was first to render an electronic image from an electronic camera tube, Zworykin, believed that he should have priority based on an earlier demonstration to Westinghouse executives during the period 1923-1925. This was a claim which proved difficult for Zworykin to defend. Abramson [16] indicated that despite several claims made by Zworykin, that he had operated a television system as early as 1923, no real evidence was found to prove that this ever took place. Abramson [17] disputes that Farnsworth, 'had the only operating camera tube in the world in 1927', and argued that Zworykin operated the first camera tube sometime between the middle of 1924 and the end of 1925.

Although relying on anecdotal evidence Burns wrote: [18]

> "In the late summer/early autumn of 1925, Davis, Kitner and Schairer witnessed a demonstration of Zworykin's television scheme. 'A small cross was held in front of the transmitter cathode-ray tube and its image appeared on a screen at the end of the receiver cathode-ray tube."

Abramson is convinced that Zworykin was first: [19]

> "This created a problem for me until I discovered the Westinghouse Memo dated 25 June 1926. It was actual evidence that tubes, both transmitting and receiving, had been built and operated. "

The Westinghouse Memo was entitled "Problems of Television, Closing Report." Abramson quoting from this Memo wrote: [20]

> "This comes from the archives of the Westinghouse Labs in East Pittsburgh. This was in the form of a Westinghouse Research Report R429A (marked "Confidential"), dated June 25, 1926, written by V. Zworykin. This report indicated that some form of research project had been funded and worked on. It indicated that both camera and receiving tubes had been built. The difficulties in making camera tubes were noted. The project was to be temporarily discontinued in order to work on a mechanical method that was still in progress. It was planned to continue the work on new orders 6-4520 and 6-4522 (which I have not been able to find). This agrees with the decision by management to have Zworykin work on something more practical. It is to be noted that Zworykin did not participate in any of the future Westinghouse television projects."

The above Memo serves to prove only that tubes existed for transmission and reception but it does not indicate that an image was sent and received prior to Farnsworth's success.

Although, the intellectual property rights for electronic television were awarded to Farnsworth after a long and protracted patent interference against Zworykin, it appears that the question should remain open until more conclusive evidence is located. The next section describes the technology of Zworykin's first camera, the iconoscope which used the storage principle and the Kinescope television receiver tube.

Zworykin's Television Technology

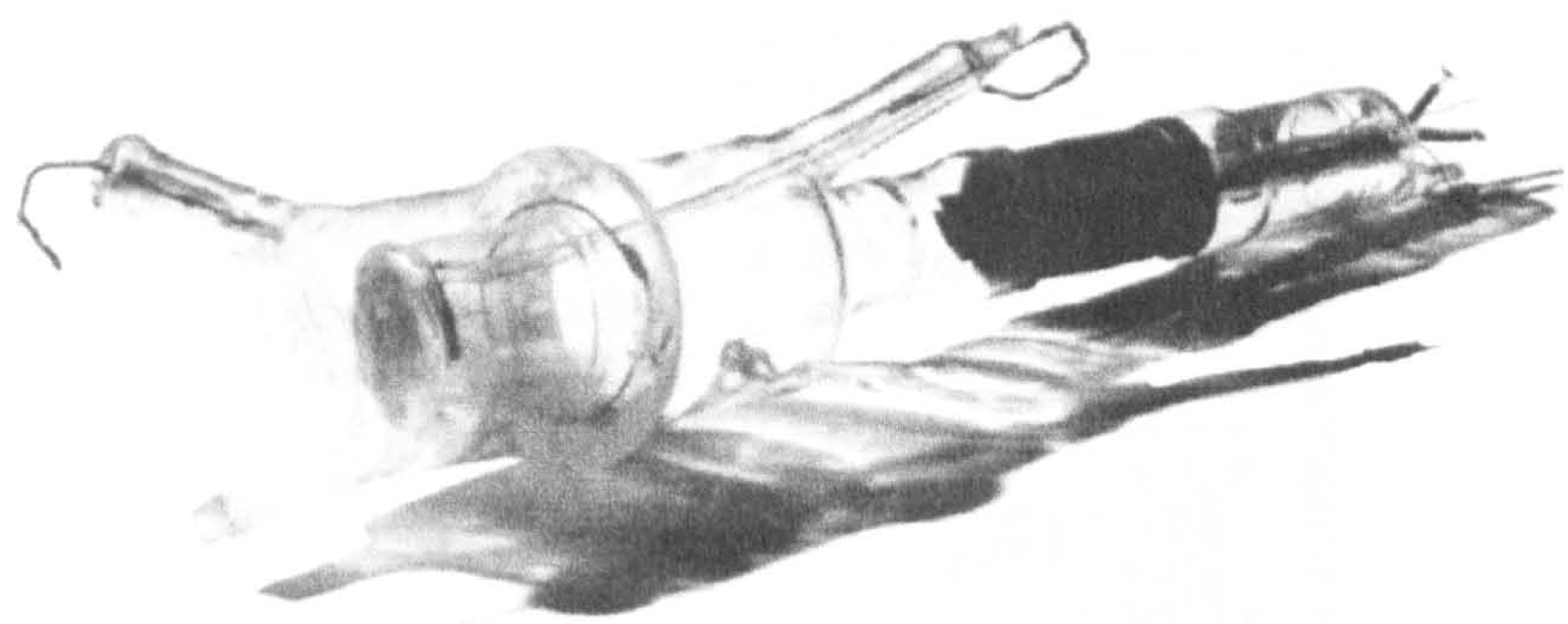

Figure 2.5: Zworykin's first camera tube

Although Farnsworth and Zworykin were independently working on electronic vacuum pick-up tubes for television their methods were quite diverse. Unlike Farnsworth, Zworykin had already gained some useful electronic television knowledge and experience from an earlier association with Boris Rosing. [21] Zworykin visualised an evacuated camera tube with an image focused on a photoelectric grid and scanned by a concentrated beam of electrons to return an electronic television picture signal.

Figure 2.5, shows the camera tube which Zworykin claimed to have demonstrated to the executives at Westinghouse. His first electronic US television patent (Figure 2.6a) was filed on 29 December 1923. [22] With reference to figure 2.6b, the sensitive area of the tube comprised of a plate of aluminium foil, (1) which it was claimed, could be easily penetrated by a beam of cathode rays (2). A layer of aluminium oxide (3) was deposited on the plate and on top of this there was a coating of a photoelectric material such as potassium hydride (4).

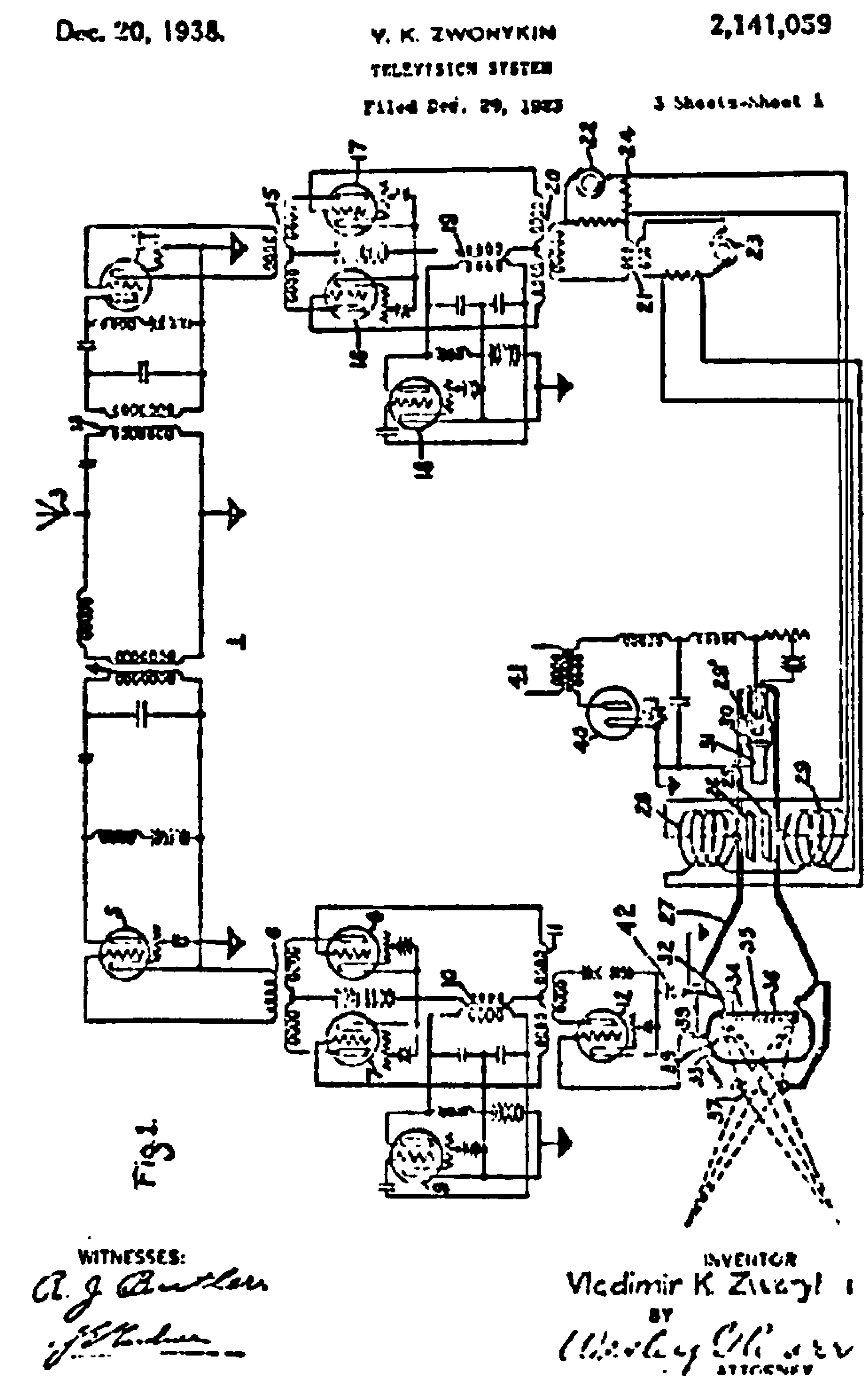

Figure 2.6a: Zworykin's 1923 Television Camera Patent

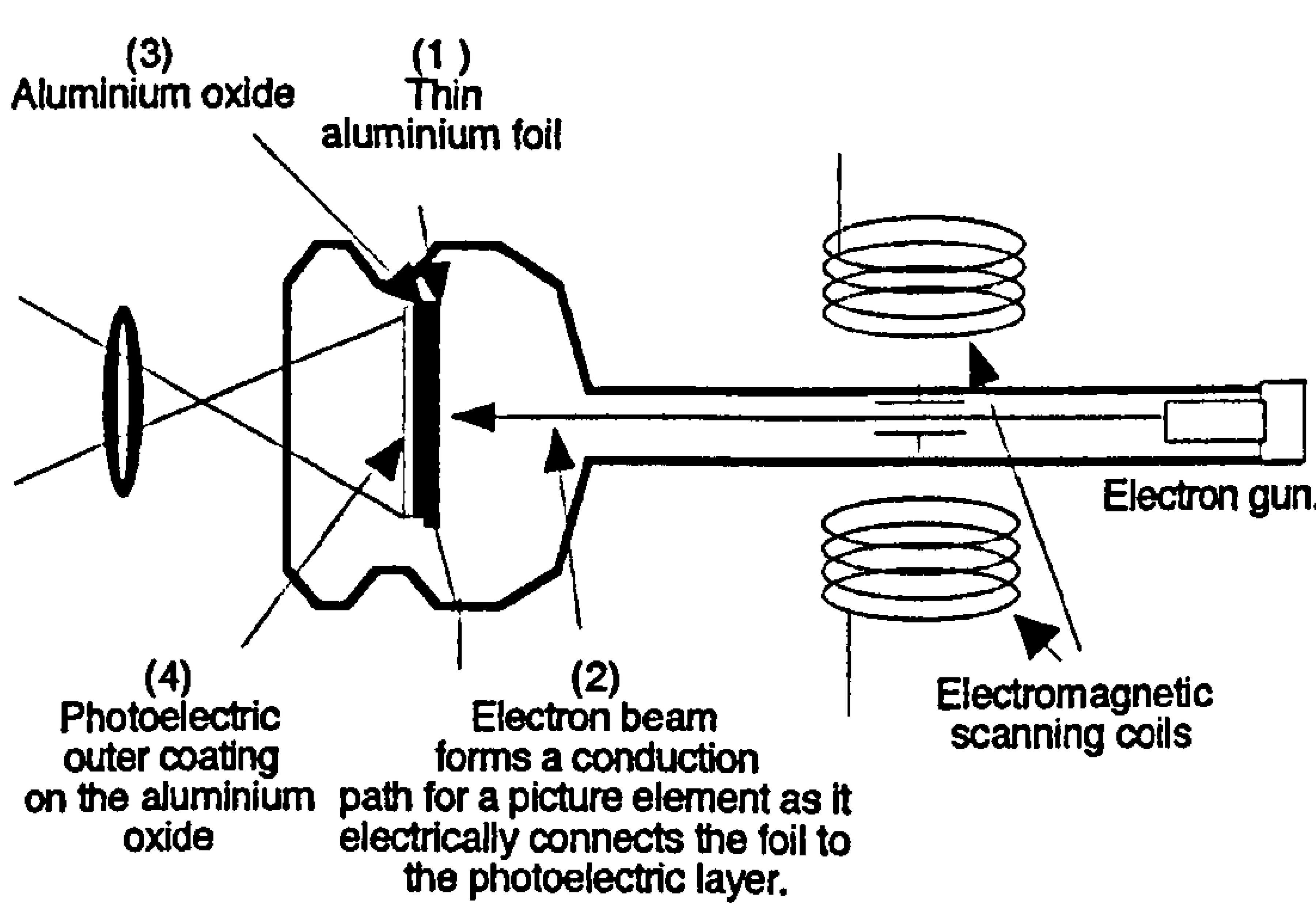

Figure 2.6b: Detail of Zworykin's 1923 camera tube

The tube was to be filled with a low pressure gas such as argon. A lens would focus light from the optical image on to the photosensitive grid to produce electron emissions in relation to brightness areas of the scene. The intermediate layer of aluminium oxide, which normally insulated the grid from the plate, was to temporarily break down to become locally conductive when penetrated by the narrow scanning electron beam in the presence of the gas. It was suggested that a sensitive valve circuit connected to the plate would return the electrical picture signal.

Abramson asserted: [23]

> "There has been much controversy as to whether a tube of this type would actually work as Zworykin described it. There was much doubt cast on the ability of the high velocity cathode ray beam to penetrate the thin aluminium foil and properly discharge the photoelectric layer."

Zworykin's first patent application did not describe the concept of a photoelectric surface which consisted of a 'matrix' of 'globules' or 'islands', which was essential to enable the 'storage' principle later attributed to success of the iconoscope.

Abramson wrote: [24]

> "Zworykin made no reference to globules until 2 October 1925, when he tried to amend his 29 December 1923, patent."

Although this amendment was rejected as being 'new material' it was included as a feature of another of Zworykin patents [25] filed on 13 July 1925, in which a colour television system was described based on the 1923 patent. Another later amendment was the name given to the device the 'iconoscope.'

Abramson wrote: [26]

> "The design of the new single sided camera tube was finalized, and on

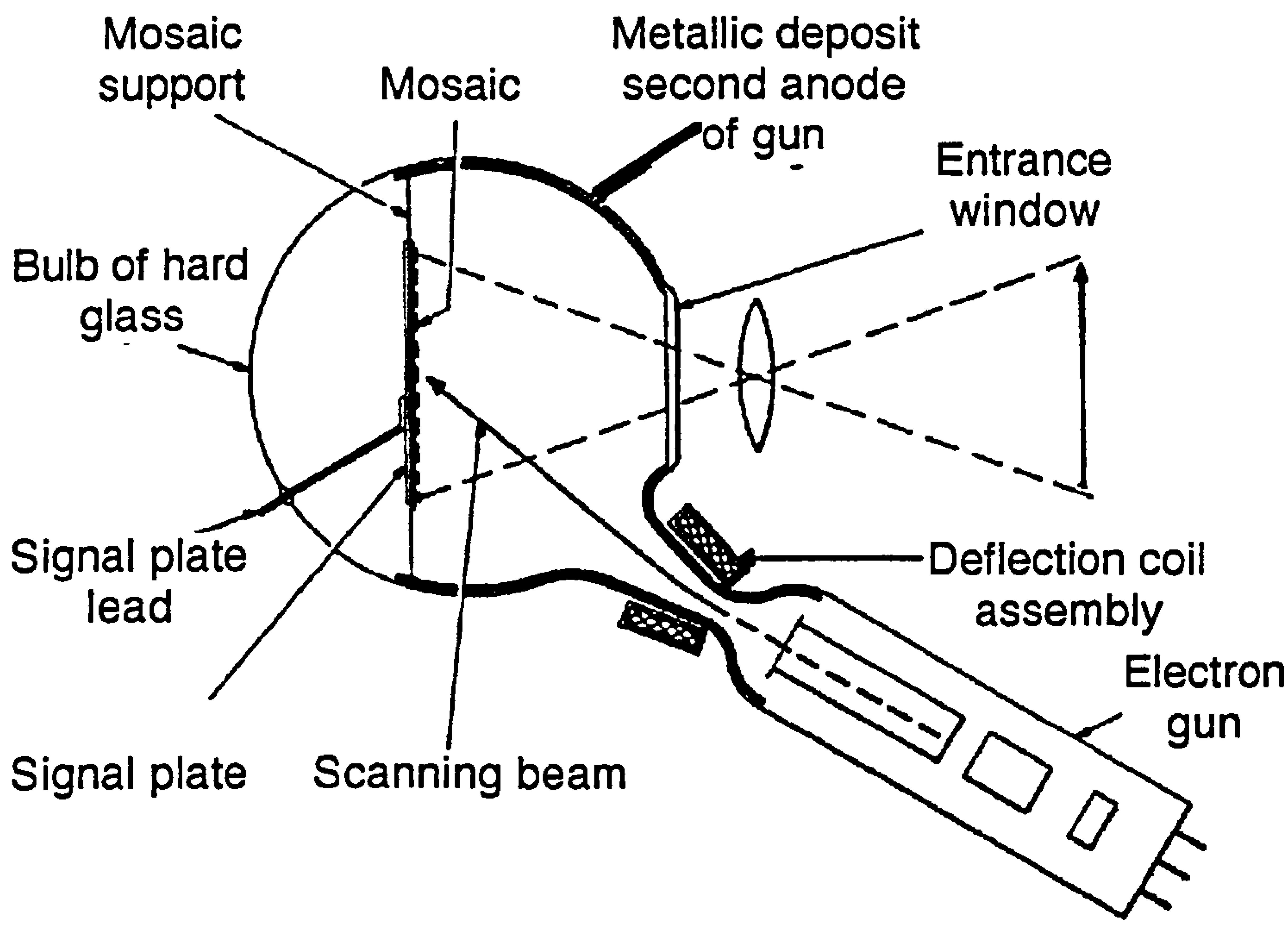

Figure 2.7: Outline schematic of the iconoscope type tube

23 October, 1931, it was named the Iconoscope...."

Turner [27] described the function of the iconoscope, see Figure 2.7:

> "The optical image is projected on to the photosensitised mosaic of silver globules so that by photoemission each element becomes charged proportionately to the elemental image brightness. Scanning by the electron beam discharges each element and produces, by capacitive coupling a series of impulses in the signal plate. These constitute the video signal."

Inherent in the theory was the assumption that the electron beam would take one complete television field to sequentially discharge each of the islands (pixels) of stored charge on the mosaic. This would in turn enable the mosaic to be given a long exposure time to the small amount of available light from the scene thus allowing the charge to accumulate over time. This long exposure time would produce a greatly enhanced image sensitivity when compared to a single aperture scanner which collects picture elements instantaneously. However, in practice, storage could only exist for a portion of a line time. McGee and Lubszynski of Marconi-EMI who worked on a British version of the iconoscope (Emitron), described the problem: [28]

> "The high potentials necessary for focusing the scanning electron beam caused the mosaic to assume a stable value of potential near to that of the second focusing anode of the electron gun. Under these conditions no field to collect the photoelectrons existed. However at the beam's point of contact with the mosaic a temporary higher potential was produced by secondary emission and this attracted photoelectrons from surrounding areas and in particular from points about to be scanned."

Maloff and Epstein [29] of the RCA research division wrote:

> ".... there is a variation in the current reaching the second anode as the mosaic is scanned. This gives rise to a spurious signal which produces irregular shading over the picture. In practice this spurious signal is compensated by means of electrical correcting networks."

Maloff and Epstein continued: [30]

> ".... the effective photoelectric emission of the mosaic in the standard iconoscope is only 20 to 30 per cent of its saturated value. This means that the overall efficiency of the iconoscope is only 5 to 10 per cent. In spite of this inefficiency, the very great advantage resulting from the use of the storage principle makes the iconoscope a very effective pickup tube."

On November 1929, Zworykin first described the 'Kinescope' [31] this was an evacuated cathode ray display tube utilising both electrostatic and

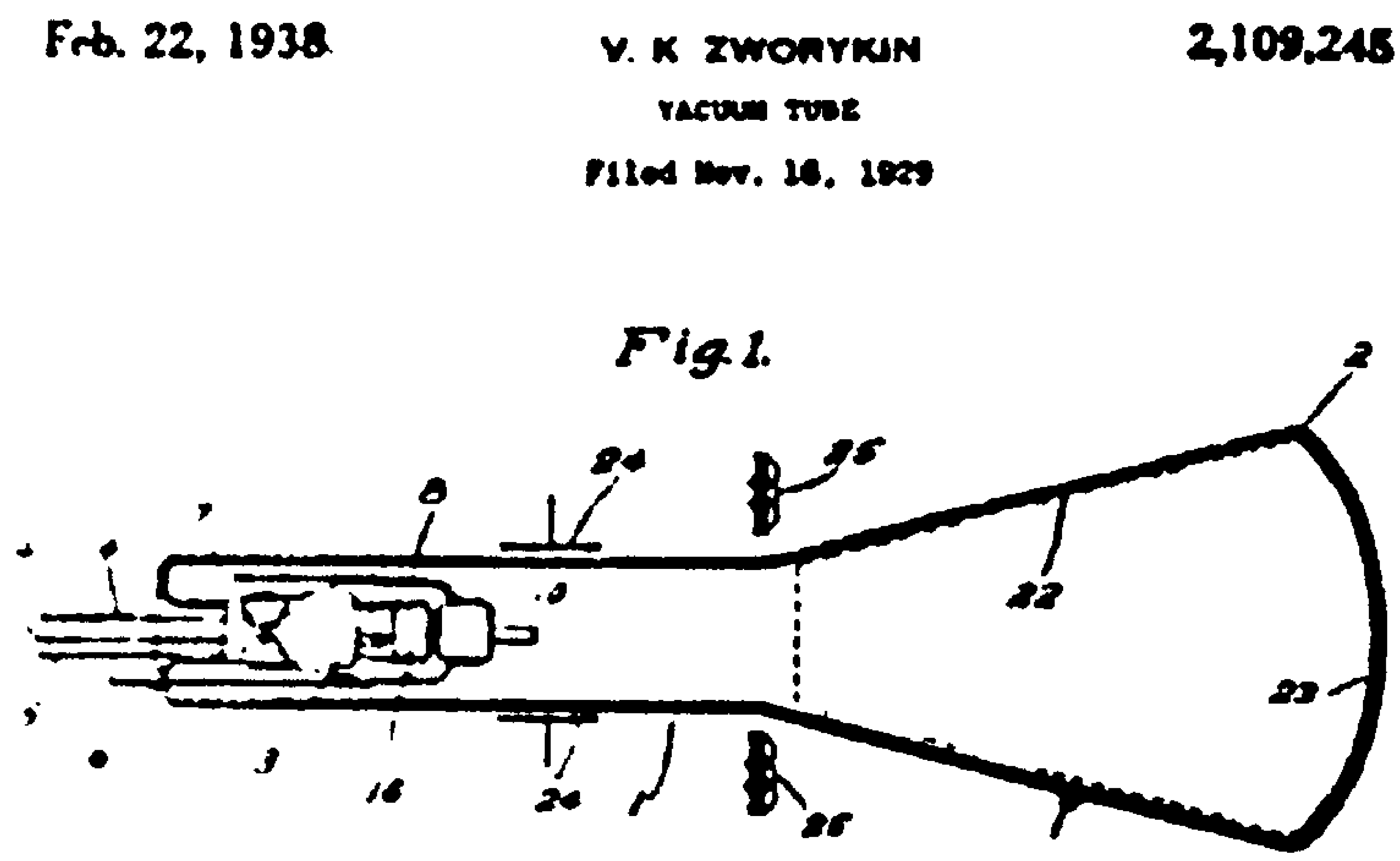

Figure 2.8: The Zworykin Kinescope

magnetic deflection. In demonstrating the kinescope (Figure 2.8) in 1929, RCA broadcast 60-line definition motion pictures at 12 frames per second on 90 and 150 metre wavelengths. [32] It is interesting to note that mechanical vibrating mirrors were used for scanning the film and not an iconoscope tube.

The image dissector, based on a completely different mode of operation to the iconoscope process, is described in the following section.

Farnsworth's Television Technology

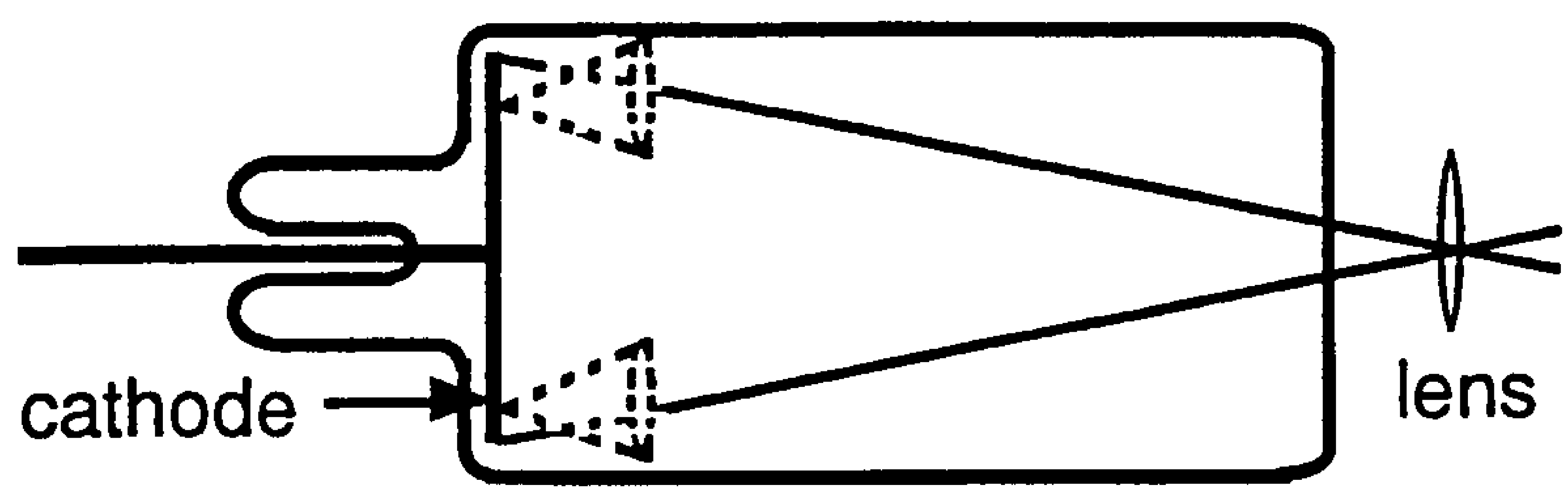

Figure 2.9: Optical image producing cones of emerging electrons

In his first patent Farnsworth defined the term 'electron image': [33]

> " The fundamental idea underlying electron image scanning is to receive from the optical image an electronic discharge in which each portion of the cross-section of such electronic discharge will correspond in intensity with the intensity of the light incident on that portion of the sensitive plate from which the electronic discharge originated. Then, if the electron image is bombarded against a fluorescent screen, the optical image will be reproduced there. Such a discharge is termed an 'electron image'."

Initially the production of an electron image could not be easily realised. Figure 2.9 illustrates that, despite employing a substantially flat photoemissive cathode, electrons emerge from the surface as diverging cones. To correct the path of the diverging electrons, Farnsworth added two components, a focusing coil (1) and an anode (2) shown in Figure 2.10 (a). Instead of producing the theoretical phalanx of electrons along the length of the tube (where any random cross-section would represent a sharply focused image) an alternative approach was to produce a sharply focused electron image at a specific distance from the cathode. The purpose of the

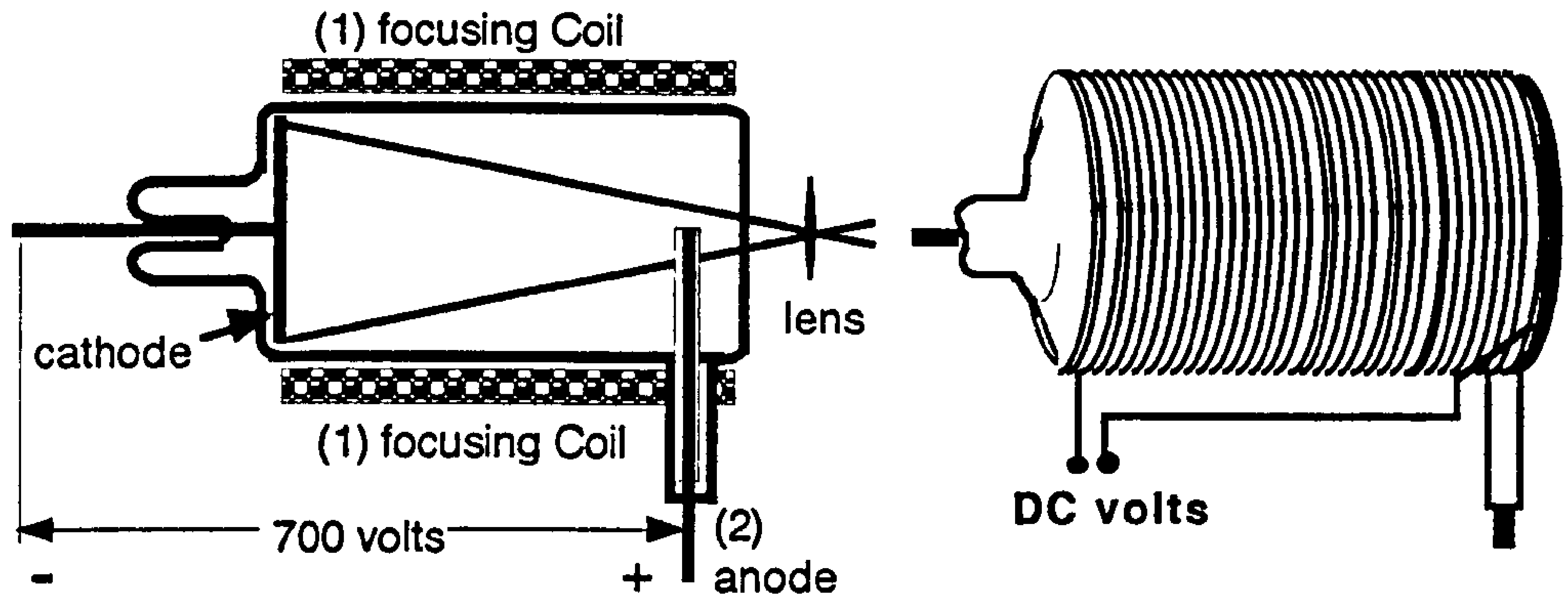

Figure 2.10: (a) Dissector with focus coil and anode (b) Focus coil wrapped around the tube

anode, which is positive with respect to the cathode, is to accelerate the negatively charged free electrons towards the other end of the tube. The focusing coil surrounding the evacuated dissector tube shown in Figure 2.10 (b) carries a steady direct current.

The following is based on a description given by Wilson [34]: With reference to Figure 2.11, the arrow indicates the direction of an electron emerging from point (P) of the photoelectric surface. The straight parallel lines through the surface represent lines of magnetic force.

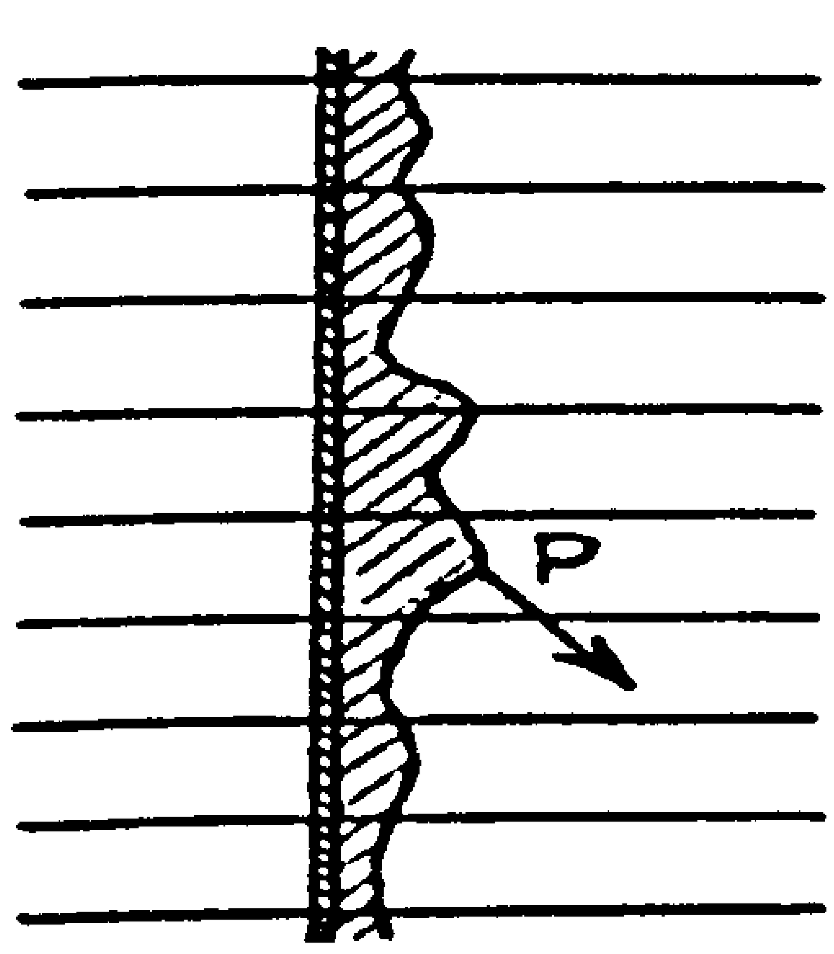

Figure 2.11: Magnified section of the photosurface

The photosurface is greatly magnified to illustrate that released electrons are unlikely to return directly back along the path of the applied image due to surface irregularities. When the direction of the movement of an electron is parallel with the field there is no force on it and it returns correctly, but should it cross the field, then a force proportional to its sideways velocity acts upon it causing it to curl around the lines of force without altering its velocity down the tube.

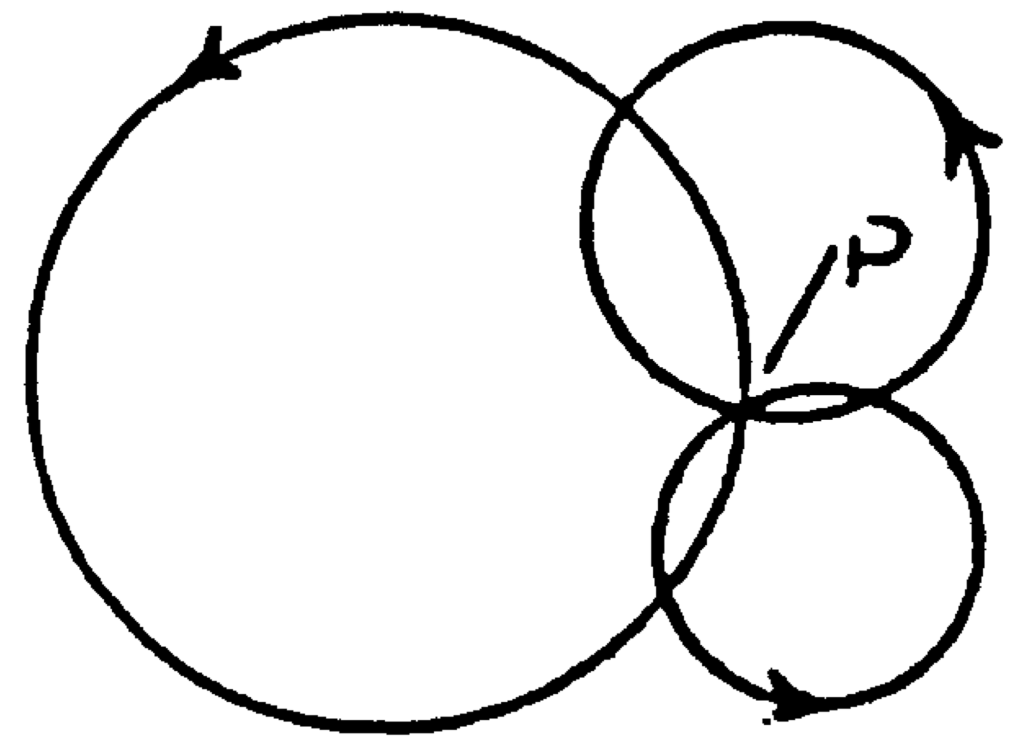

Figure 2.12: Electrons under the influence of a magnetic field

Figure 2.12 is an end-on view of the cathode in which three notional electrons from point (P) (see Figure 2.11) are represented as emerging in different directions and with different sideways velocities. Wilson explained that each electron follows a separate helical path down the tube, where the size of the circular path is dependent on the initial sideways velocity and the strength of the applied magnetic field. However, the time taken for each electron to complete one convolution is the same regardless of the initial velocity, because the larger the velocity the larger the circle, and vice versa. The accelerating force caused by the polarity of the anode causes the rotating electrons to describe spiral paths down the tube. When each electron has rotated one full circle a point is reached where the divergent cone of electrons converge to produce a point of sharp focus. This point of focus can be made to coincide with the target at the other end of the tube by accurate adjustment of the strength of the magnetic field.

Figure 2.13, illustrates the action of the focus coil. The electrons released in a diverging cone from the cathode are accelerated along the tube to be converged at the anode by the magnetic field. With the electron image sharply in focus at the location of the anode of the tube it is then

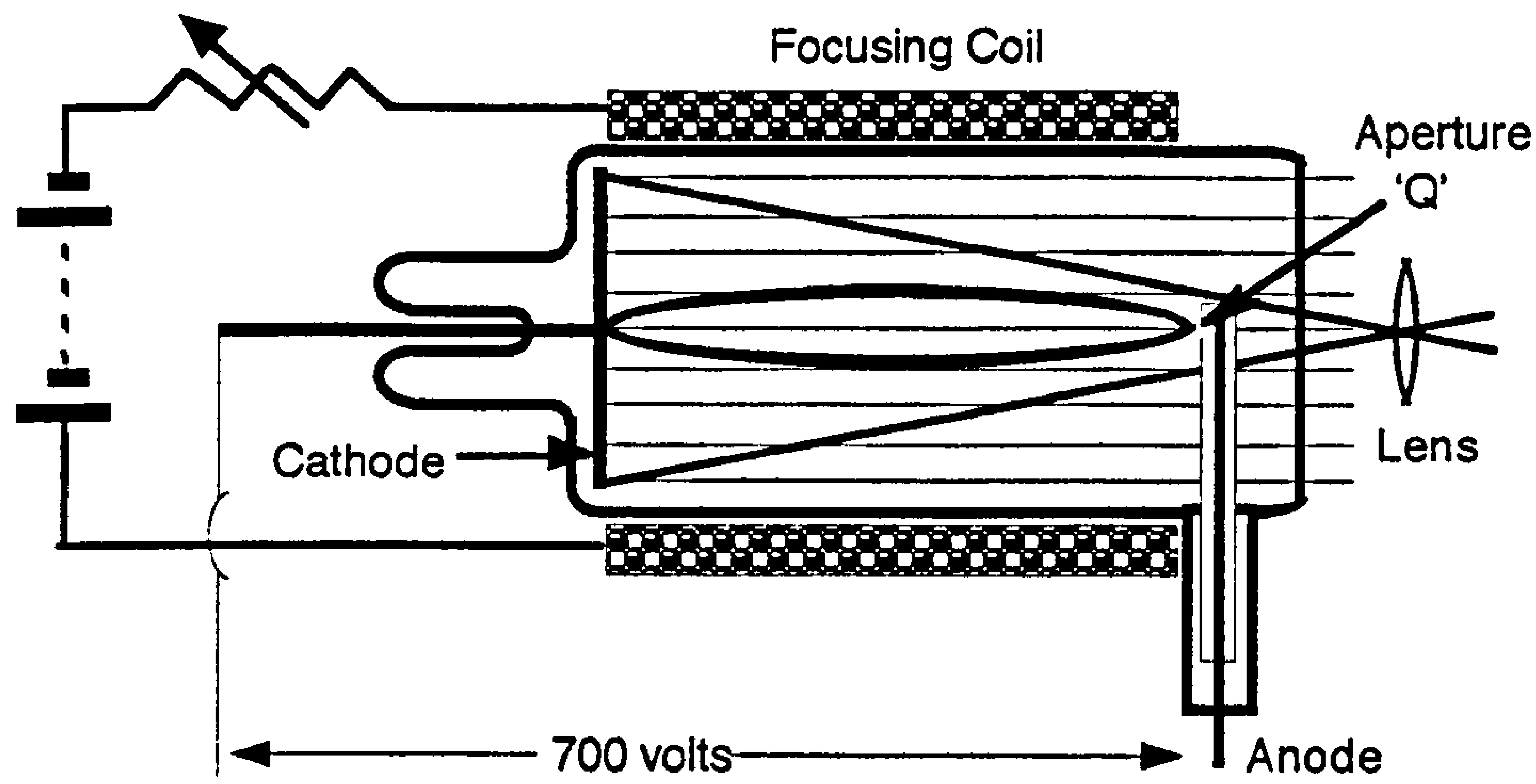

Figure 2.13: Dissector with a point of focus at the anode

necessary to scan the electron image so that each tiny picture element in turn is interrogated to render a television signal. The anode has a small aperture (Q) through which a stream of electrons coinciding with it will flow, thus representing one discrete image intensity of the original scene. But if the focused electron image remains stationary only the electrons representing that one picture element will continue to flow through the aperture. To convert the entire electron image into a serial stream of information representing the picture, it is necessary to move the electron image about the aperture in a regular scanning pattern.

Figure 2.14, shows two sets of scanning coils (A) and (B). Scanning is accomplished by magnetically displacing the focused electron image with these two mutually perpendicular magnetic fields. The current through the coils (A) which produced the vertical displacement required a sawtooth waveform of constant frame frequency in the range of from sixteen to thirty repetitions per second. The current through the coils (B) which produced the horizontal displacement of the electron image also required a sawtooth waveform, but in this case the line frequency was in the range of from five to

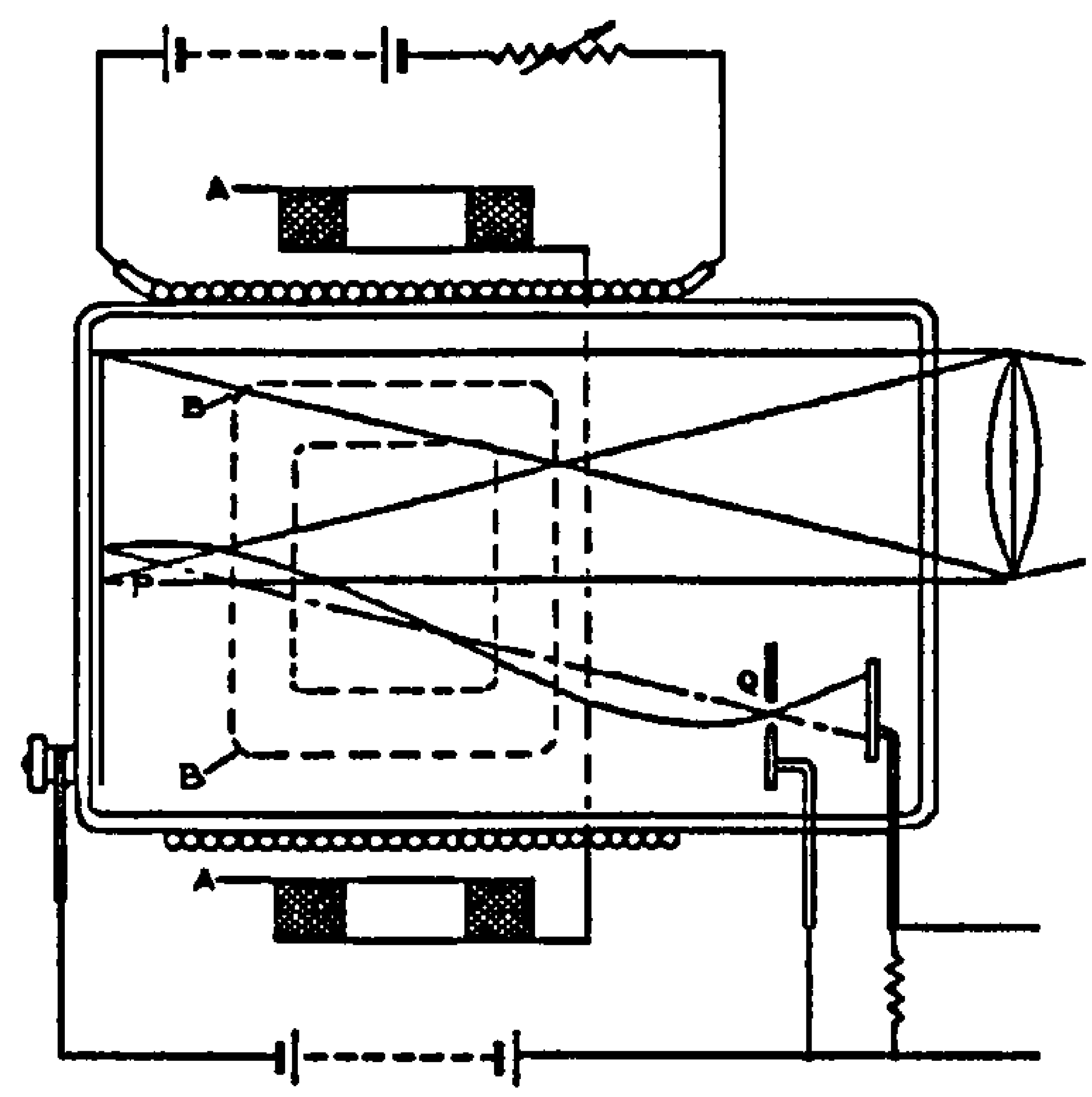

Figure 2.14: Scanning coils: vertical 'A', horizontal 'B', scanning aperture 'Q'

ten thousand repetitions per second. [35] Electrons which coincide with the aperture (Q) as shown in Figure 2.14, travel through to constitute the television signal.

Although the image dissector solved the problems of inertia exhibited by mechanical scanners, it had low sensitivity compared to the iconoscope which had the advantage of the storage principle. In this form the image dissector was successful as a television pick-up for motion films. Farnsworth had plans to improve the sensitivity: [36]

> "The sensitivity of the dissector tube when used with a 15,000 ohm coupling resistor is not adequate for scanning directly from the subject," .... "very intense light is required for illuminating the subject. This type of tube is used, therefore, only for motion picture work, and for such use a light source is used which gives 15 to 25 lumens in the optical image on the cathode. With this light intensity the average signal in the output of the dissector target across 15,000 ohms, is approximately one tenth of a millivolt."

Farnsworth developed an ingenious method of amplifying the feeble electric currents produced at the anode and first described this in a paper for the Journal of the Franklin Institute in October 1934. [37] He based his design on the knowledge that certain materials emit a larger quantity of electrons when bombarded with a single electron. This effect is known as secondary emission.

Farnsworth: [38]

> "When an electron stream is directed against a surface, it causes the emission of secondary electrons. These secondary electrons may exceed in number, those of the original or primary beam, if the primary electrons have sufficient velocity. This fact may be utilized to amplify an electron flow. Thus, an electron stream which is to be amplified is directed against a surface capable of emitting as many secondary electrons as possible by the impact of the primaries. The secondary electrons themselves are then directed against a similar surface. This process is repeated as many times as desired and the total electron flow finally collected."

Figure 2.15 shows the radio frequency type electron multiplier which Farnsworth designed for the outdoor and studio type image dissector. The multiplier tube is a cylindrical evacuated envelope with cathode disc plates of silver at either end, each of which have been oxidised and coated with caesium to produce secondary emitting surfaces. A cylindrical anode of nickel or molybdenum is situated between the cathode plates and may be in the form of a small central ring. A direct current solenoid focusing coil surrounds the tube and a radio frequency signal of approximately 50 MHz is applied alternately between the plates causing free electrons to continually multiply as they travelled from cathode to cathode.

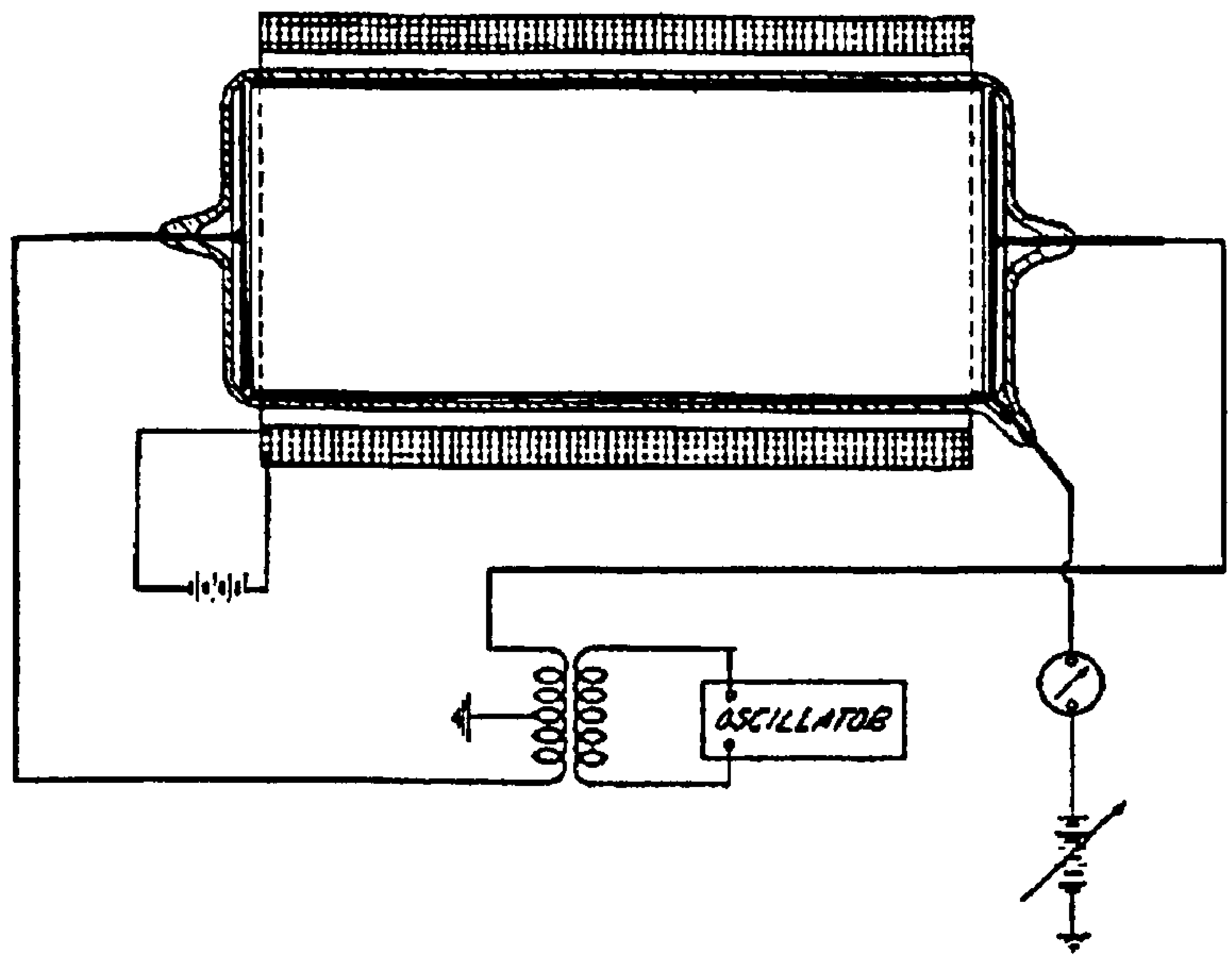

Figure 2.15: Radio frequency type electron multiplier tube

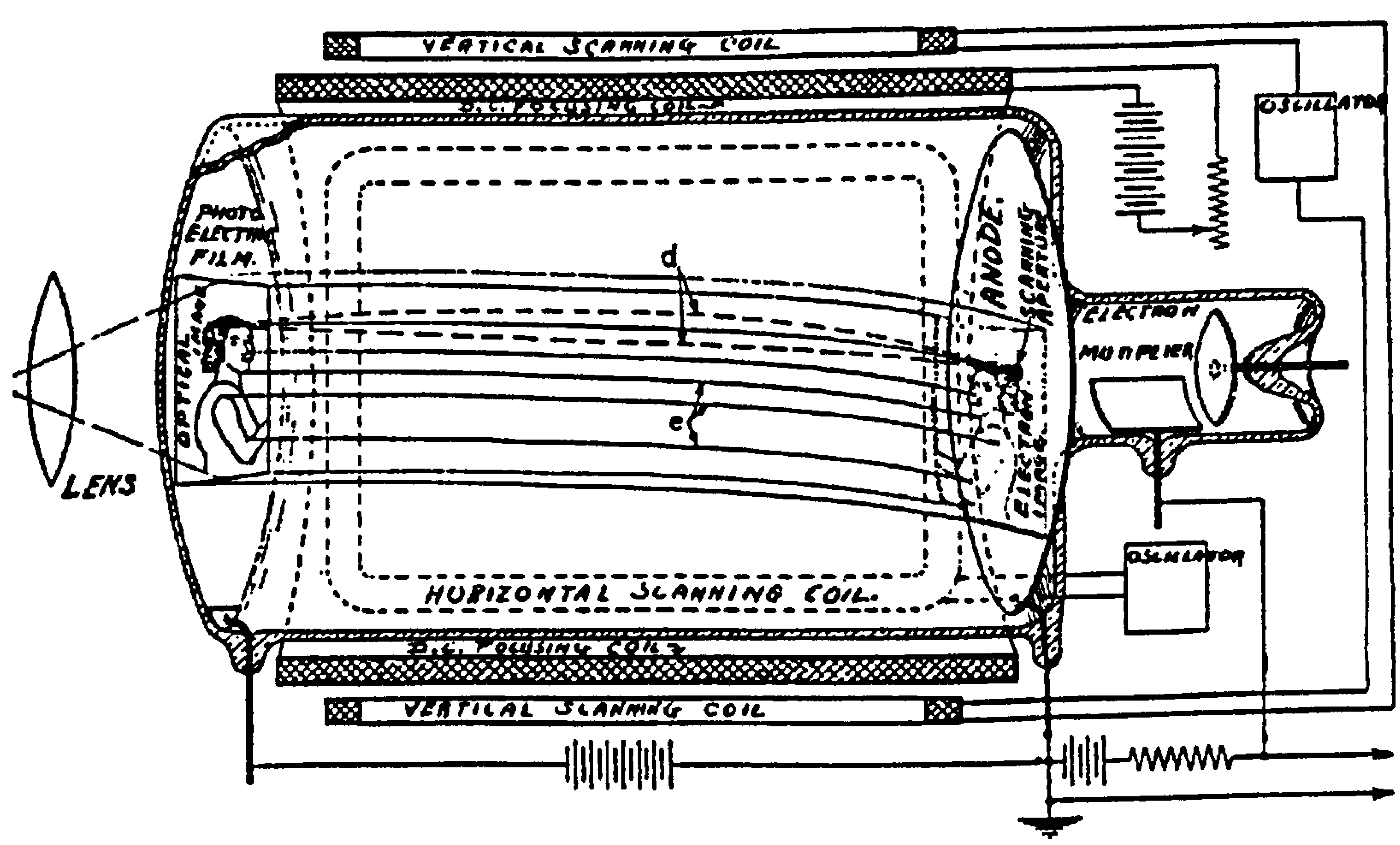

Figure 2.16: image dissector utilising the Electron Multiplier

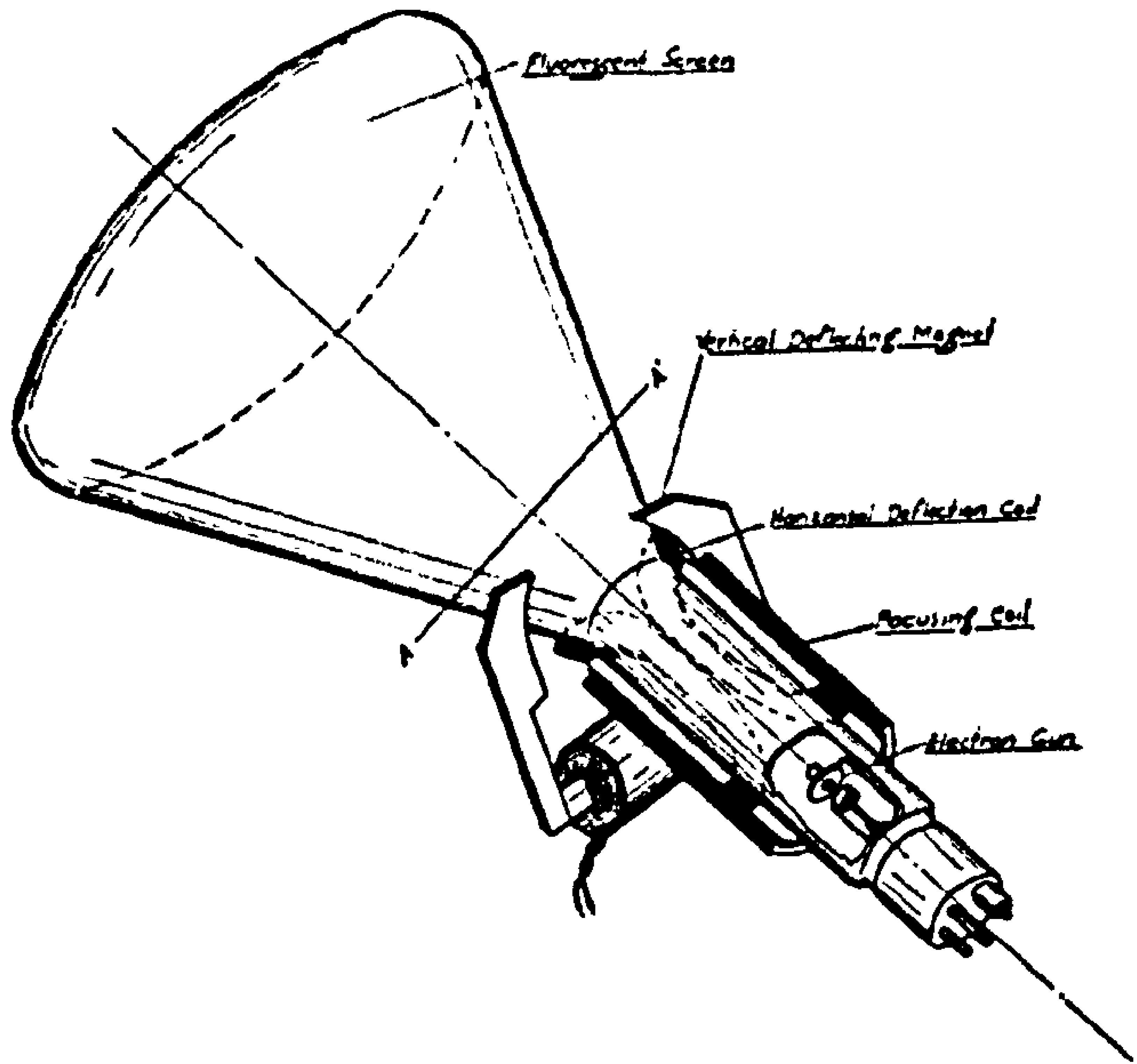

Figure 2.17: Oscillite Tube and Coil System

By introducing an electron multiplier tube within the structure of the image dissector tube as shown in Figure 2.16, and placing it behind the image receiving aperture, the currents within the tube are amplified more than one thousand times without appreciably increasing the noise level of the tube. The Electron Multiplier image dissector tube is sensitive enough to pick up images from directly illuminated subjects or from outdoor scenes under moderate daylight conditions without using the storage effect.

Farnsworth's receiving tube or 'Oscillite ' Figure 2.17, consisted of a cathode-ray tube with an electron gun delivering a beam of one to fifteen milliamps within an angle of fifteen degrees. This beam is focused on the fluorescent screen by means of a short magnetic solenoid around the neck of the tube, near the gun and coaxial with it. The horizontal (line frequency) scanning is produced by magnetic deflection coils which are at right angles to the axis of the electron gun and carry the same waveforms as the corresponding waveforms for the image dissector tube.

Farnsworth's achievements came to the attention of Zworykin who visited his laboratory apparently on behalf of Westinghouse.

Elma Farnsworth: [39]

"19 April, 1930, an entry in Farnsworth's journal stated: Dr Zworykin spent three days in the laboratory. Demonstrations were given of motion picture transmission, admittance-neutralized receiver, slope wave, deltatron, mutual conductance, etc. The demonstrations were all successful."

Mrs Farnsworth indicated that Zworykin was impressed and also asked to see an image dissector being constructed, after which he remarked: [40]

"This is a beautiful instrument. I wish I had invented it myself."

It later emerged that Zworykin was already employed by David Sarnoff, at RCA and was visiting on the pretence of working with Westinghouse. It would not be long before they would meet again but this time in a less courteous fashion during Patent Interference litigation, the details of which are outside the remit of this research and were thoroughly investigated by Hofer (1977). [41] After a long and protracted legal battle a settlement was made in 1939 by RCA in favour of Farnsworth.

Elma Farnsworth wrote: [42]

" After weeks of testimony in Washington, the Patent Examiners, in a forty seven page ruling number 64,027, gave priority to Farnsworth on the grounds that Zworykin's 1923 tube was inoperable."

In 1933 The major shareholder of the Baird Company was Gaumont British. [43] They were concerned about the implications of Marconi-EMI's electronic camera system the Emitron. They had heard about Farnsworth due to publicity over the patent suit, and subsequent demonstrations of the

Advantages	Image Dissector	Iconoscope
Charge storage for sensitivity		✓
Electron multipliers for sensitivity	✓	
Real-time image capture	✓	
Sensitivity down to 15 candles/sq.ft		✓
Resolves excellent images from film	✓	
Disadvantages		
Produces unwanted spurious signals		✓
Requires minimum 100 candles/sq.ft	✓	
Charge storage only 5-10% efficient		✓
No charge storage	✓	
Requires keystone correction		✓
Not sensitive enough for daylight conditions	✓	

Figure 2.18: Table comparing the advantages/disadvantages of the Zworykin and Farnsworth tubes

image dissector at the Franklin Institute of the State of Pennsylvania. [44] Baird recognised that an arrangement with Farnsworth would enable them to enter the electronic race for television by offering a British version of the image dissector in competition to EMI. A small delegation of Baird engineers was sent to the USA to commence licensing negotiations with the Farnsworth Company.

The next chapter will describe the importance of the 'Baird and Farnsworth' negotiations and will illustrate the industry which the Baird Company developed to accommodate electronic high definition television.

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CHAPTER 3

Baird and Electronic Television

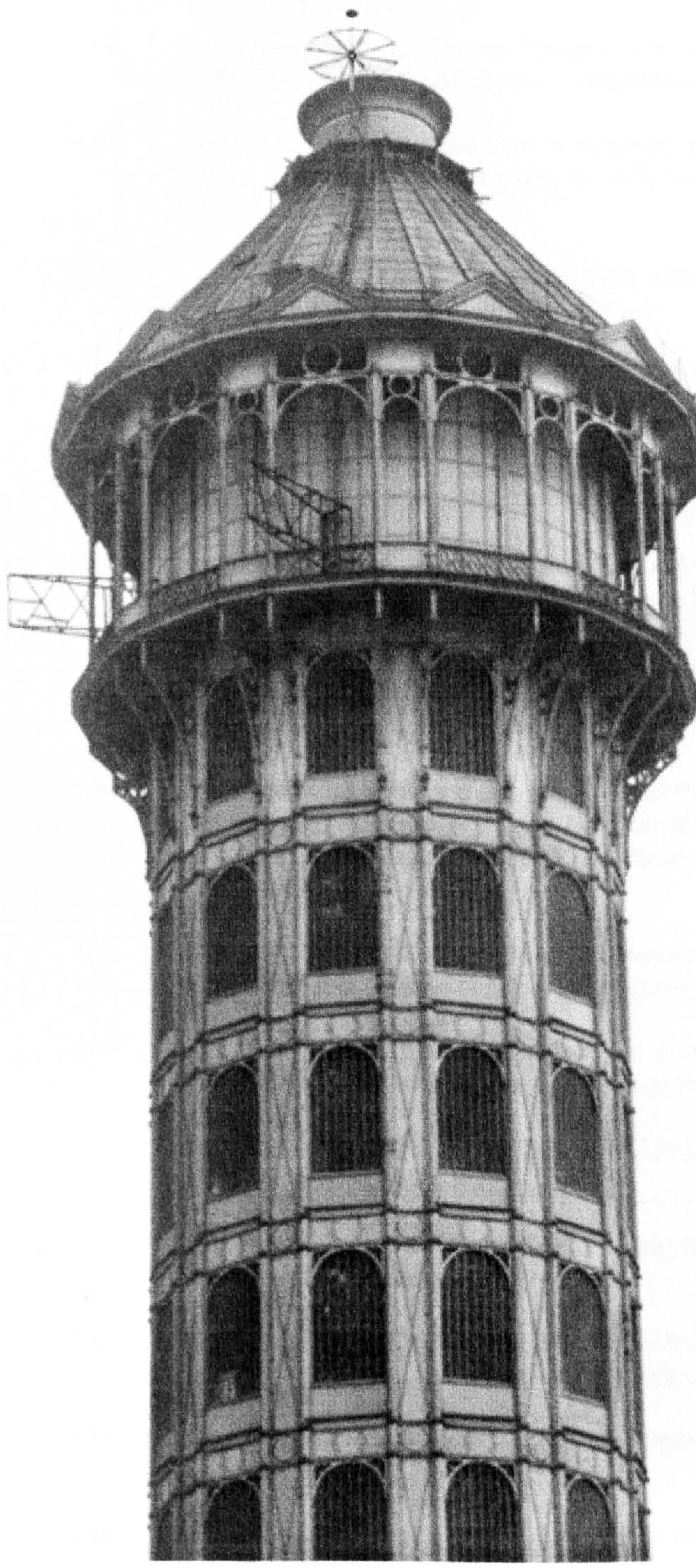


Figure 3.1: Baird Television Ltd, Crystal Palace South Tower, London. Dipole aerials on the balcony and an umbrella vision aerial situated on the corona

List of Illustrations: Chapter 3

Section 3.1

Key Television Developments in Britain 1931-1934

This section brings together the various influences, developments and personalities which converged on the Baird Company in the early 1930's culminating in its adoption and development of electronic imaging systems. Pull-out charts serve to show the working layout of the Baird Company premises at the Crystal Palace in London, (Figure 3.8); describe the intercompany technology transfer, (Figure 3.16); and illustrate the organisational structure of the Company 1934 to 1936 (Figure 3.19).

In 1933, the Baird Company was worth fifty thousand pounds, which in terms of the net present value of money [1] is equivalent to 2 million pounds.* The company's main business was the broadcasting of low definition television programmes through the BBC and supplying television receivers for sale to the general public. Although they had a monopoly of television in the British Isles [2] the radio industry was poised and ready to challenge Baird. Baird Television was not a part of the established radio industry; instead it had been controlled by the cinema industry since 1932, when Isidore Ostrer of Gaumont British became the principal shareholder.[3] Reflecting in his autobiographical notes, J. L. Baird wrote: [4]

> "Rivals had appeared in the field, the Marconi Company having staged a demonstration at the British Association in Leicester, and the HMV Company having also given a demonstration at the Physical Society

* This figure represents the comparative value of money but not the comparative value of the company in terms of the very different ratio of labour to capital/machinery. Suggested reading: Foley, K. D and Michl. **Growth and Distribution**. Camb., Mass., Harvard University Press. 1999.

meeting in 1931. Both these companies had however shown the now obsolescent mirror drum apparatus, We alone had shown high definition cathode-ray pictures."

Abramson described the British Post Office's reticence to act directly on behalf of the new competition: [5]

"The British Post Office sent engineers to EMI at Hayes in February 1933. The engineers reported that the picture was good and the film was easy to follow. But the Post Office decided not to let EMI transmit from Broadcast House until further demonstrations of the Baird system had taken place."

The Post Office asked for a shortwave demonstration of television from both Baird Television and Marconi-EMI. Research by Abramson [6] has shown that this took place on 18 April 1933 by Baird from Long Acre, and 19 April 1933 from EMI at Hayes.

"Again it was agreed that the EMI transmissions and equipment were far superior to those of Baird. However, the Post Office still refused to let EMI use Broadcast House as it might prejudice Baird's case." [7]

These demonstrations mark the starting point of Baird Television's interest in electronic cathode-ray tube television. Later, in the same year, the Baird Company successfully carried out preliminary transmissions of high definition television using cathode-ray tube receivers.

Abramson reported: [8]

"Baird Television had a cathode-ray system operating. The first public demonstration was given to the British Association on September 12, 1933. Pictures some eight inches square were shown on cathode-ray receivers. Baird was transmitting 120-line pictures at 25 frames/sec. Both films and cartoons were shown."

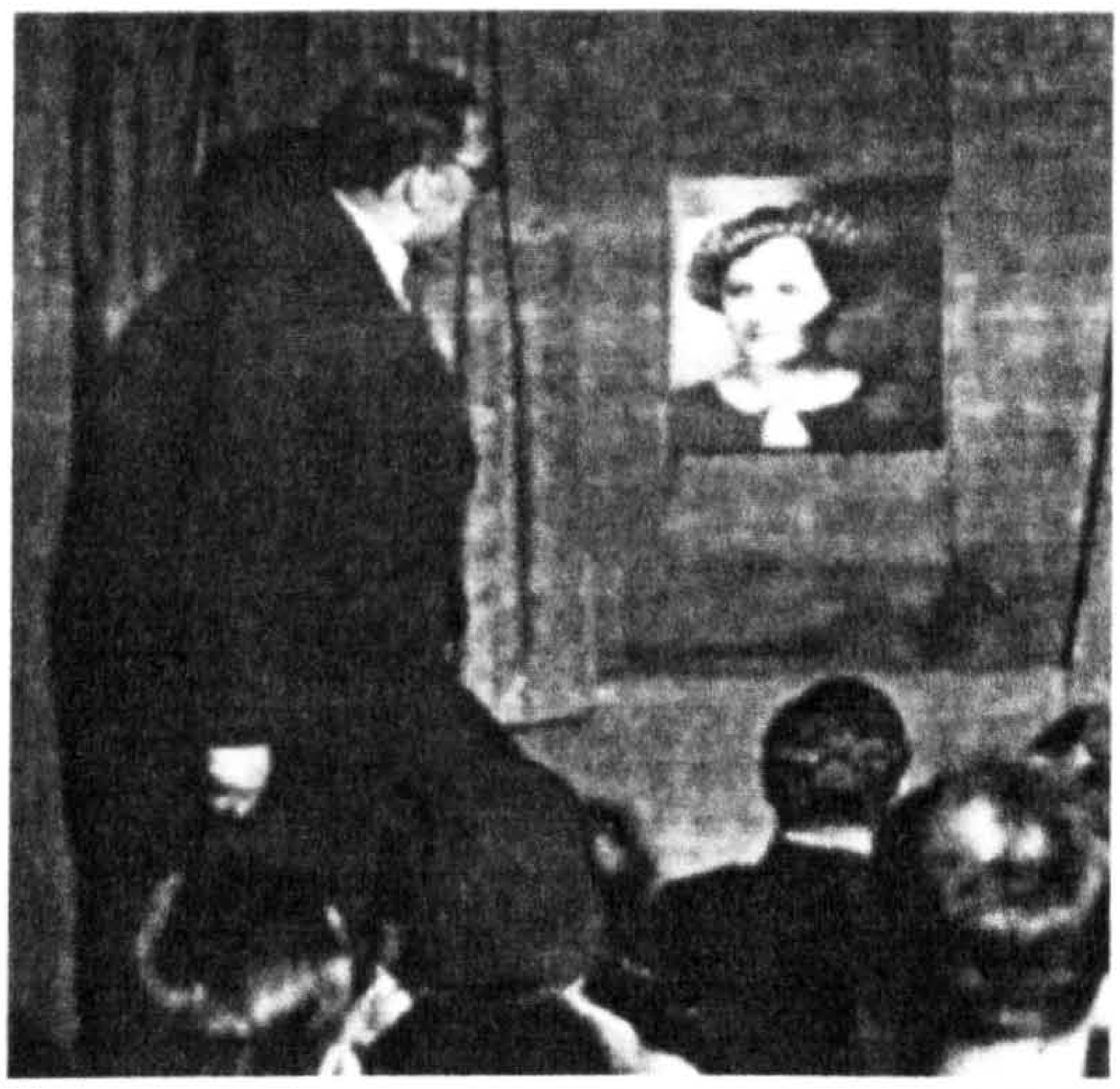


Figure 3.2: Baird's cathode-ray tube picture received at Film House, Wardour Street, London

Figure 3.3: Cabinet model of the Baird cathode-ray tube receiver. (1933)

In October 1933, Baird Television increased their image resolution to 180-lines and transmitted pictures to cathode-ray tube receivers at Film House, Wardour Street in London (Figures 3.2 and 3.3.) [9]

On 22 May, 1934, the Marconi Wireless Telegraph Company joined forces with EMI to form Marconi-EMI, a British company partly owned and directed by RCA. They began testing the 'emitron' electronic television camera (Figure 3.4) in 1934, which they claimed had been conceived independently, and in parallel, with Zworykin's iconoscope (Figure 3.5), but the emitron was virtually identical to the iconoscope. The news of the Marconi-EMI merger and their freedom to use an iconoscope came as a disappointment to J. L. Baird. In 1932, the Marconi Company had approached Baird with suggestions for a Marconi-Baird merger, but due to an error of judgment by the Baird Company board, this became a lost opportunity. In his autobiographical notes, Baird later wrote: [10]

"The first catastrophic thing to happen after the alteration on the board was the closing of the negotiations with the Marconi Company.......

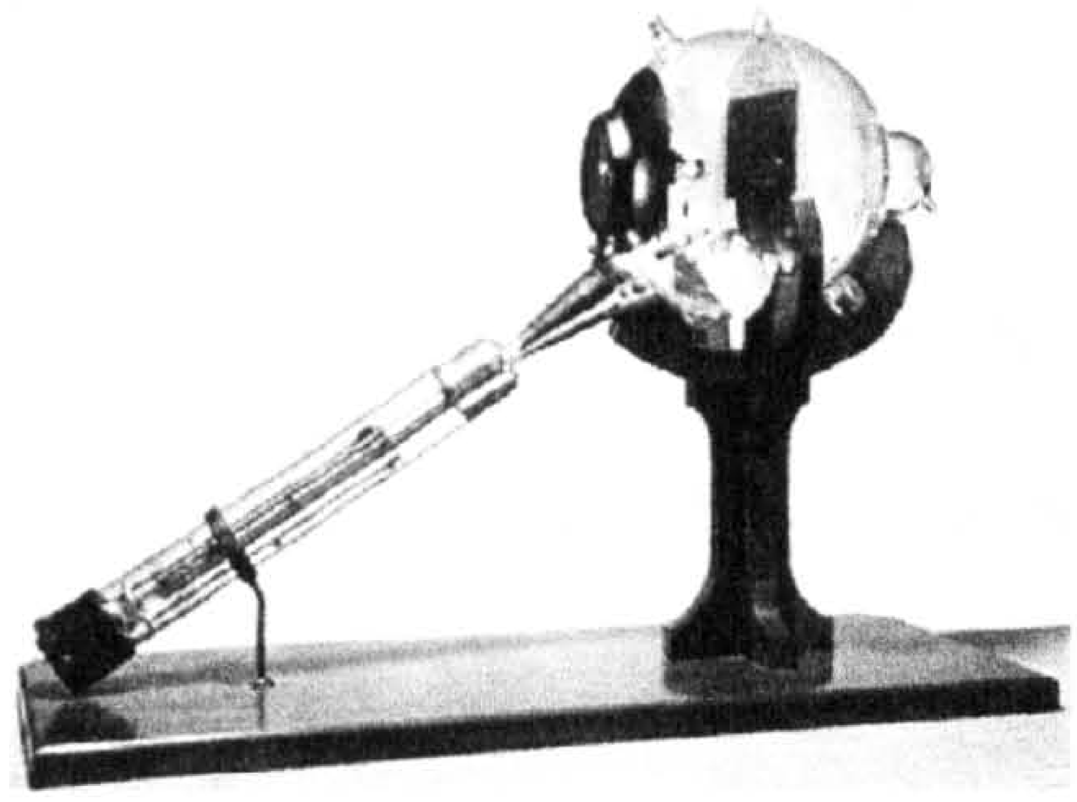


Figure 3.4: The Emitron (Marconi-EMI)

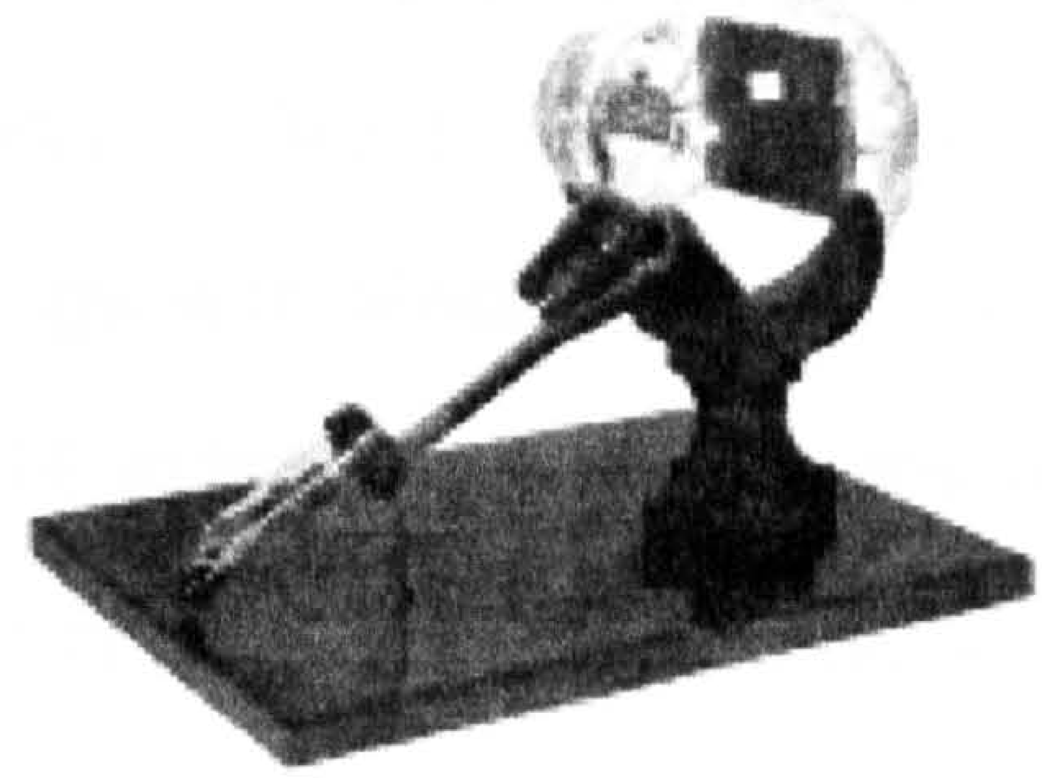


Figure 3.5: The Iconoscope (RCA)

.......the final step was certainly taken by Isidore Ostrer. I had nothing to do with it and thoroughly disapproved; it was all done over my head."

In a review relating the success and failure of J. L. Baird, Burns wrote: [11]

"Of all the various factors which determined the fortunes of Baird Television Ltd one of the most important was the failure of the Company to reach an agreement with the Marconi Wireless Telegraphy Company in 1932"

It is important to note that these references relating to the proposed Baird and Marconi merger have in each case been sourced from J. L. Baird's autobiographical notes. [12] Moseley [13] doubted if Baird's perception of the merger was accurate and felt sure that Baird was mistaken in thinking that it had reached anything approaching a final agreement. Moseley conceded, however, that if such an agreement had taken place then Baird's future would have been assured. Elma Farnsworth described the link between RCA and EMI: [14]

"In the late 1920's, two English record companies, the HMV Gramophone and the Columbia Gramophone Company decided to merge in order to cut expenses. The new company was called Electrical and Musical Industries Ltd (EMI.) Since RCA held a substantial interest in the Gramophone Company, this interest now transferred to EMI ."

But although never publicised EMI and Marconi had already merged. In 1898 the Gramophone Company which was formed to produce acoustic gramophones and records decided to merge with Marconi in 1929 and Columbia in 1931 to form EMI. [15] White [16] indicated that EMI received kinescopes from RCA in 1931 to develop the emiscope. About 30% of EMI shares were held by RCA. Abramson [17] indicated that Zworykin had gone to London in July 1933 to visit the laboratories of Marconi-EMI and, within two months of the visit, Isaac Shoenberg the EMI manager of patents had set up a laboratory to build English iconoscopes at Hayes, under the direction of J. D. McGee.

Captain A. G. D. West was hired in May 1933 as technical director of Baird Television. He was educated at King's School, Canterbury, and took his M.A. at Cambridge and B.Sc at London University. During the (1914 - 1918) war he served as Wireless Experimental Officer, and was formerly Head of research at the BBC, (1923 - 1929). Prior to his appointment with Baird Television he was Chief Recording Engineer of A.T.P. Studios, EMI, (1929-1932). [18] Abramson indicated that he brought with him knowledge of the most recent technical developments at EMI and details of the RCA iconoscope. [19] In a private communication to the author Tomes wrote [20]

> "West's first problem must have been to cope with J. L. Baird who, I suspect, was a law unto himself. Experience at Long Acre, where demonstrations of 120 line television had taken place, must have told West that Baird was very difficult to handle. Baird was not particularly worried about making a profit and was happiest beavering away breaking new ground and trying out new ideas."

Strangely, J. L. Baird indicated to the contrary: [21]

Figure 3.6: Sir William Mitchell-Thomson
Lord Selsdon (Postmaster General)

"West and I got on well and he was my champion in the boardroom."

Tomes continued: [22]

"Baird was the darling of the media, always presenting himself as an eccentric scientist, with long growing hair and occasional absent - mindedness. He was seen as a brilliant scientist, likely to be exploited by ruthless businessmen waiting in the wings and ready to make fortunes out of his inventions. He pretended he knew little about business affairs, but the truth was that he was a shrewd businessman and there was nothing he did not know about the gentle art of publicity."

By July 1933 Baird Television moved to the Crystal Palace and John Logie Baird conducted most of his business from his own small laboratory in Crescent Wood Road, Sydenham. Both Szegho [23] and Tomes [24] confirmed that there was little if any day to day contact between the two camps.

The experimental high definition television short-wave broadcasts of Baird and Marconi-EMI in 1933 encouraged the British Government to set up a Parliamentary Committee to investigate the future of television. This resulted in the appointment of the Television Advisory Committee on

14 May 1934 led by Lord Selsdon (Figure 3.6). The following terms of reference were announced in the House of Commons: [25]

"To consider the development of television and to advise the Postmaster General on the relative merits of the several systems and on the conditions under which any public service of television should be provided."

The Selsdon Committee gave the following recommendations: [26]

"Paragraph 55

It seems probable that the London area can be covered by one transmitting station and that two systems of television can be operated from that station. On this assumption we suggest that a start be made in such a manner as to provide an extended trial of two systems, under strictly comparable conditions, by installing them side by side at a station in London where they should be used alternately - and not simultaneously - for a public service.

Paragraph 56

There are two systems of high definition television - owned by Baird Television Limited and Marconi-EMI Television Company Limited respectively - which are in a relatively advanced stage of development, and have indeed been operated experimentally over wireless channels for some time past with satisfactory results. We recommend that the Baird Company be given an opportunity to supply the necessary apparatus for the operation of its system at the London station, that the Marconi-EMI Company be given a similar opportunity in respect of apparatus for the operation of its system also at that station."

Marconi-EMI would use a 405 line interlaced scanning system while Baird would increase their mechanical scanning rate from 180 to an ambitious

240 lines. The significance of these terms is shown in the analysis of system resolution which follows in Chapter 4.

John Logie Baird clearly recognised the significance of these events. He was the pacemaker who brought television to the attention of the world and had spawned the interest of the radio industry. As early as 1928, Baird Television had formed Baird International and opened branches in the USA, France and Germany. [27] It also appears that Baird had recognised that there was a connection between EMI and Marconi (prior to their merger in 1934) and therefore had useful links with RCA, when he later wrote: [28]

> "Now we were faced at last with really serious competition. We had against us the whole resources of the vast RCA combine, comprising not only the biggest companies in the USA but the great Telefunken Company in Germany and a host of others. If we had joined Marconi we would have been with this combine, not against it. Our policy of facing the world single-handed was sheer insanity - we should have made terms."

Baird Television in the Crystal Palace

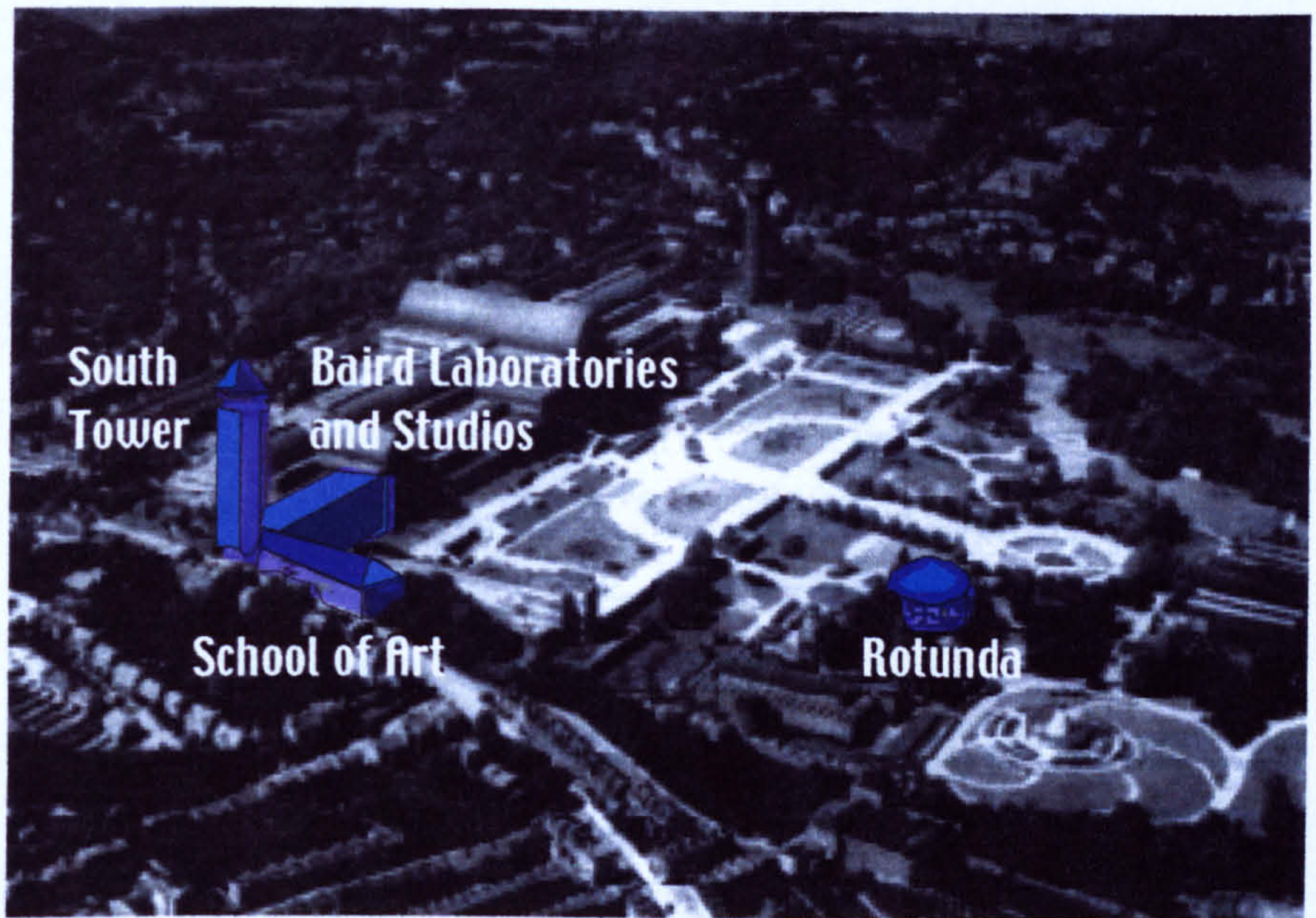


Figure 3.7: The Crystal Palace, London. Site of Baird Television 1933 - 1937

It was reported [29] in March 1935 that Baird Television occupied an area of 40,000 square feet, (Figure 3.7) at the Crystal Palace, in London. Figure 3.8, which provides a plan of the Baird Television facility has been produced with the assistance of Gilbert Tomes who worked with Baird Television from 1935 until 1945. Although the first 'high-definition' television receivers were in the course of production at this time the efforts of the staff were largely devoted to research and development.

Szegho wrote: [30]

> "Baird selected this location because television transmission from the two towers of the building, and the elevation on which it was erected could cover the whole London area."

Although the Baird television transmissions took place only from the South Tower, the point which Szegho was making was that, shortwave radio

Figure 3.8

Layout of the Baird Studios and Laboratories in the Crystal Palace

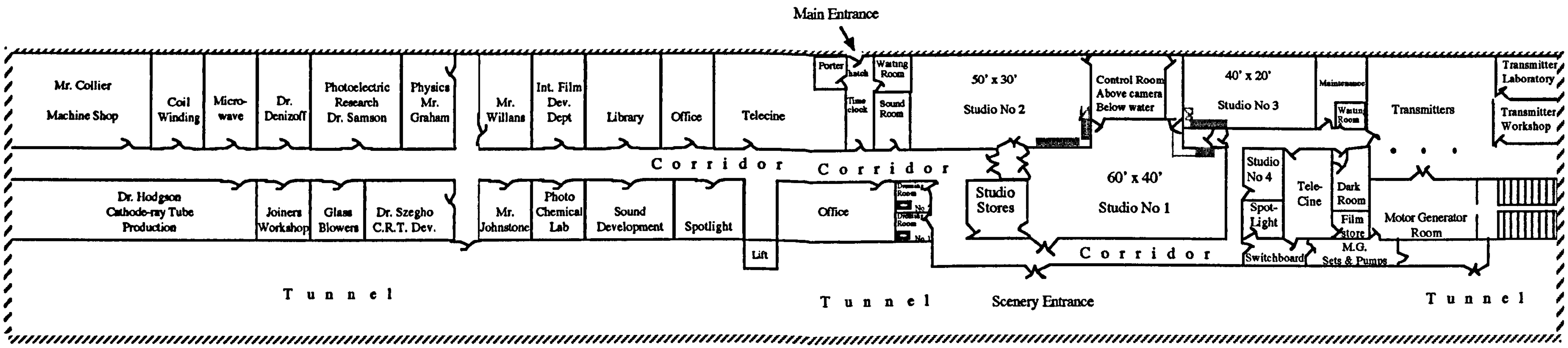


Figure 3.8:
Plan of the Baird Television Studios and Laboratories
Crystal Palace 1936.

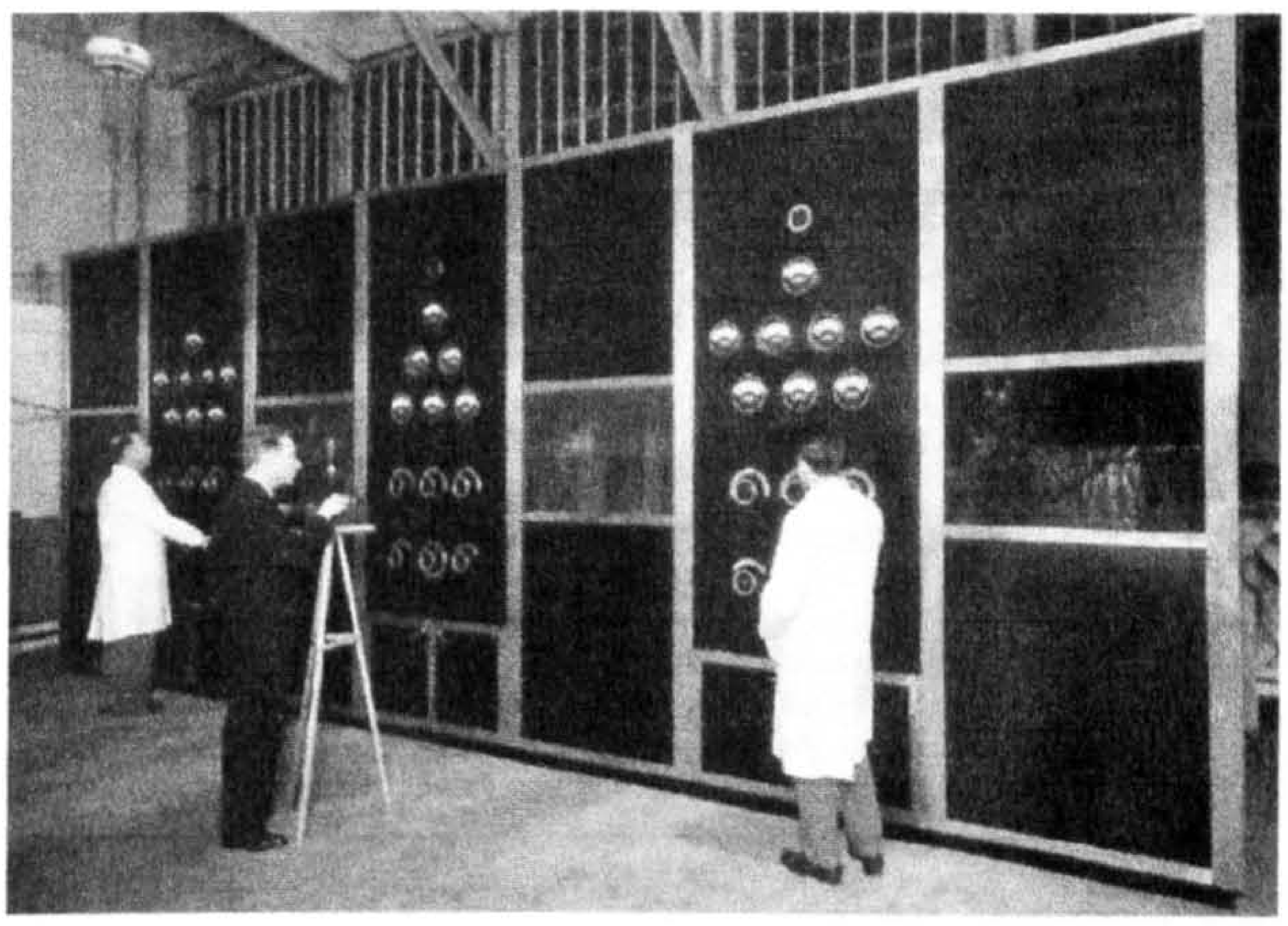


Figure 3.9: Baird's 10 kilowatt vision transmitter

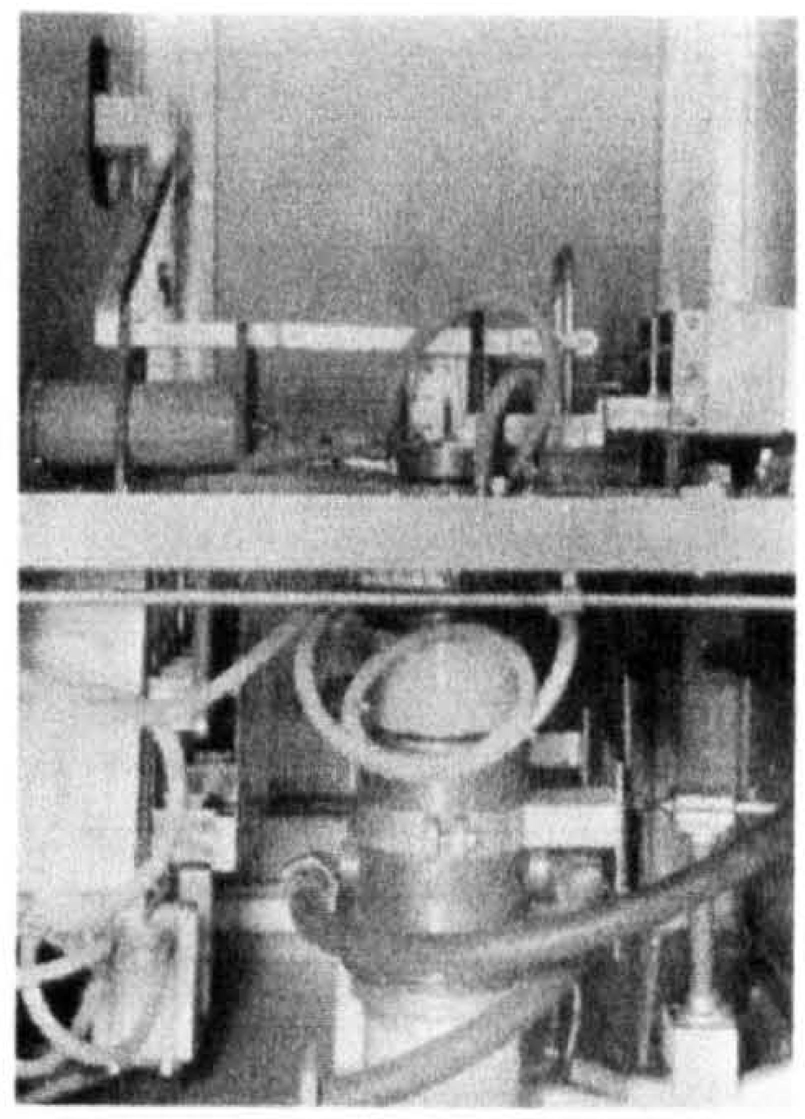


Figure 3.10: Baird Television's demountable tetrode

signals propagating from an aerial travel in straight lines, and due to the curvature of the Earth the range is virtually limited by the visible horizon. It follows that to obtain the largest service area from a given transmitter it is important to mount the broadcasting aerial as high as possible above the ground. The higher the aerial the greater the useful service area. The aerials (see Figure 3.1) on the South Tower (680 feet above sea level) could radiate television signals to homes within 35 miles of Central London. The power of the transmitted signal is also very important and guarantees that sufficient field strength reaches to the outer limits of the service area. Herbert wrote: [31]

> "The original vision transmitter which had a power of 500 watts and operated on 6 metres, was situated on the first floor of the South Tower. A year later, in December, 1934, a high power, 10 kW replacement using constantly evacuated tetrode valves, went into operation. Designed by Baird engineers it represented the most powerful ultra short-wave transmitter in existence."

Figure 3.9 shows the 10kW Baird transmitter in the Crystal Palace. The water-cooled demountable tetrode is shown in Figure 3.10.

Herbert [32] indicated that the British coastal radar defence stations, known as 'Chain Home' which became operational in 1938, used the same valves in a similar circuit and considers that the Baird transmitter had a strong influence on their design.

Callick wrote: [33]

> "The transmitters built by MetVick (*Metropolitan Vickers*) for the Chain Home defence network used water cooled continuously evacuated demountable tetrodes which they had developed and manufactured for high power broadcast and communications transmitters........
>
> ......they gave peak powers around 600kW in pulses with up to 35 microseconds duration at intervals of 20 milliseconds."

Swords wrote: [34]

> "Because of the extra reliability afforded by the use of demountable valves in the drive and output stages of the transmitters, these valves must be considered to have been a key factor in the overall success of the radar chain. To F. P. Burch and to his brother C. R. Burch, of Metropolitan-Vickers, goes the principle credit for the creation of these valves."

The extra reliability is inherent in the design of tetrode valves when compared with triode valves which become unstable when used for radio transmitter high power output stages.

Callick explained: [35]

> ".....tetrode amplifiers have the advantage over triodes in requiring no neutralisation of positive feedback from the output to the input circuit through the anode-grid capacitance, which could otherwise cause uncontrolled self-oscillation."

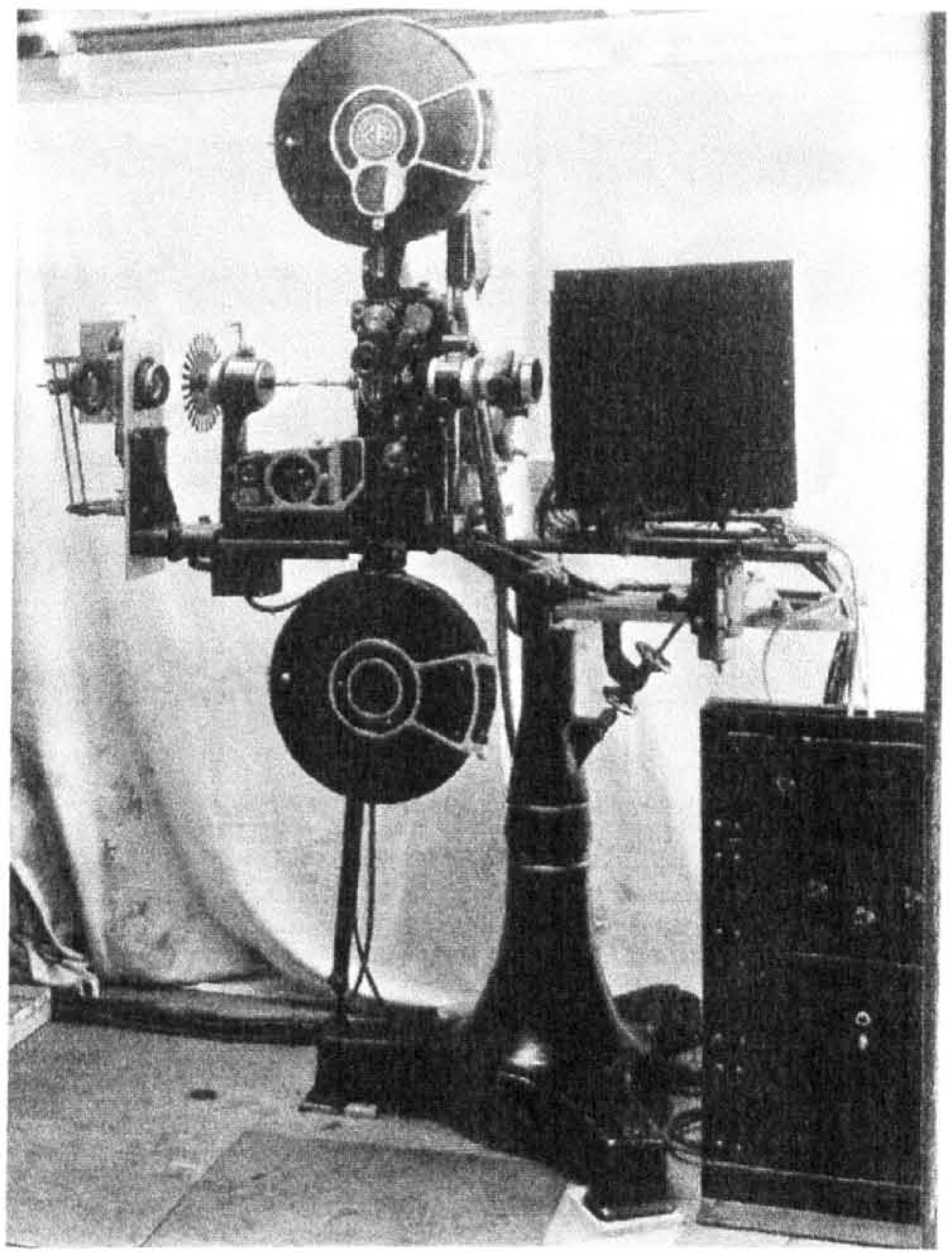


Figure 3.11: The Telecine Scanner

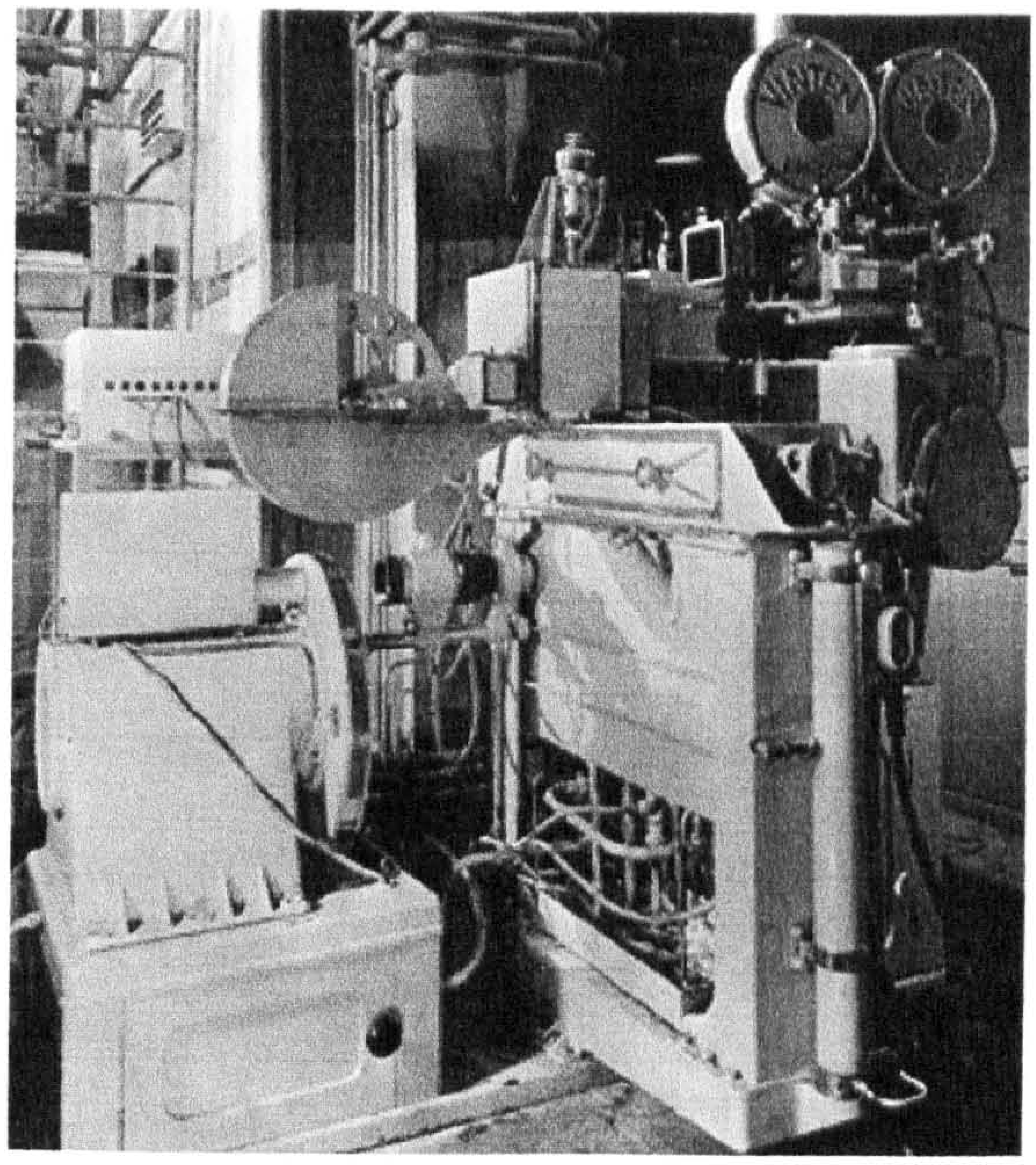


Figure 3.12: The Intermediate Film Scanner

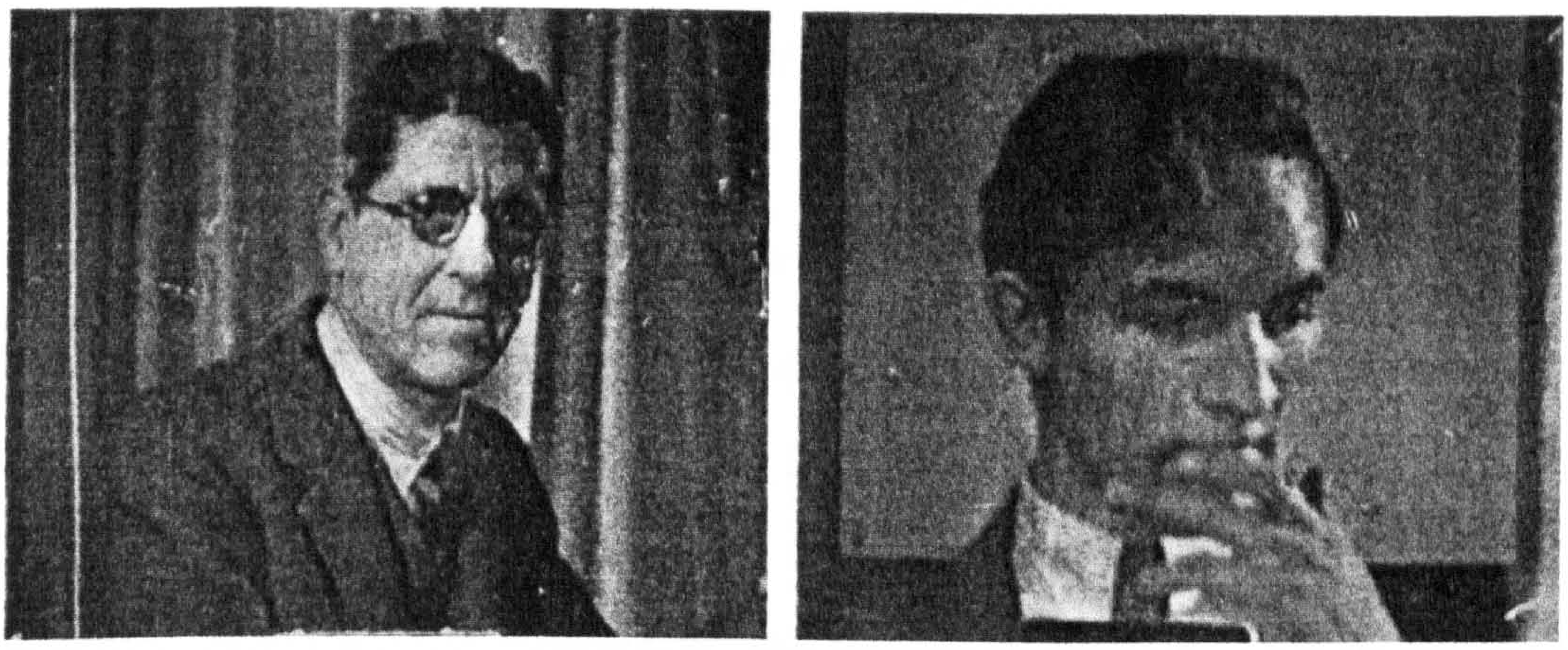


Figure 3.13: Two untouched enlargements of film from the Intermediate Film Scanner.

Figure 3.14: Baird 180 line Telecine picture (1935)

According to Abramson [36] although Baird Television had turned to cathode-ray television for reception they still depended on the flying spot scanner and intermediate film system for studio and outdoor live pick-up. It was reported [37] that they also used a telecine scanner, (Figure 3.11) which produced excellent television pictures directly from cinema films.

Gilbert Tomes in his privately published diaries wrote: [38]

> "Long term there could be no future for the Baird mechanical systems, although the Baird telecine film transmissions produced better and clearer pictures than those of EMI."

The intermediate film scanner, (Figure 3.12) which, although capable of daylight and studio pick-up, lacked finesse and flexibility. Prone to failure, the intermediate film system became known by many Baird engineers as "The intermediate failure system." [39]

Herbert described the intermediate film process: [40]

> "The studio scenes were shot using a 17.5 mm cine camera and the exposed film passed immediately to processing tanks for developing and fixing which took about 30 seconds. It was then scanned while still wet by telecine equipment for conversion into television signals. Due to the time lag the sound had to be recorded as well."

Banks [41] described the intermediate film system and produced two untouched enlargements from experimental 9.5 mm film (Figure 3.13). Although normally producing very high quality pictures, Figure 3.14 shows a 180 line television image which has been distorted by streaks caused by clogged apertures in the mechanical disc scanner.

Abramson wrote: [42]

> "However, the need for an electronic camera tube was imperative. Control of the iconoscope was in the hands of RCA, EMI and Telefunken.

The only other device was the image dissector."

Baird Television awaited a possible licensing agreement with Farnsworth who was due in Britain to give them a demonstration of the image dissector at the Crystal Palace.

The next section describes the significance of the Baird-Farnsworth agreement.

Section 3.3

The Baird-Farnsworth Agreement

Figure 3.15: Image Dissector image (1934)

Late in 1934, Farnsworth, Turner, Rutherford and Brolly booked a passage on the S.S.Bremen with their portable all-electronic television equipment. This incorporated an electronic image dissector camera, a cathode-ray tube, a television monitor and the required control apparatus. The equipment was stowed as private luggage on board the passenger ship and was perfectly safe until the crates were lowered down to a smaller craft near Southampton.

> "A huge wave tossed the waiting deck up to meet the cargo, and they collided with a sickening crash". [43]

When the damaged crates were opened at the Crystal Palace it looked like a pile of junk and the Baird engineers were not initially impressed but fortunately the damage was more cosmetic than functional.

Elma Farnsworth wrote: [44]

> "All the tubes had come through unbroken, and most of the electronic components were in fine shape, This was really fantastic, considering

how heavy, but delicate, such gear and components were in those days." Elma Farnsworth also [45] indicated that they soon had the gear together with a clear picture on the monitor. An Image Dissector image of Elma Farnsworth is shown in Figure 3.15. Very soon the room was filled with Baird personnel trying to get a look at the electronic picture. The Baird Television board were impressed with the Image Dissector camera and the cathode-ray tube receiver. After serious negotiations, Baird finally agreed to purchase the exclusive British rights to exploit and develop Farnsworth's patents for the sum of a single payment of fifty thousand dollars, [46] which in accordance with the US Consumer Price Index [47] has a net present value of approximately six hundred and twenty thousand dollars. However, Szegho indicated: [48]

"Inflation between 1939 and 1991 had reduced the buying power of 1 dollar to 3 cents therefore fifty thousand dollars is today the equivalent of over 1 million dollars. *$1.66 million.*" Note: Authors italics.

Cross licensing and collaboration were not new concepts for Baird Television or Farnsworth. J. L. Baird had made attempts to merge with Marconi in 1932 and GEC in 1933. Although a mutual agreement had been reached with both concerns, the vote went against a merger by the Baird Company Board. [49] Farnsworth signed agreements with Philco in 1931, Baird Television in 1934, Fernseh in 1934, and AT&T in 1937. [50]

In a private communication to the author, Gilbert Tomes [51] made it clear that Farnsworth's contribution had its limitations. On the positive side, Tomes indicated that he considered Farnsworth's choice of a wide diameter 15 inch dia. cathode-ray tube was both wise and forward looking. Tomes also recalled that the tube which Farnsworth demonstrated had worked well although it had a short life. But Tomes is much more critical of the Farnsworth image dissector electronic camera tube: [52]

> "I always understood from those in the beginning, that the sample tubes that Farnsworth provided only worked after a fashion. The tubes did not give the appearance of having been made by professional tube engineers. The cathode sensitivities were low (twelve microamps per lumen) and there had been problems with the sensitising which resulted in uneven picture quality. The Farnsworth multipliers were unstable and were never made to work properly."

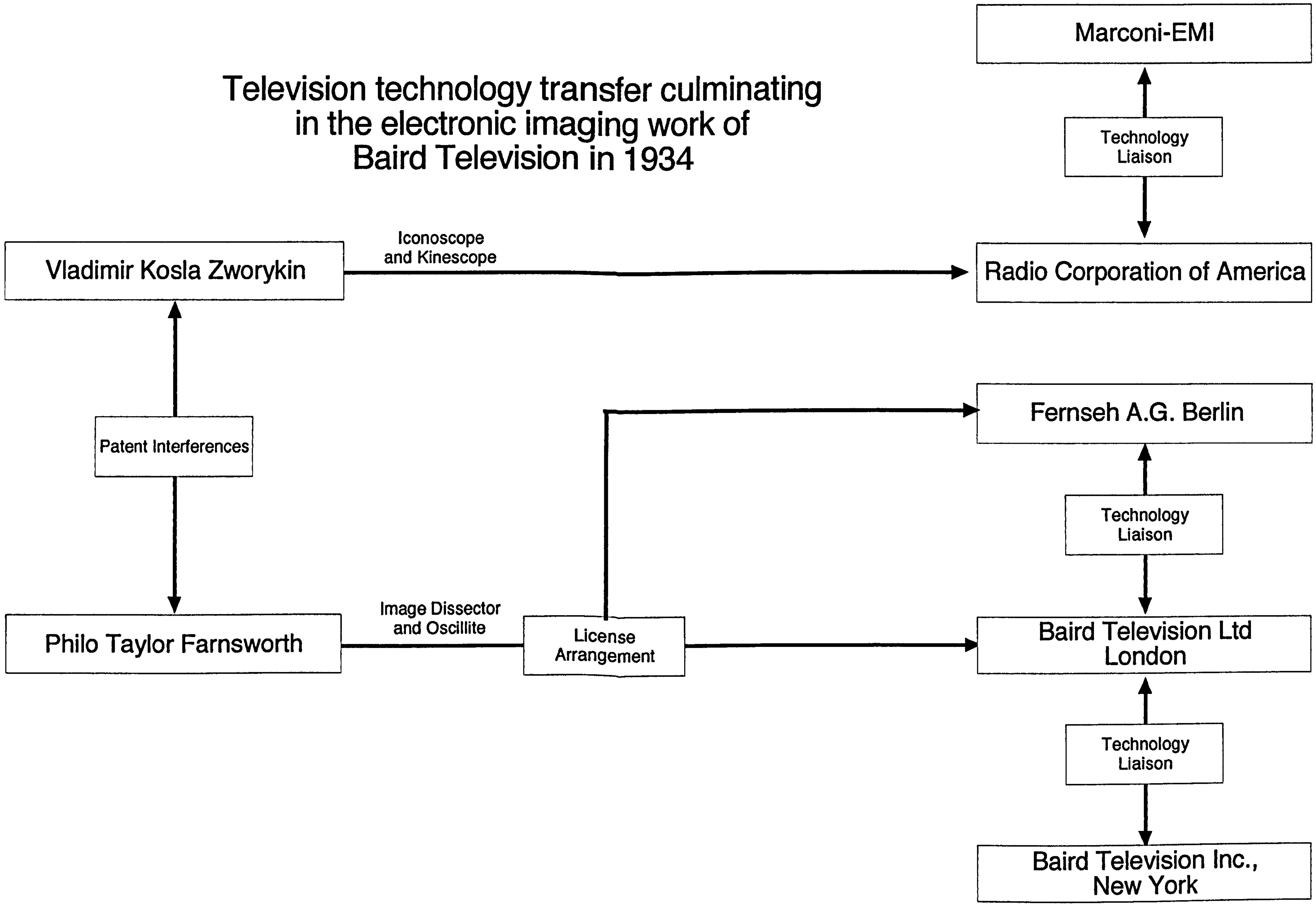
A tremendous amount of work by competent scientists during a five years period was required by Baird Television before the Baird electron camera (image dissector) became a plausible, albeit imperfect, device.

The pull-out chart Figure 3.16 illustrates, by means of a set of interconnecting arrow links the technology transfer which influenced the Baird Company's first endeavours towards electronic television. The technology developed by Farnsworth and Zworykin are shown to be pivotal in persuading the Baird Company to enter the electronic arena. The chart also shows that patent interferences existed between Zworykin and Farnsworth, and that there was patent reciprocity arrangements between: RCA and Marconi-EMI; Farnsworth and Baird Television; and Baird Television and Fernseh AG in Berlin.

Figure 3.16

Technology Transfer

Television technology transfer culminating in the electronic imaging work of Baird Television in 1934



Section 3.4

Baird Electronic Laboratories

Figure 3.17: Capt. A.G.D. West (1942)

Figure 3.18: T.M.C. Lance

In 1935, the Principal Shareholder of Baird Television was Isidore Ostrer of Gaumont British. The directors were: J. L. Baird (director); A. G. Church (director); W. J. Jarrard (director); I. H. Cremieu Javal (director); Sir Harry Greer (chairman); Sir Harry Clayton (deputy) and Captain A. G. D. West, (Figure 3.17) managing director, formerly the chief engineer of the BBC. T. M. C. Lance (figure 3.18) was head of research and B. Clapp was the general manager. The Baird staff structure from approximately 1934 until the devastating fire which virtually raised the Crystal Palace to the ground in 1936 is charted in Figure 3.19.

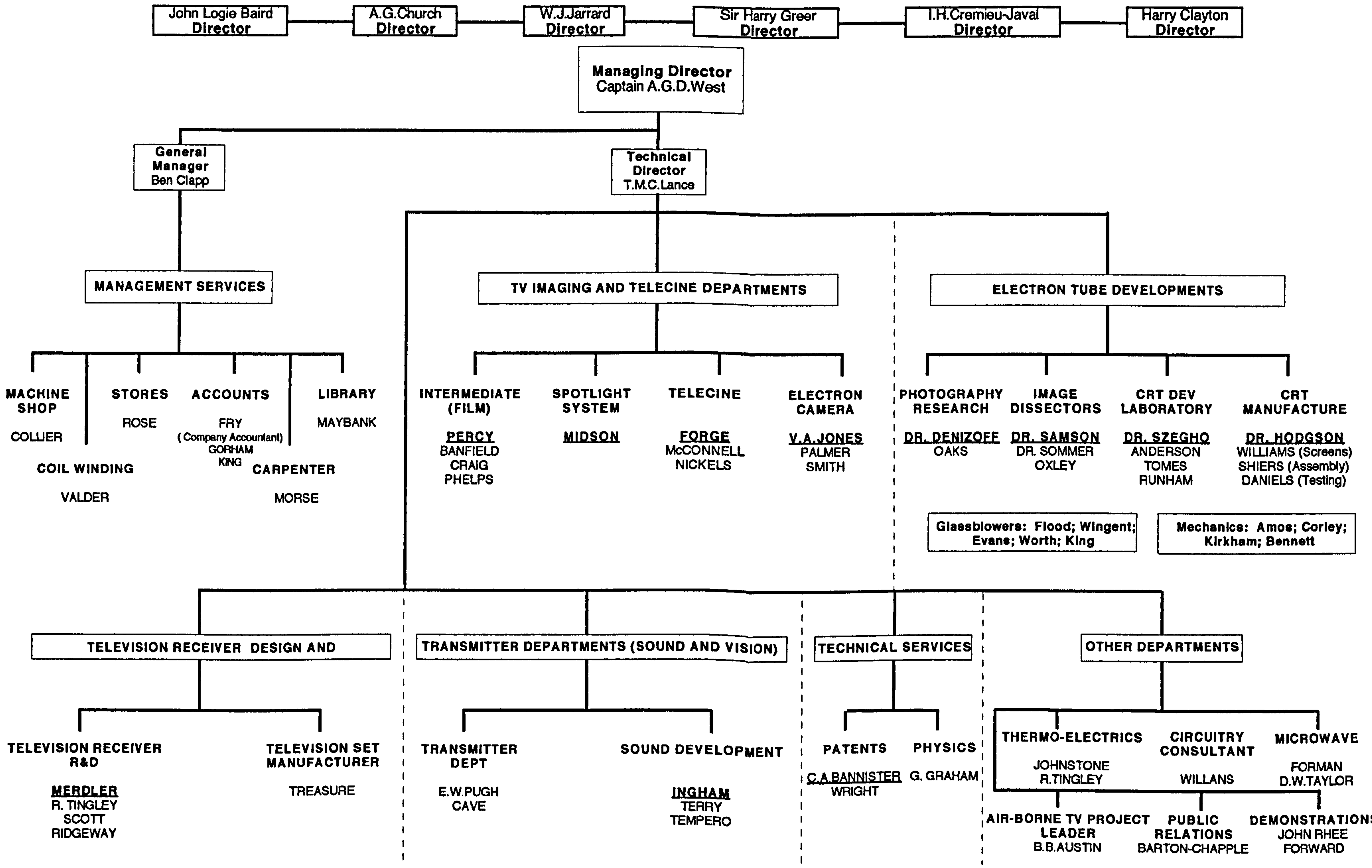
A laboratory (Figure 3.20) was established at Baird Television under the direction of Szegho (Figure 3.21), head of cathode-ray tube research. This employed: Flood - a skilled glassblower; Anderson - an assistant engineer formerly with Lissen Radio Valves; and Kirkham - a mechanic.

Figure 3.19

The Baird Company Staff Structure

Crystal Palace 1934 - 1936

Baird Television Company Structure
CRYSTAL PALACE 1936



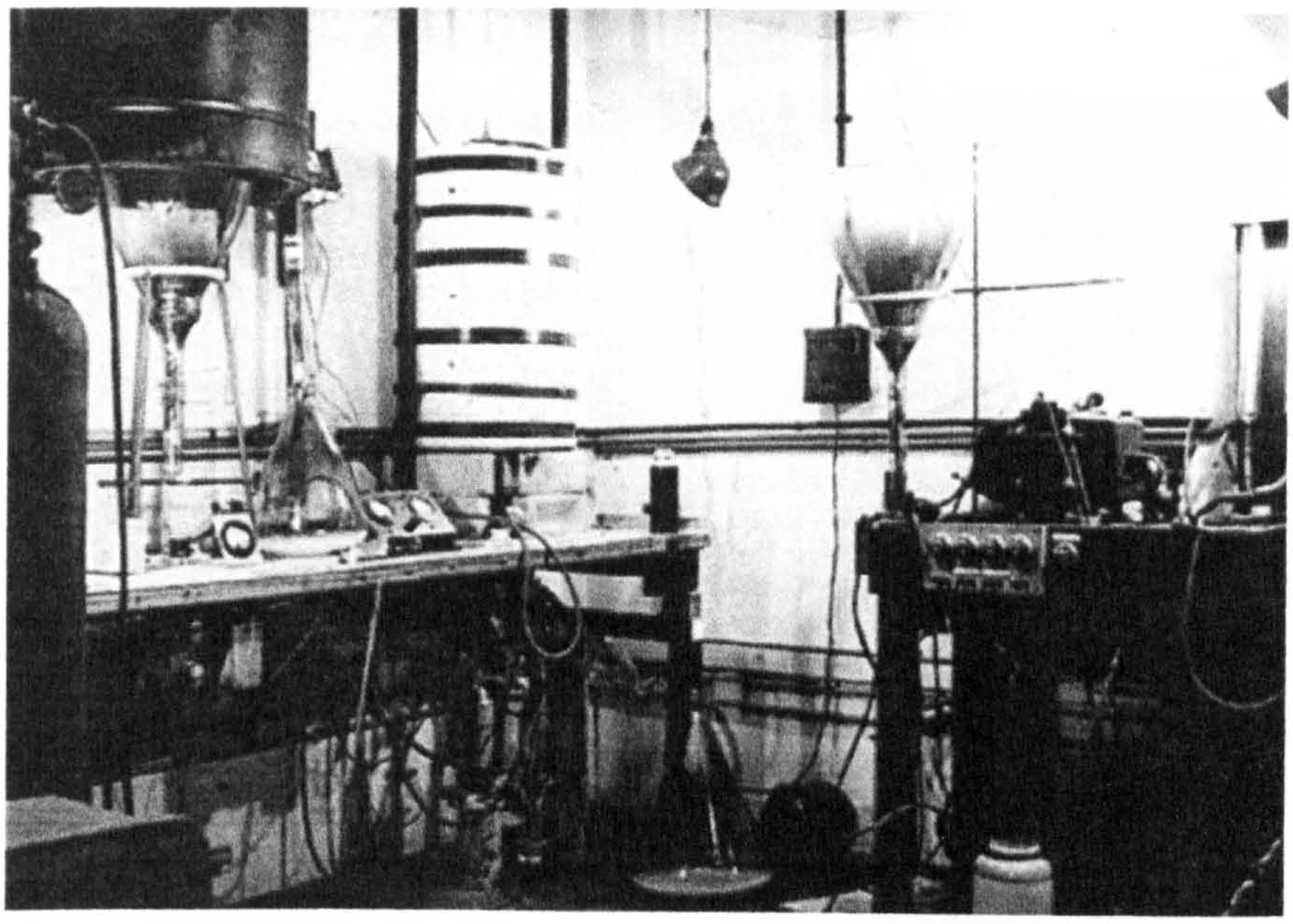


Figure 3.20: View of Szegho's first CRT facility at the Crystal Palace

The role played by Anderson in setting up the CRT research lab was crucial. He designed and set up the pumping stations, built the Eddy current heater and ionisation gauges and assembled CRT test gear. Although Tomes [53] indicated that the Farnsworth technology was minimal, Szegho considered the information imparted by Farnsworth to be worthwhile. In his unpublished memoirs Szegho wrote: [54]

> "Farnsworth brought with him some of his collaborators from his firm 'Electronic Tubes' in Philadelphia. Among them were Rutherford and Arch Brolly. My experience hitherto was with cold-cathode, cathode-ray tubes, and they taught me how to fabricate cathode-ray tubes for television with thermionic cathodes."

The Farnsworth team also instructed Szegho on the production of fluorescent material, willemite and zinc borate, and the fabrication of television screens. Of the thirteen patents taken out by Szegho between 1934 and 1939 at Baird Television, he indicated that one in particular, in the joint name of Szegho and Anderson, had the greatest impact on the

Figure 3.21: Dr C. S. Szegho

Figure 3.22: Dr K. A. R. Samson

Figure 3.23: G. A. R. Tomes
(Supplied Diaries)

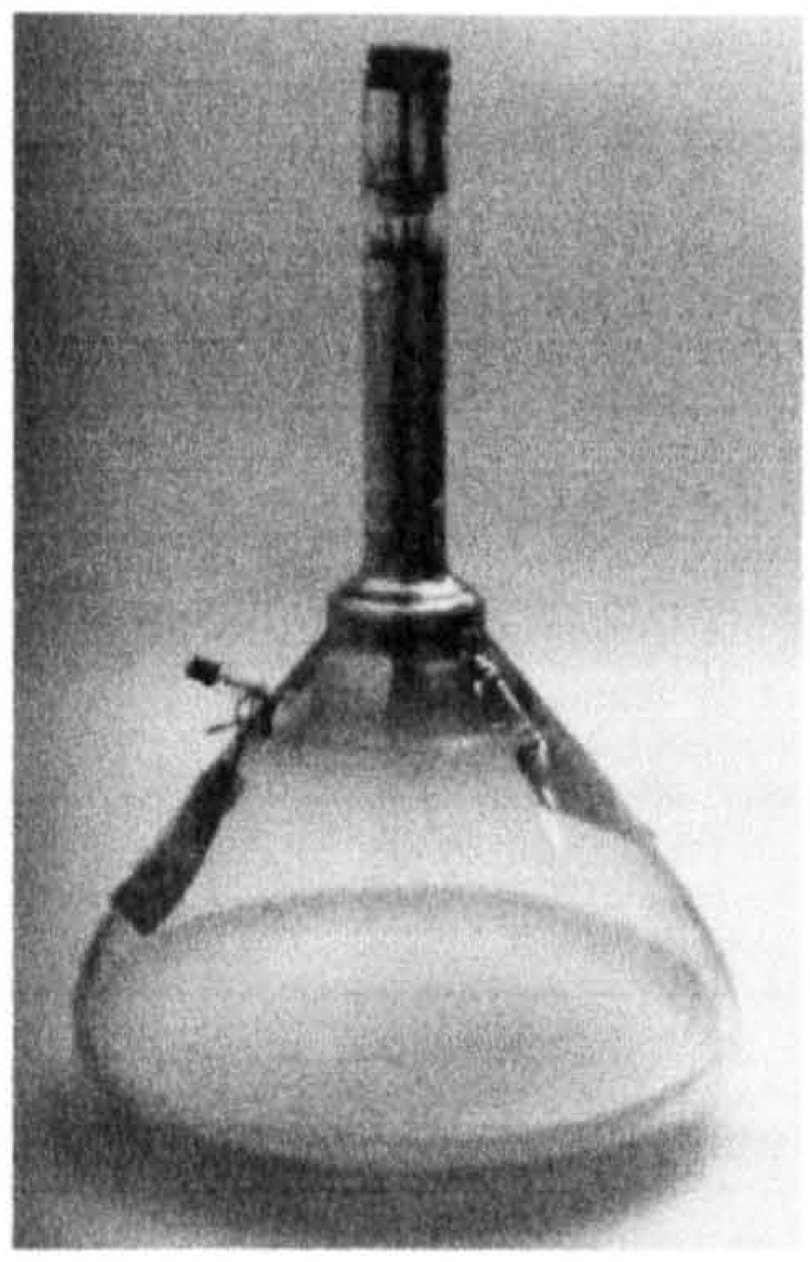


Figure 3.24: Baird Cathovisor

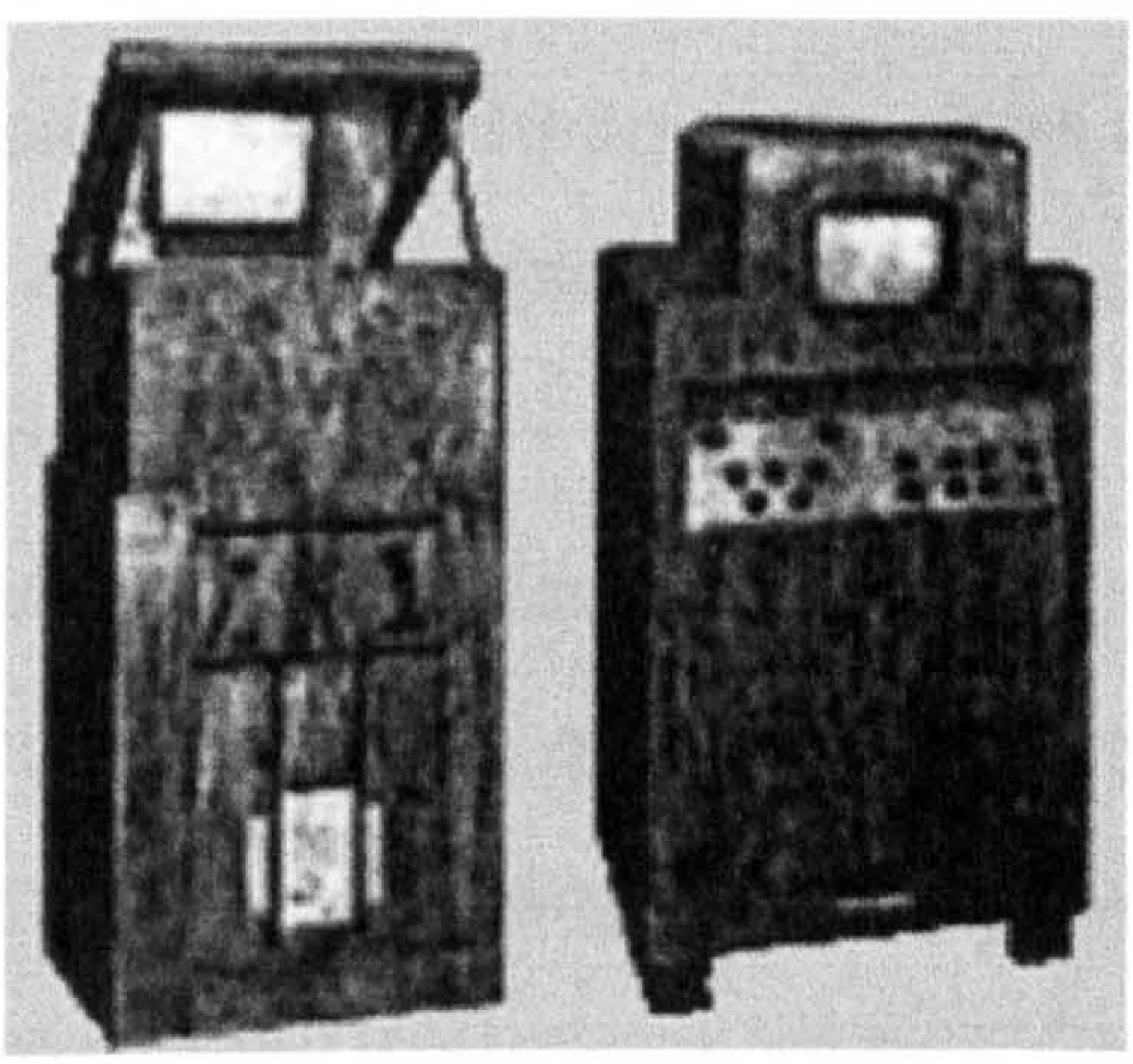


Figure 3.25: Baird Cathovisor television receivers (1935)

Figure 3.26: Dr A. H. Sommer

cathode-ray tube industry: [55] "Outside Wall Coating on Cathode-Ray Tubes to serve as a High Voltage Filter Capacity." Although a simple innovation Szegho explained that this method has been incorporated in many millions of cathode-ray tubes built since the Second World War. [56]

Tomes wrote: [57]

> "Szegho's department's prime task was supplying workable 15 inch tubes for Merdler, who was the head of Television Receiver Development. In addition, 15 inch monitor tubes for telecine, intermediate film and spotlight were provided, usually on a hand to mouth basis."

Dr Samson, (Figure 3.22) formerly with Blaupunkt in Germany, was hired as head of the photoelectric department in 1935 to develop the image dissector tube, and on 15 June 1935 Tomes (Figure 3.23) was hired as the fifth and most junior member of the cathode-ray tube development department. Tomes soon learned that there were dangers in working with vacuum tubes. Some of the first glass envelopes available for cathode-ray tubes had uneven wall thickness which resulted in about six per cent of the bulbs being lost by implosion. This occurred when a tube was evacuated and sealed followed by a stress crack weakening the glass. The effect is like an explosion, but instead of the glass and material immediately flying outward it is forced inwards through the centre of the tube.

Tomes wrote: [58]

> "The scream of the glass-blower's flames made me temporarily deaf and when a tube imploded, showering me with glass, I felt slightly nervous. The technology of making electron tubes was quite new to me."

Baird's cathode-ray tubes were named 'Cathovisors' (Figure 3.24). Szegho [59] indicated that the tubes were magnetically focused and deflected, and operated at an anode voltage of 6.5 kV. The first models of Baird television receivers to use 15 inch tubes were made in 1935. (Figure 3.25).

On 1 January, 1936 the vacuum team was further complemented by the addition of Dr Sommer (Figure 3.26) a brilliant German research chemist, who had formerly designed large area photomultipliers for a mechanical television system developed by the German Post Office.

Sommer wrote: [60]

> "Basically, I have spent all my life developing new photocathodes and to incorporate them into three types of tubes, viz., photomultipliers, TV camera tubes, and image tubes. Most of my work was done on the first two, but I was also involved in the development of Image tubes."

The first photocathode available for use in the image dissector, the iconoscope, the emitron, photocells and photomultipliers was chemically produced from silver-oxygen-caesium (Ag-O-Cs) and was called S-1. This photoemissive surface had a peak in the infrared making it useful for night vision tubes. Sommer [61] indicated that S-1 was a most unsuitable cathode for television due to its non panchromatic response curve. Performers had to use heavy make-up and tongues always looked like white paper.

There was a great deal of interest in image converter tubes at Baird's. These devices were half photocell and half cathode-ray tube.

Tomes wrote: [62]

> "Szegho and I had constructed the tube and made the fluorescent screen; Dr Sommer had sensitised the cathode, while we watched. I tested the tube afterwards using a large cylindrical focussing coil."

The image converter was a cold cathode device based on the image dissector tube and required a conductive wall coating and a suitable

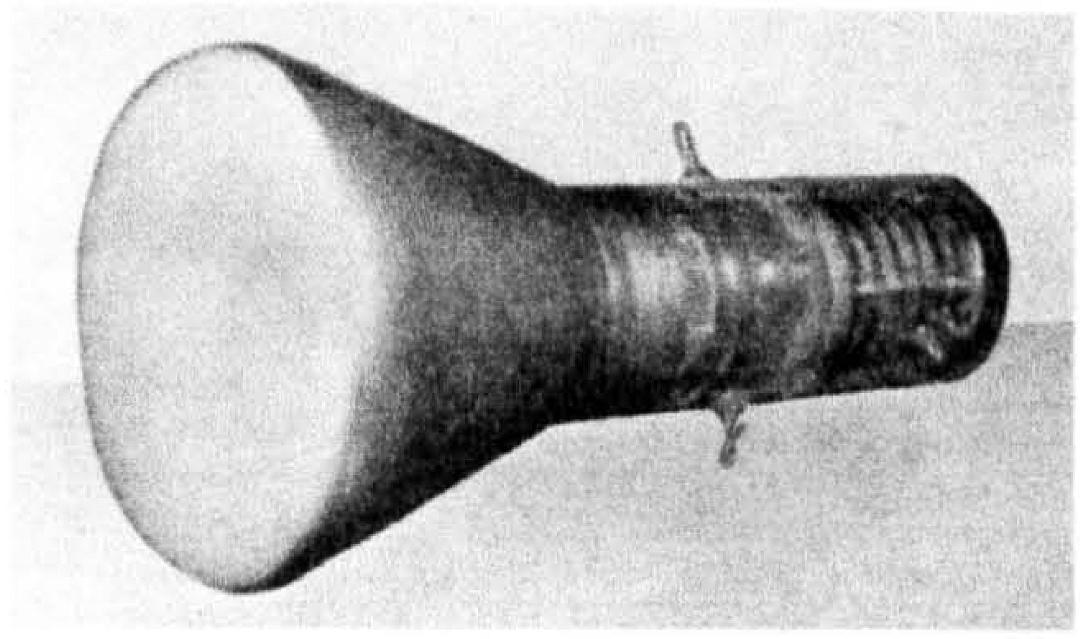


Figure 3.27: RCA Image Tube

magnetic field. Szegho indicated that he made this tube to demonstrate the principle of the image dissector: [63]

"I remember how overjoyed Captain West was when I built an image converter. In this, an optical image on the photocathode releases an electron replica, which in turn is made visible on the fluorescent screen."

Szegho recollected that he made this tube in 1936, and that Captain West was impressed with the image of Mickey Mouse made visible on the screen from the picture thrown on the cathode. Tomes [64] remarked that although the image convertor was only of academic interest to the Baird Company, the technique was later successfully adopted by EMI as an imaging stage for the super emitron camera. In this type of tube which utilised an S-1 photocathode a grey scale image could easily be rendered in virtual darkness with the help of infrared floodlights. Another example of this type of device was later described in 1938 by Maloff and Epstein [65] of RCA (Figure 3.27). Although Baird Television did not invent the image tube this serves as an illustration of the company's technical ability. It will be shown in chapter six that the British Air Ministry were taking an active interest in the electronic imaging work of the Baird Television Company.

Another interesting imaging device produced by Szegho at Baird Television was a 'still' television scanning camera tube. Nixon [66] cited Dr Knoll as being first to describe this type of picture generator tube.

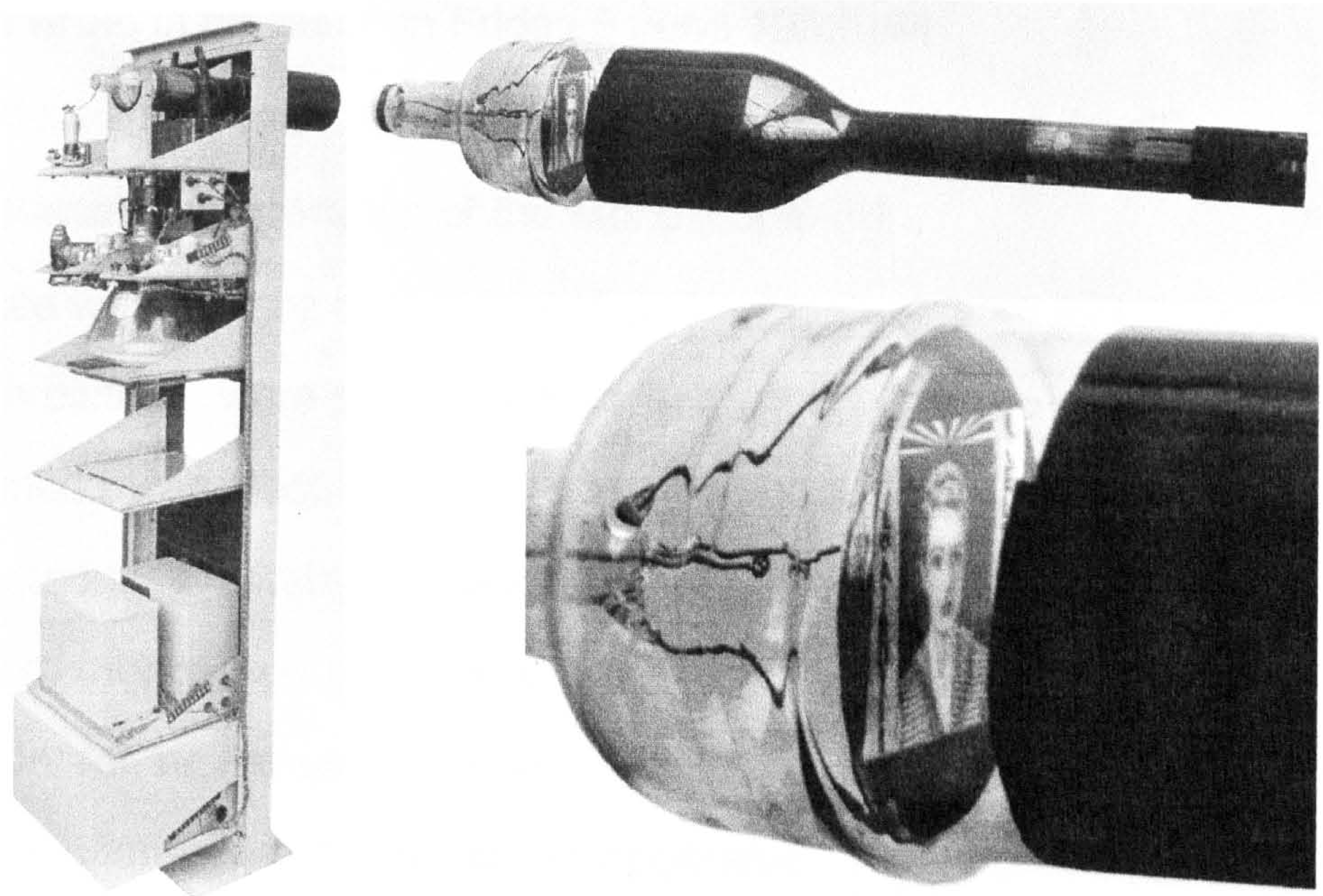


Figure 3.28: Baird Monoscope Camera and Baird Monoscope Tube

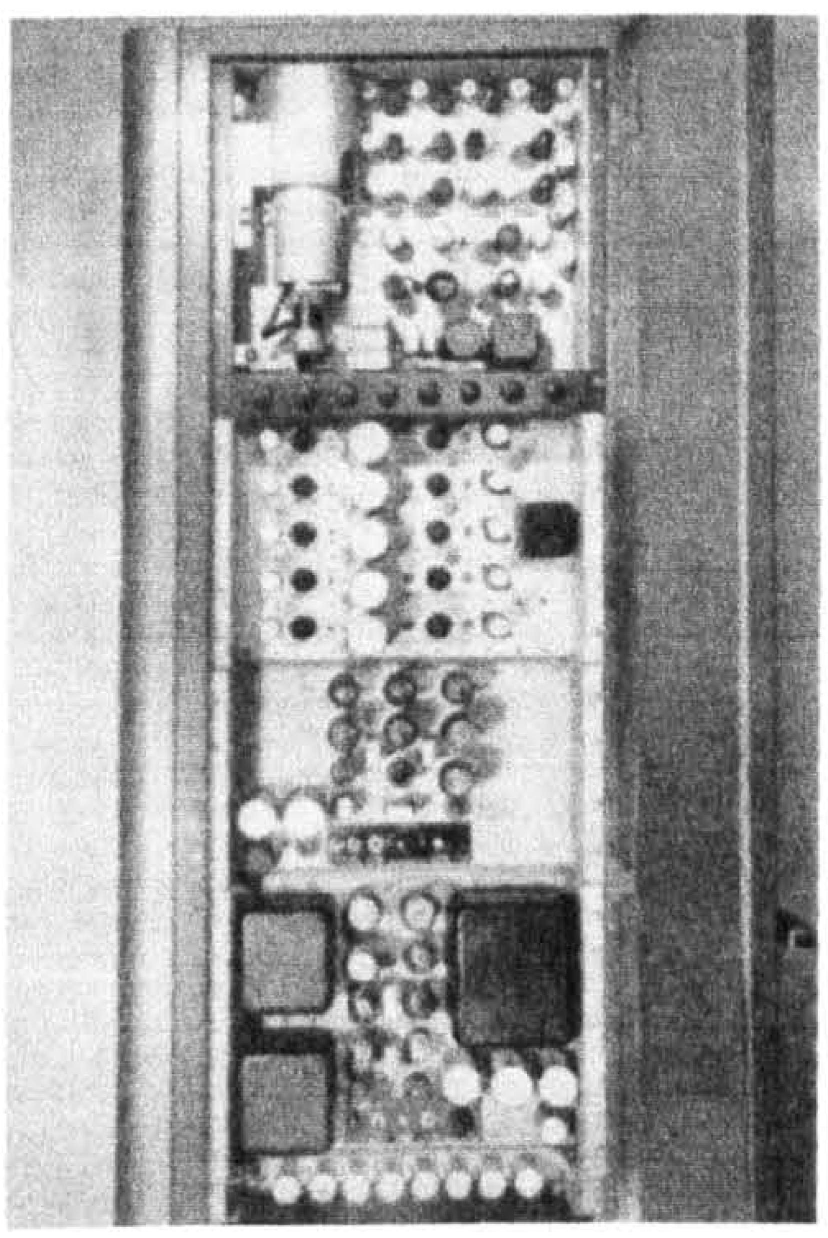


Figure 3.29
RCA's Monoscope

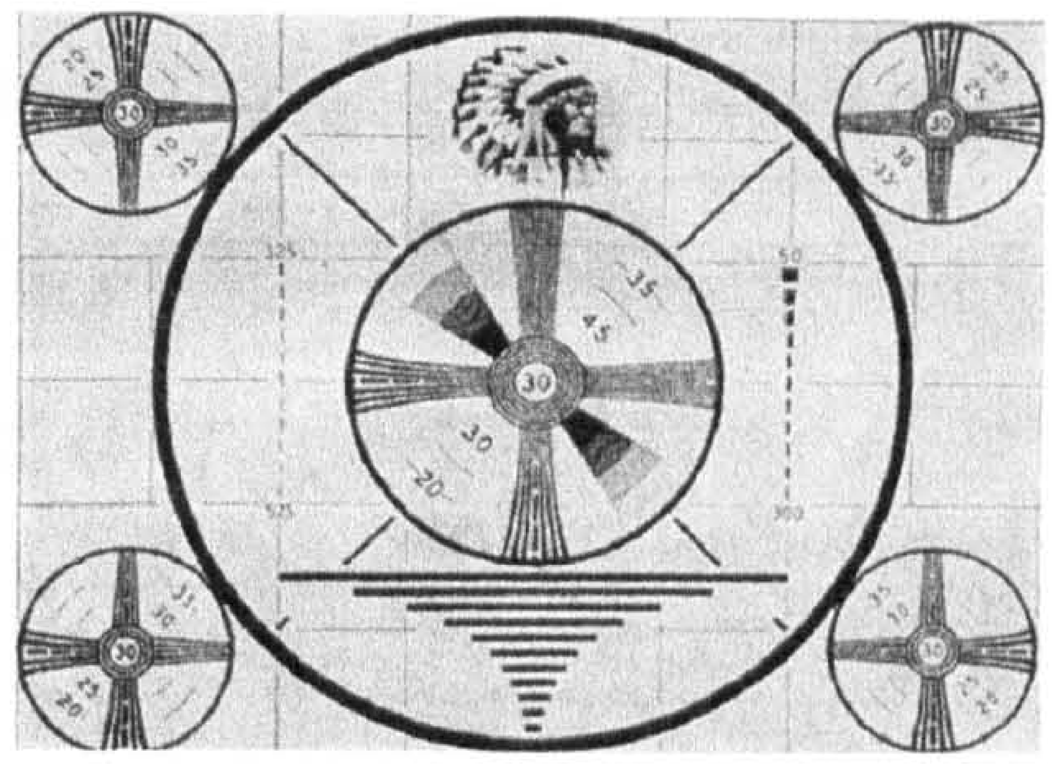


Figure 3.30: RCA's
Monoscope Test Card

Recalling Knoll in his memoirs Szegho wrote: [67]

"One of my enduring friendships was struck up with Dr Knoll, then the director of electron tubes at Telefunken. He published among many other things (he is, for example, credited with being the first inventor of the electron microscope,) about the possibility of creating images by secondary emission of plates printed by materials with differing secondary emission yields. I at once reduced this to practice at Baird, making monoscopes."

Tomes wrote in his diary on Friday 5 June 1936: [68]

"Made a small tube with a pattern that could be scanned well"

He described the operation of the Monoscope: [69]

"These were simple cathode-ray tubes, which scanned metal plates on which pictures were printed with carbon. When the target anode was scanned by an electron beam, secondary electrons were emitted and collected by a suitably disposed signal electrode."

The Baird monoscope gave excellent still pictures and was put into operation for setting-up cathode-ray tube receivers without the need for television cameras and other studio apparatus. Figure 3.28 illustrates the Baird monoscope rack assembly, the tube and a close-up of the target within the tube showing the carbon picture of Madeleine Carroll from the film 'I was a Spy'. In 1938, Burnett [70] of RCA also produced a monoscope (Figure 3.29) for use as a television test card. (Figure 3.30).

Section 3.5

The Baird Electron Camera

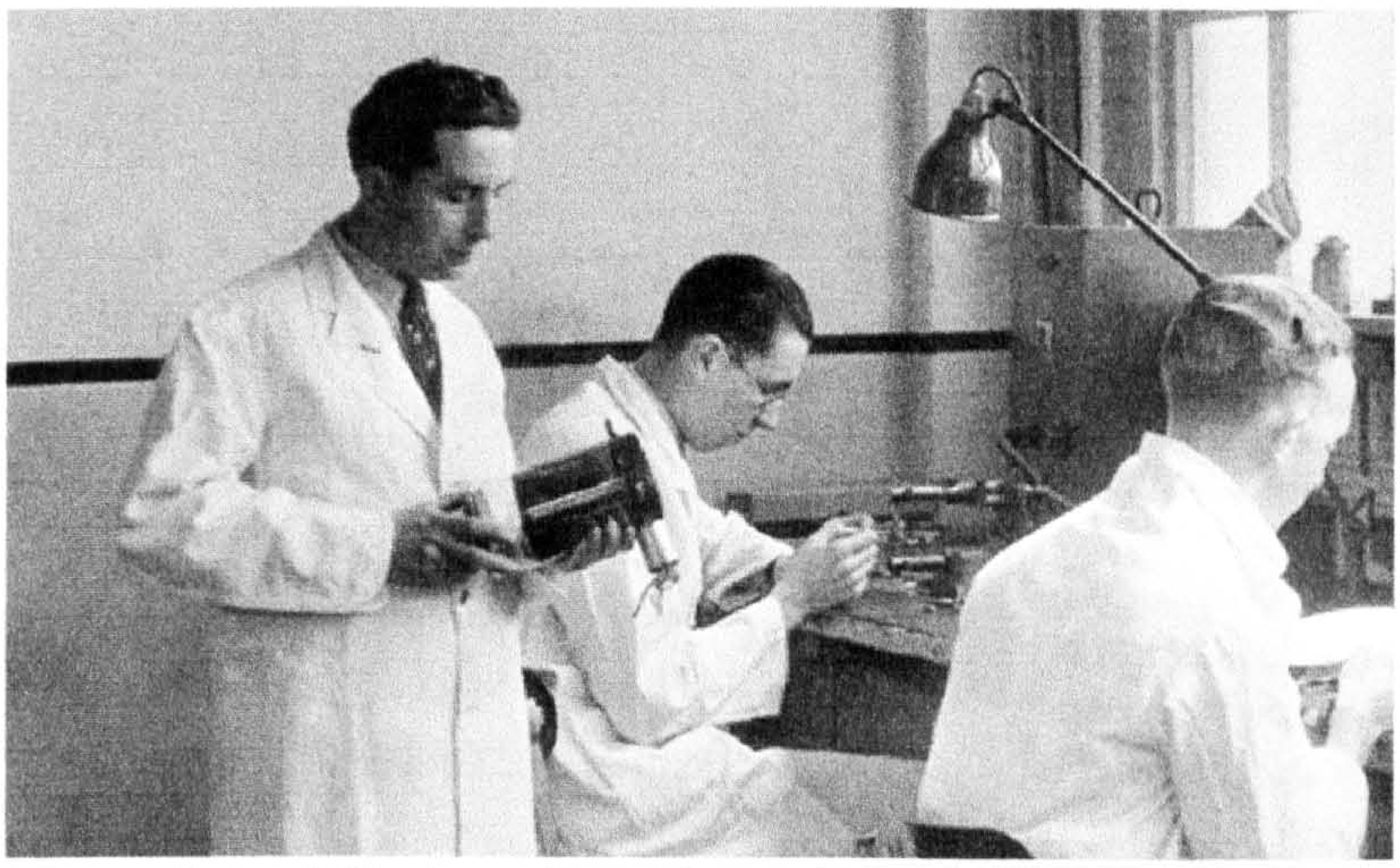


Figure 3.31: Amos inspecting an Image Dissector tube

In Britain the Farnsworth image dissector became known briefly as the Baird electron camera, but it appeared that the sensitivity of the tube was not as high as the Marconi-EMI emiscope. Figure 3.31 shows Mr Amos (Baird mechanic) with a group of glassblowers inspecting an image dissector tube. A photograph of the Baird electron camera in operation is shown in Figure 3.32, and the resulting quality of television image on a monitor screen is reproduced in Figure 3.33.

Although the electron multiplier enabled the Baird electron camera to be used in bright daylight there was insufficient sensitivity to guarantee that a noise-free image could be obtained during the passage of clouds. Sommer [71] explained that the lowest light level that can be used for television transmission is determined by the signal-to-noise ratio in the original conversion of photons into electrons. His point is that in a tube working on the storage principle the signal is stored during the whole frame

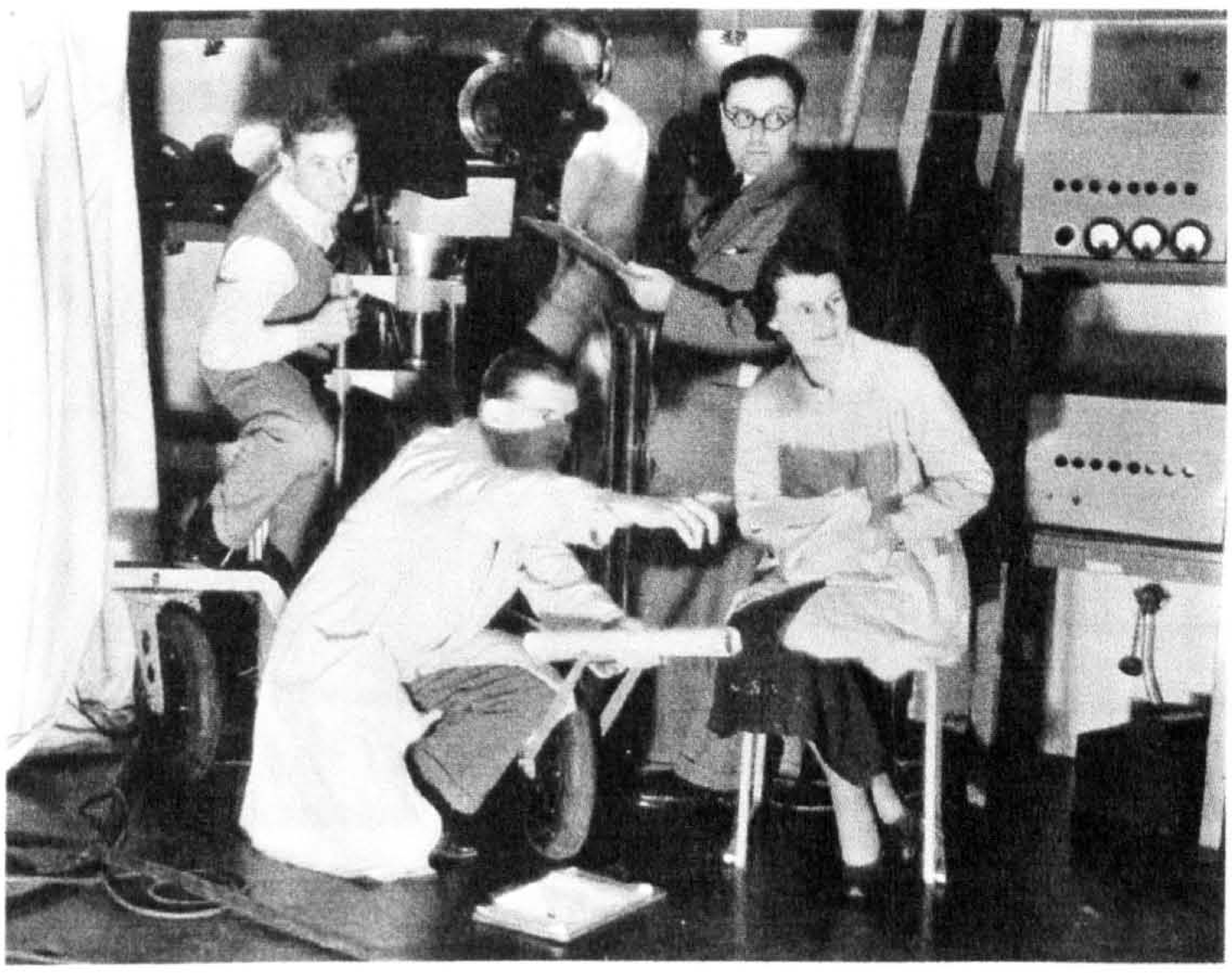


Figure 3.32: The Baird Electron Camera in operation

Figure 3.33: Photograph of a Baird Electron image as it appeared on the screen of a Baird television monitor.

time, but image dissectors and Nipkow discs can only produce photoelectrons during one single scanned picture element. Sommer concluded that the difference in sensitivity between storage and non-storage cameras is several hundred thousand times. When asked about the addition of the electron multiplier Sommer explained: [72]

"It is true that the dissector plus internal electron multiplier is an improvement because the multiplier is more efficient than an external amplifier, but this is a relatively minor improvement."

Sommer is correct, if it is assumed that real frame storage existed in the iconoscope, but I have earlier presented evidence [73] to show that the device was only capable of producing storage for a part of a 'line' time. Knox McIlwain compared the sensitivity of the iconoscope with the image dissector in 1939 and concluded: [74]

"The iconoscope was sufficiently sensitive to permit a usable picture for scenes with an average brightness down to 15 candles per square foot. Assuming an f:4.5 lens of 0.75 transmission which results in a 0.37

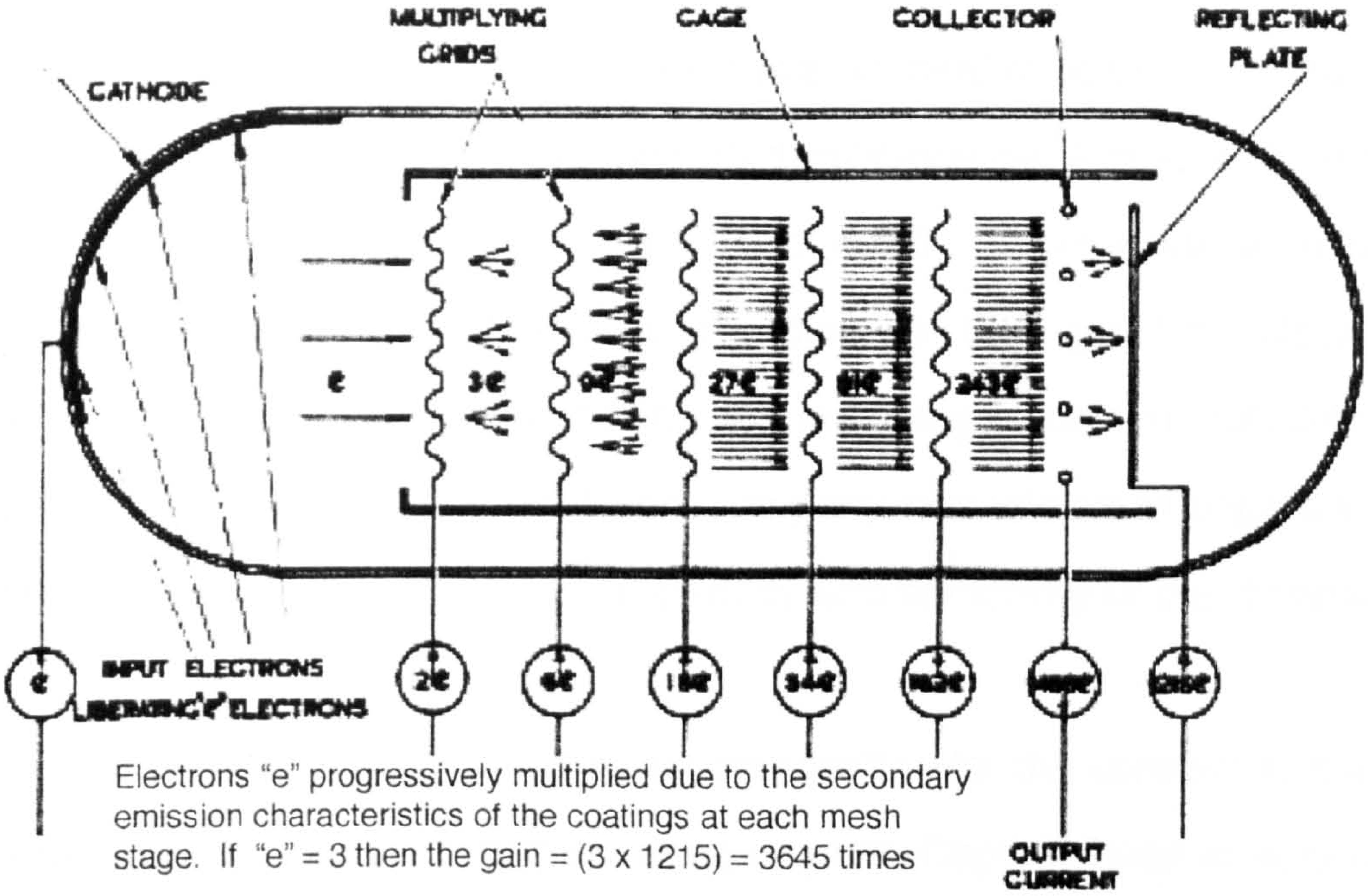


Figure 3.34: Weiss Type Electron Multiplier

footcandle on the mosaic surface. While this minimum level can be used an average brightness of at least 100 candles per square foot is desirable. Excellent results are obtained with the dissector camera using a subject light intensity of 200 footcandles. A recognisable picture is given with only 4 footcandles although the picture appears speckled with noise. The dissector requires a subject brightness level of about 150-170 candles per square foot as a minimum and has greatest sensitivity in the infrared where it peaks at approximately 8000 angstroms."

There has been much speculation suggesting that Baird Television was less fortunate than Farnsworth with the image dissector. [75] This is certainly not the case. Sommer and Samson improved the poor sensitivity which the first dissector tubes exhibited by removing the unstable Farnsworth electron multiplier and adopting Sommer's highly sensitivity Weiss type multipliers, the operation of which is illustrated in Figure 3.34.

Tomes: [76]

> "The camera tubes were beautifully made, in ideal conditions. Primary cathode sensitivities often reached 25 microamps per lumen and the ten stage multipliers had gains of the order of 4000. Sommer was an expert at processing surfaces to achieve low noise and high gain from stage one, which is the all important thing in a multistage electron multiplier."

Contrary to the opinion that the Baird Company was unable to cope with this device they had actually raised the stability and sensitivity of the dissector.

With Marconi-EMI now in direct competition for the contract to supply the BBC with television transmission equipment, Captain West arranged for the installation of the intermediate film, spotlight scanner, image dissector and the telecine at Alexandra Palace. During this time Szegho and Tomes diversified by experimenting with high brightness television cathode-ray tubes. Although John Logie Baird is well known for experimenting with apparatus for use in cinemas from as early as 1930, [77] theatre television (see Chapter 5) by means of cathode-ray projection tubes became a new field of endeavour for the Baird Television Company.

The next section describes how Baird Television developed to manufacture high quality television tubes and receivers.

Section 3.6

Electronic Television Receiver Production

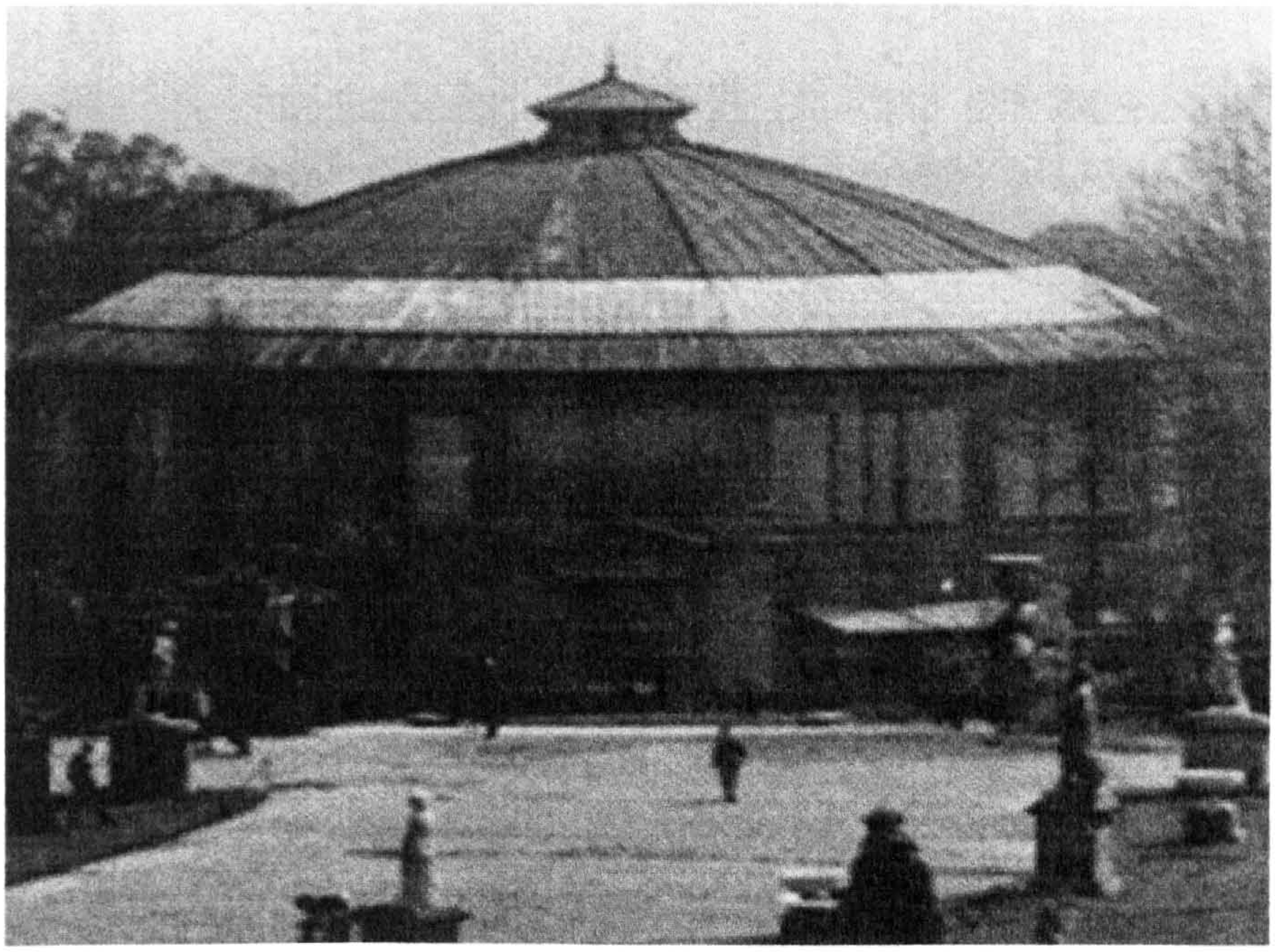


Figure 3.35: The Rotunda Building in the grounds of the Crystal Palace

A production facility for building quality electronic television receivers was provided by Baird Television at the Crystal Palace in the School of Art Building. To support this a production facility for cathode-ray tubes was in preparation in the Rotunda (Figure 3.35) under the direction of Dr Hodgson. This was a large circular building set in the grounds of the Crystal Palace, originally constructed in Victorian times to display a vast panorama of the Battle of Waterloo.

Baird cathovisor glass bulbs were prepared prior to the attachment of the tubular neck, (Figure 3.36) before fabricating the fluorescent screen with fluorescent powder by the dusting method (Figure 3.37). It was

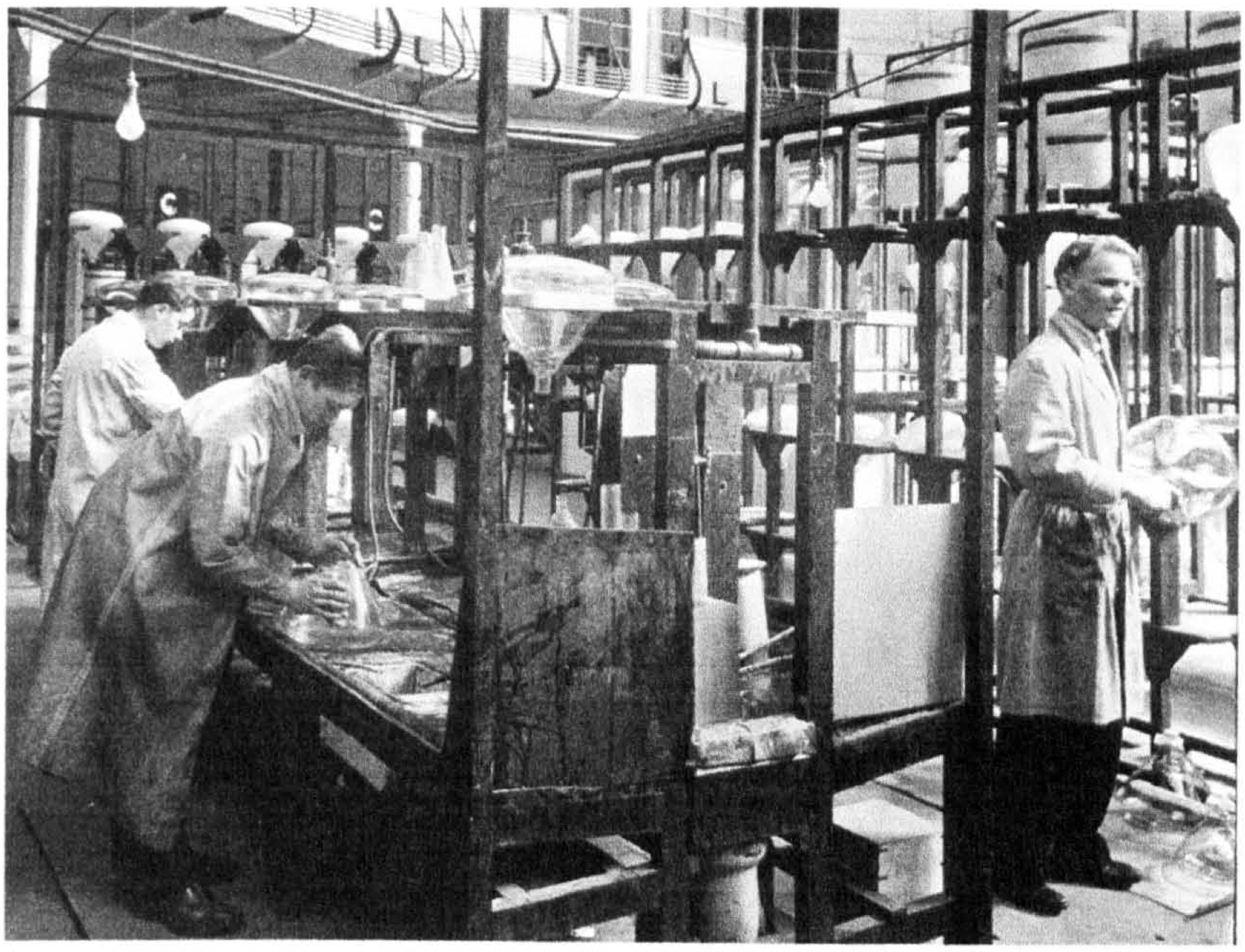


Figure 3.36: cathode-ray tube Fabrication in the Rotunda

essential to ensure that the glass assembly would not implode under the pressure of a vacuum. The tubes were inserted, one at a time into an autoclave, (Figure 3.38) which applied positive pressure to the glass walls. This was equivalent to the pressure which the walls would have to withstand when under the influence of the vacuum. After fabricating the screen, the tube was placed on a vacuum and the cathode activated (Figure 3.39). The tube was then heated up to remove unwanted gasses by means of a professionally built eddy current heater before sealing off. Tomes recalled that in 1935, as the most junior member of the CRT development laboratory, it was part of his work to operate a rather hazardous version of an eddy current heater built by Anderson: [78]

"It was the size of a washing machine and was trundled on casters. It was in effect a high power portable radio transmitter, in which all the energy was concentrated in a three inch copper cylindrical coil. Any metal placed within the coil would become red hot and we used it for de-gassing the electrodes within the CRT`s."

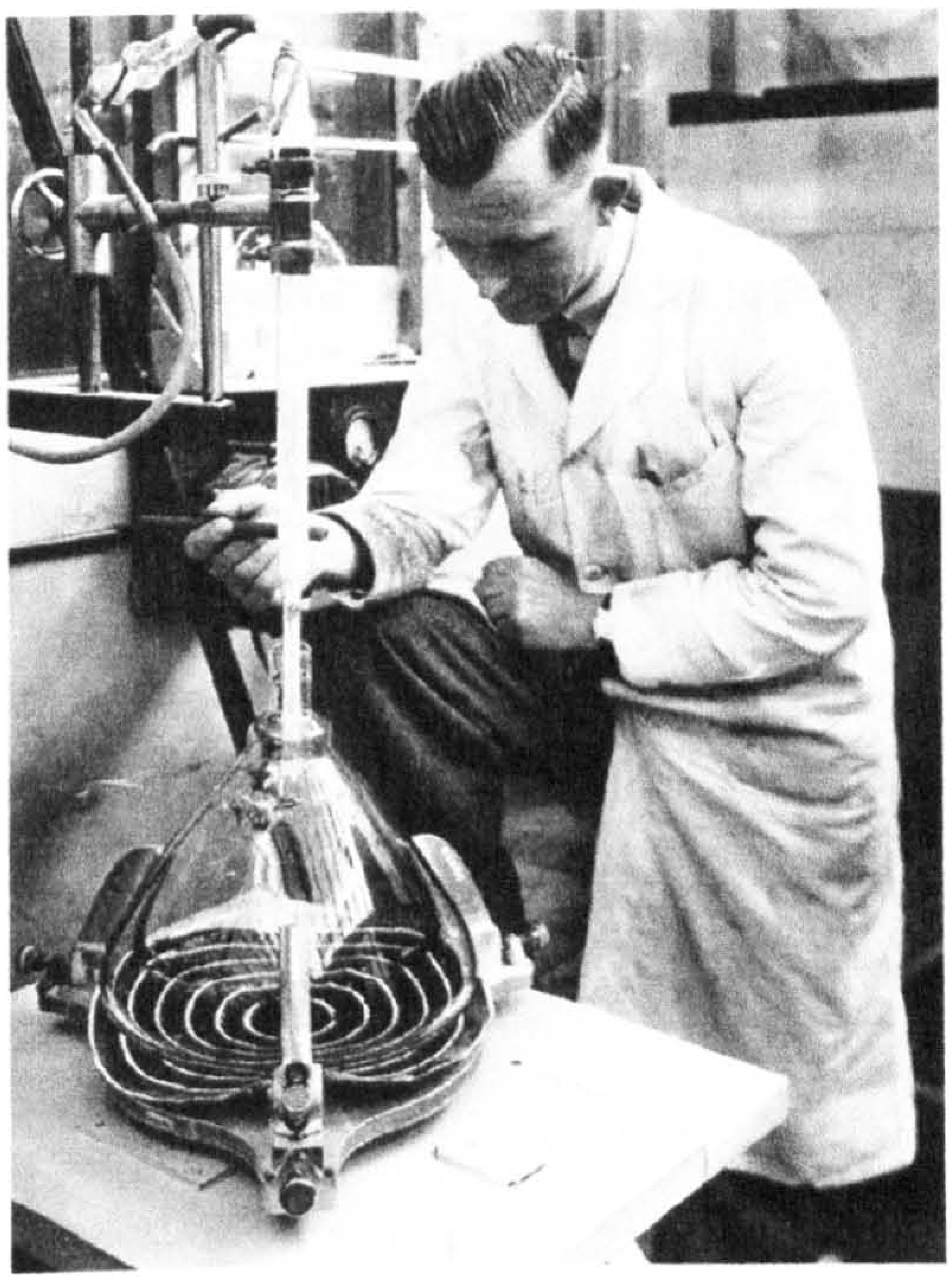


Figure 3.37: Depositing fluorescent screens by the dusting method.

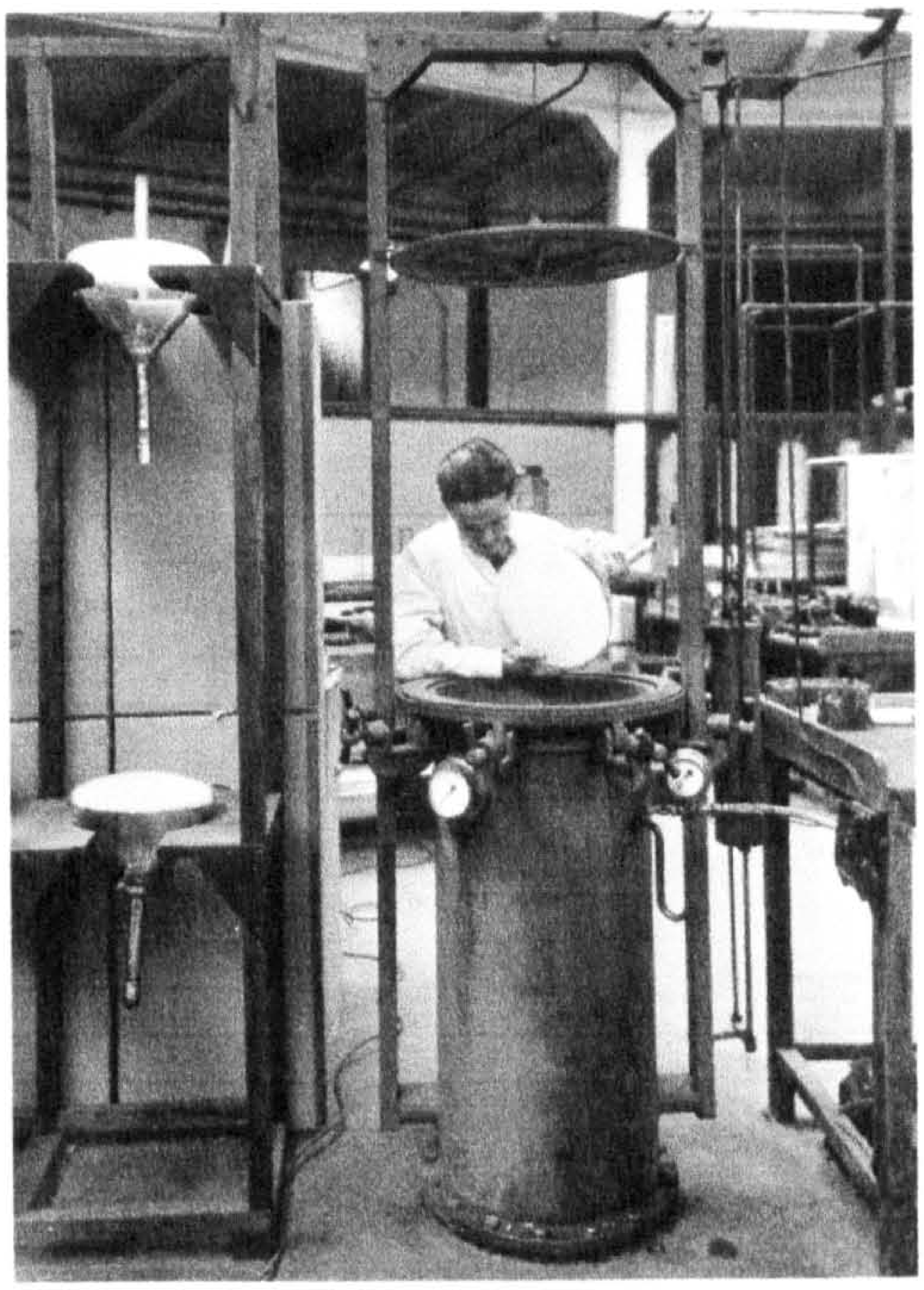


Figure 3.38: Autoclave testing of tube prior to evacuation to avoid implosion.

Figure 3.39: Using an Eddy Current Heater to Outgas the electrode structures and activate the cathode.

The next chapter identifies the Baird imaging technology in the Alexandra Palace, the effects of the Crystal Palace fire, and discusses the merits of the two different standards of systems under review. It will also be shown that, Farnsworth, Fernseh, Nazi Germany, Alexandra Palace and the fire at the Crystal Palace were linked to the apparent removal from the scene of the Baird electron camera.

References: Chapter 3

1 Note: (£50,000 x (1+0.06) to the power of 65 = £2,200,000). Calculated by reversing the net present value of money calculation using the HM Treasury recommended discount rate of 6%.

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CHAPTER 4

Baird Television at Alexandra Palace

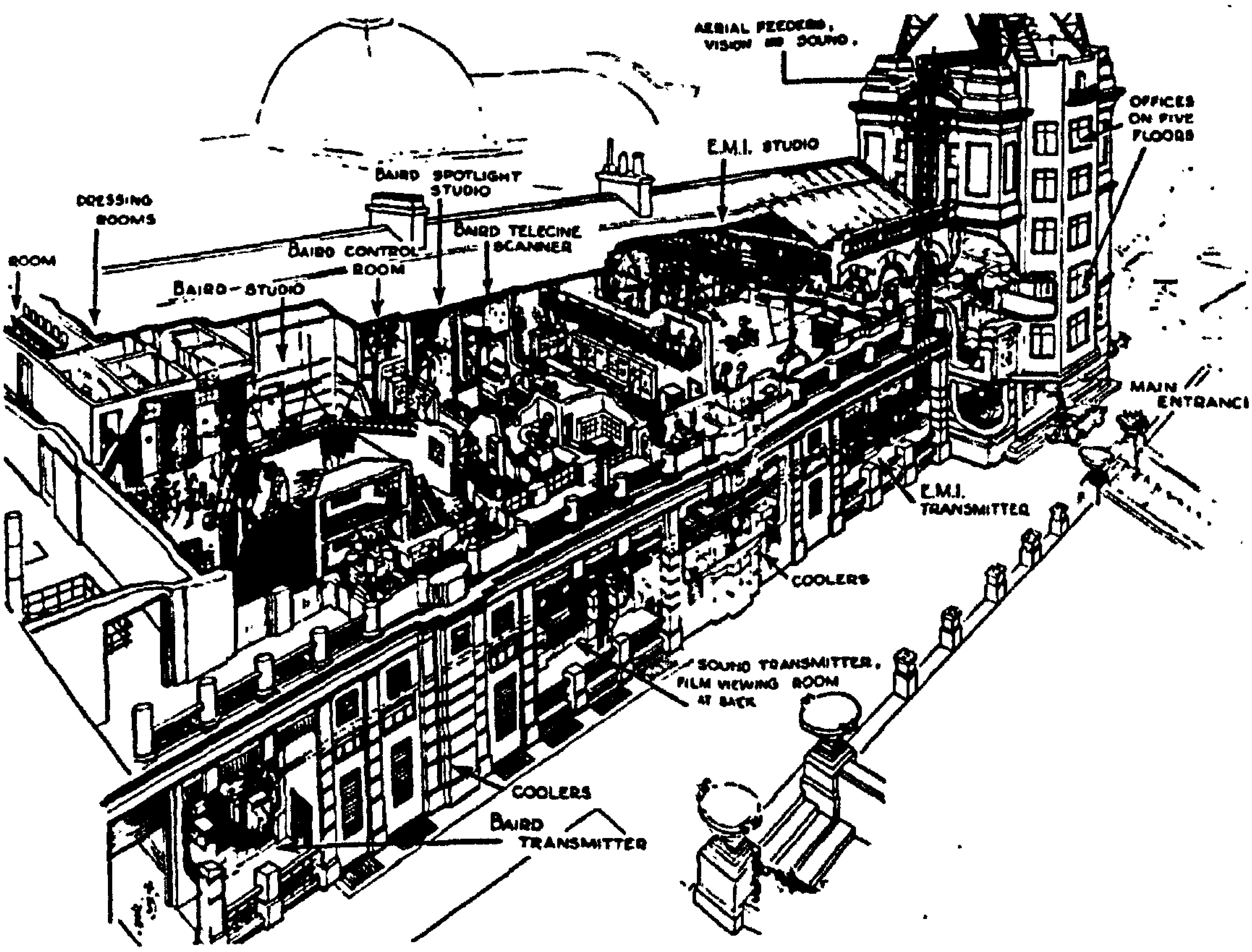


Figure 4.1: The Baird Television Installation at Alexandra Palace

List of Illustrations: Chapter 4

Section 4.1

Alexandra Palace

The British public first saw high definition television on 26 August 1936 at 'RadiOlympia' in London. The trade exhibitors at the Olympia exhibition centre were anxious to exploit the preliminary trials of Marconi-EMI and Baird Television at the BBC to demonstrate their new cathode-ray tube television receivers.

Bennett-Levy wrote: [1]

> "The world's first domestic television sets were manufactured for a few wealthy enthusiasts living in the London area in 1936. They were expensive, costing as much as a family saloon car. In return for this outlay they could receive two hours of broadcasting per day, including repeats."

Tomes indicated [2] that continuous demonstrations were given of television at RadiOlympia in what was termed 'Television Alley.' This was a dark passage fabricated to enable visitors to walk through and view pictures on the screens of a number of television receivers. Each set was supposed to be from a different manufacturer but due to defaulting set makers, five were supplied by Baird Television: [3]

> "There were 12 sets on view, each showing the identical picture. It was usually the current 'British Movietone News,' sent from Alexandra Palace using the Baird mechanical telecine scanner."

While all of the other set makers used 12 inch screens, the Baird T.5 set (Figure 4.2) produced the largest picture on its 15 inch cathovisor tube. (Figure 4.3).

Figure 4.2: The Baird T.5 (1936) with the vertically mounted 15inch 15 WMI Baird cathovisor Tube

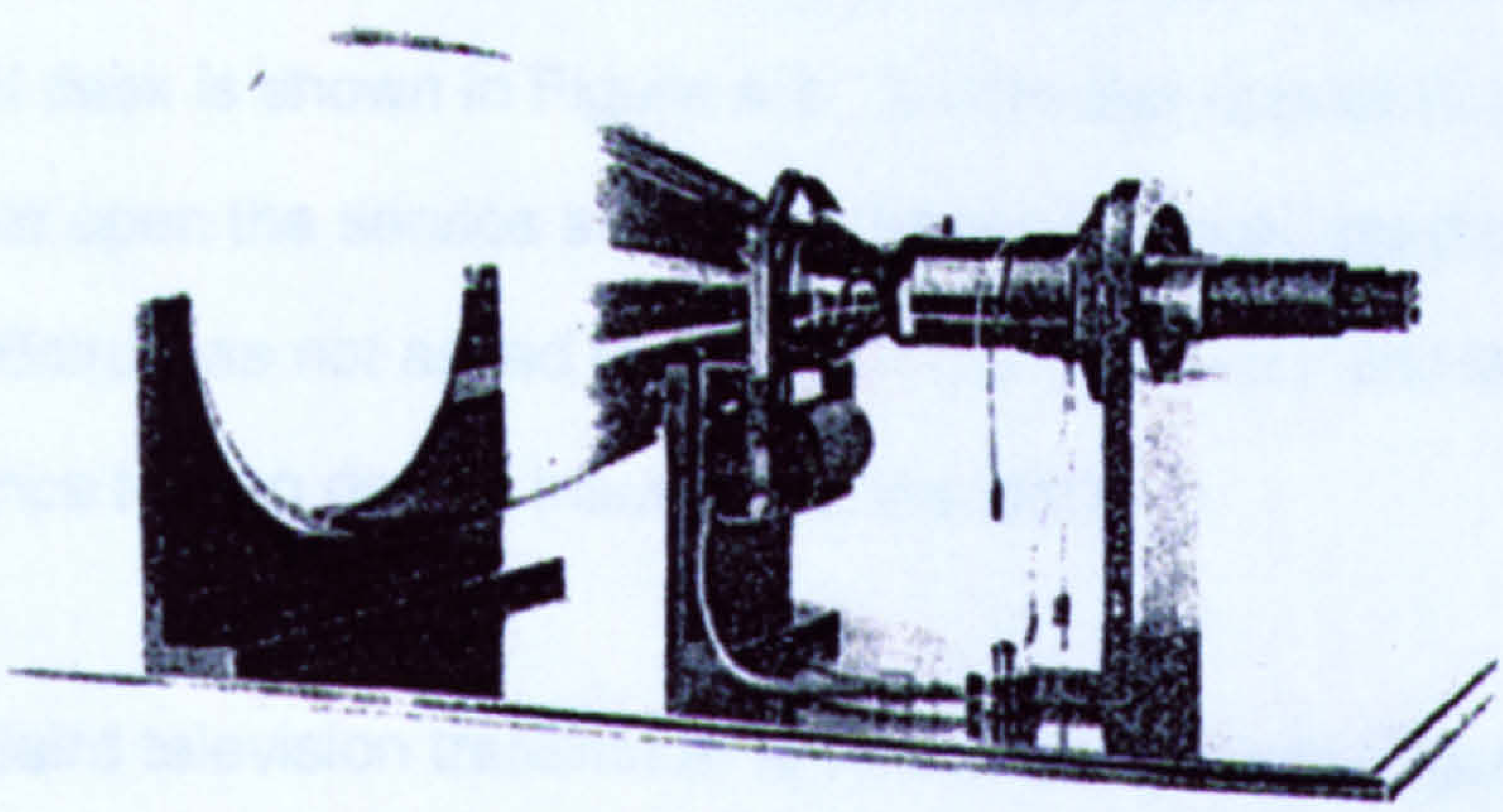


Figure 4.3: Cathovisor Cathode-ray Tube Type 15 WMI complete with Electromagnetic Scanning and Focusing Equipment

When the 1936 RadiOlympia exhibition closed it was announced that programs from the Alexandra Palace would be suspended for four or five weeks until the regular television service was organised. John Logie Baird's concern over the trials is reflected in his autobiographical notes: [4]

"There was, I think at the time, very little to choose between us. We had a system of 240 lines, the Marconi-EMI had adopted a 405 line system of scanning developed by RCA and described in a patent taken out by Ballard, one of their assistants. They also used as a transmitter an apparatus called an iconoscope, developed by the research department of RCA headed by Zworykin. As for actual results, we showed a better transmission of cinematograph films and close-ups, but our intermediate film was a clumsy and inefficient device compared to the iconoscope."

This statement reveals that despite serious competition from RCA, John Logie Baird had a great deal of respect for the electronic camera tube.

The opening ceremony of the British high definition system trials took place on 2 November 1936 at the Alexandra Palace in North London. [5] The Baird installation at Alexandra Palace is illustrated in Figure 4.1 and the Baird control desk is shown in Figure 4.4. A coin was tossed to see which system would open the service and Baird Television took first place. [6] John Logie Baird was not asked to speak at the ceremony and sat infuriated in the audience feeling deeply insulted by the BBC. [7]

The Baird television transmitter at Alexandra Palace (Figure 4.5) featuring demountable tetrodes was designed by Baird Television engineers and built by Metropolitan-Vickers.

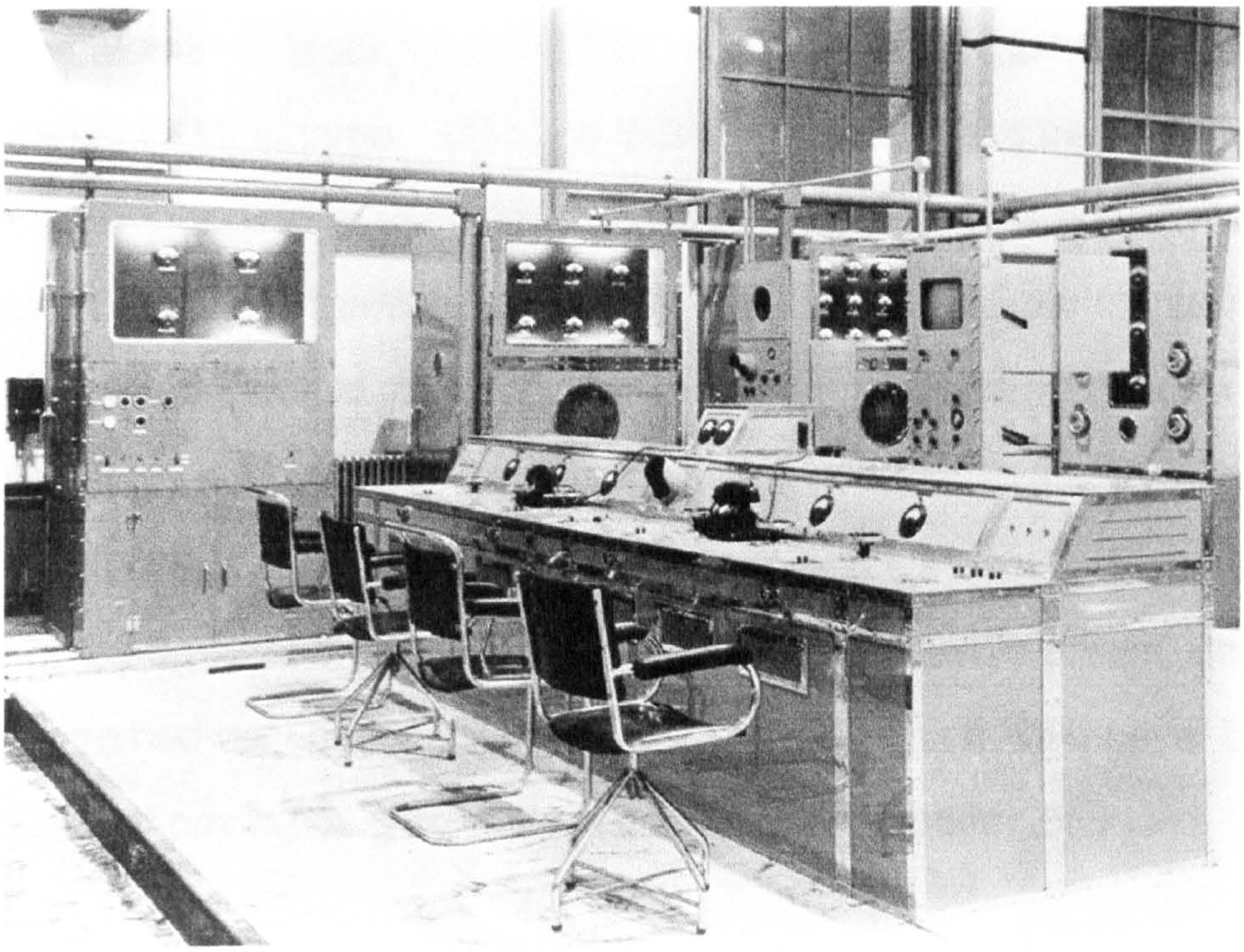


Figure 4.4: The Baird Sound and Vision control desk at Alexandra Palace

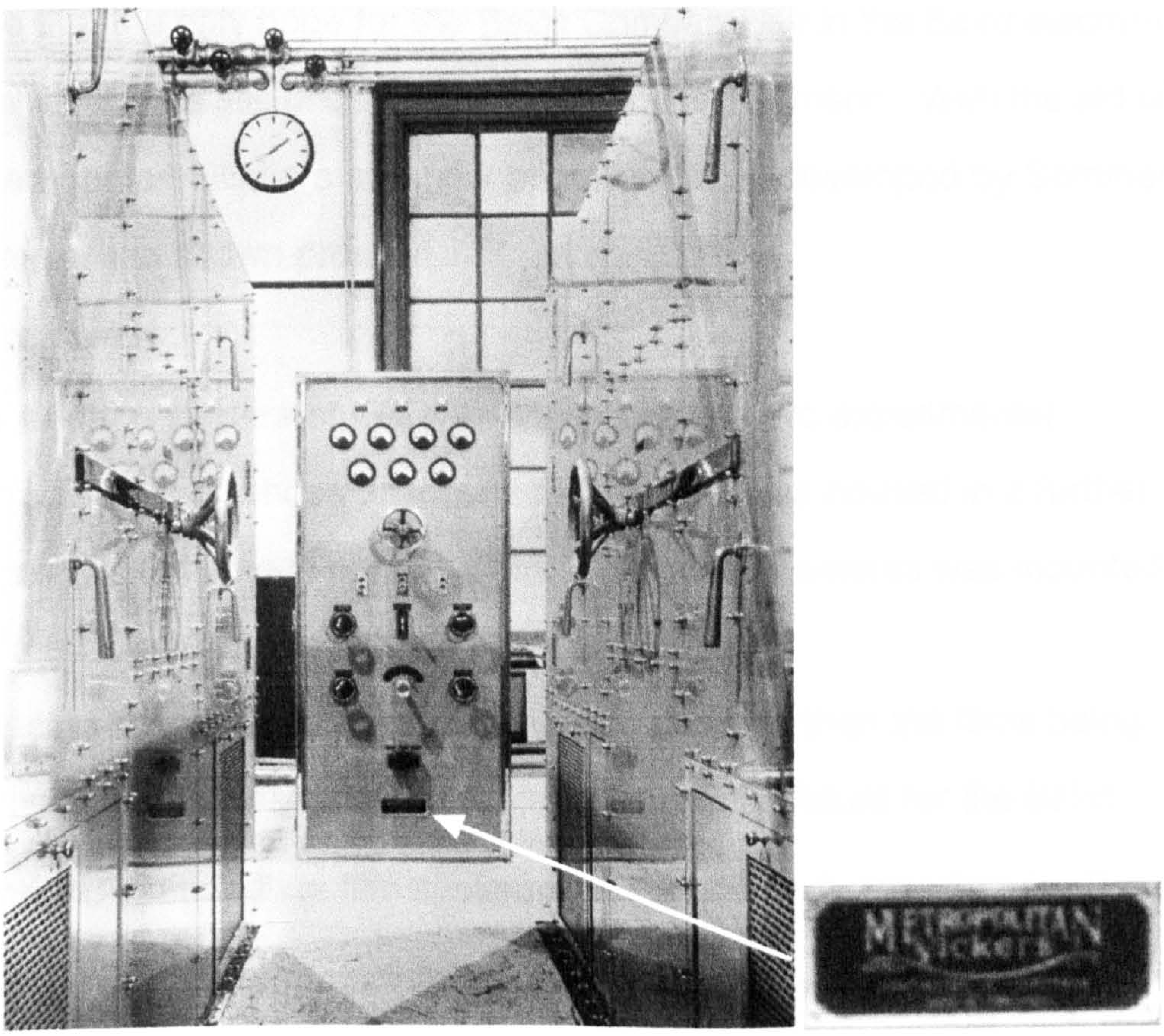


Figure 4.5: The Baird Transmitter at the Alexandria Palace showing the Demountable Tetrode Power Unit (centre) supplied by Metropolitan Vicars

The stumbling block for Baird Television remained the high sensitivity of the Marconi-EMI emitron. Although Baird Television were free to experiment with their own versions of iconoscopes they were not licensed to use them. From 1936 the Baird Company took out many experimental electronic camera patents in the hope of a breakthrough (see Appendix 5). Abramson [8]

> "Much effort was made to improve the Farnsworth electron camera. In spite of the fact that it was working quite well in the United States, Baird Television had very bad luck with it. For reasons which have never been explained, it never could produce reasonable pictures for Baird in England."

This is contrary to the opinion of Tomes [9] who indicated that he believed at the time that the only hope for the Baird Company lay in the Baird electron camera which was still under development by Dr. Samson. With the aid of improved photomultipliers and new photo-surfaces developed by Sommer this camera had shown promise.

Abramson wrote: [10]

> "The electron camera studio was equipped with two experimental electron cameras whose associated apparatus was housed in a further adjacently situated sub control room. One of the cameras was mounted on a movable run truck and the other on a tripod."

The telecine scanner was producing clearer pictures than the films being shown using the iconoscope, but there seemed little future for the Baird spotlight and intermediate film systems. Abramson indicated that the Baird system was in trouble from the beginning and would not be able to hold out for long: [11]

> "The spot-light studio, operating in near darkness, was hopelessly out of

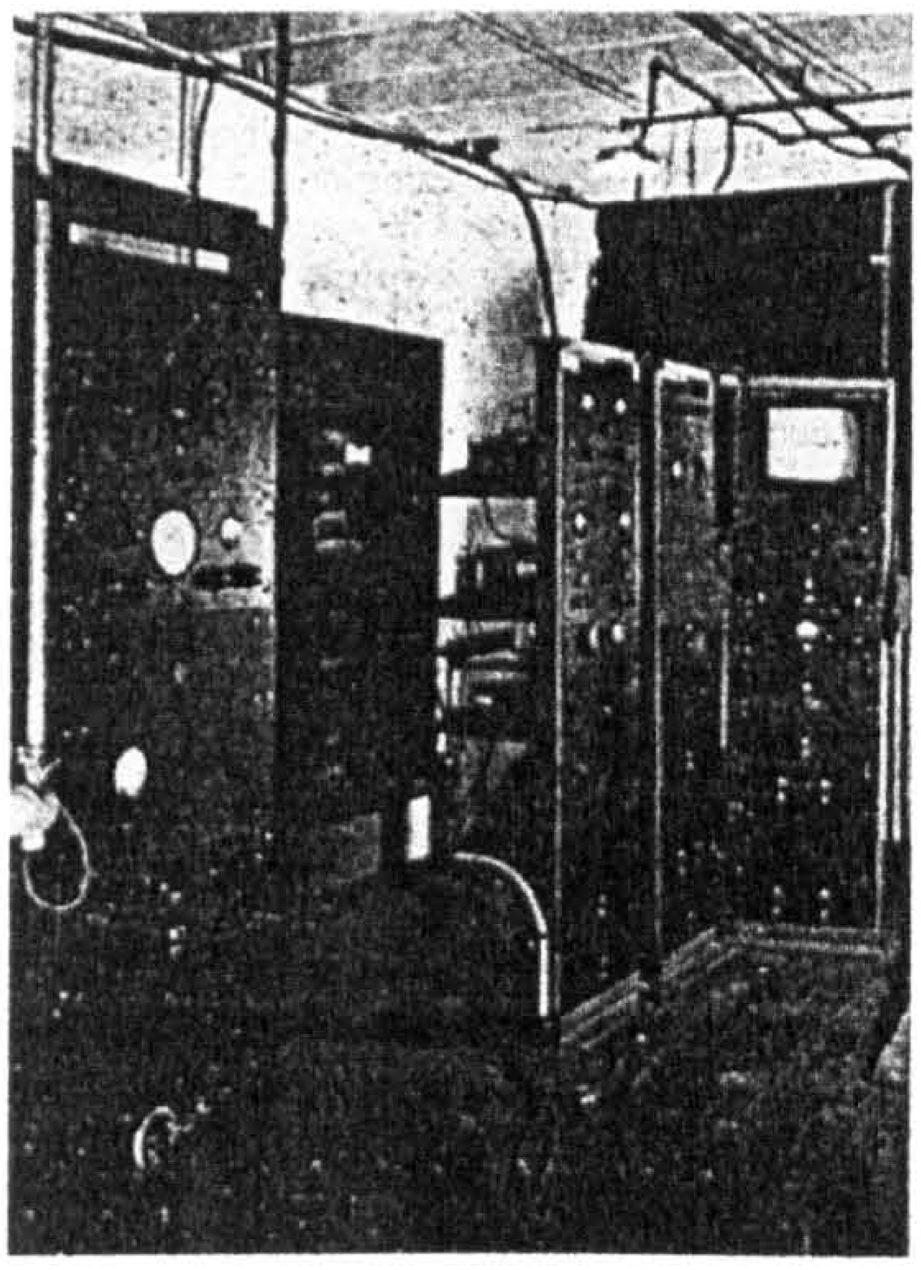


Figure 4.6: Electron camera racks

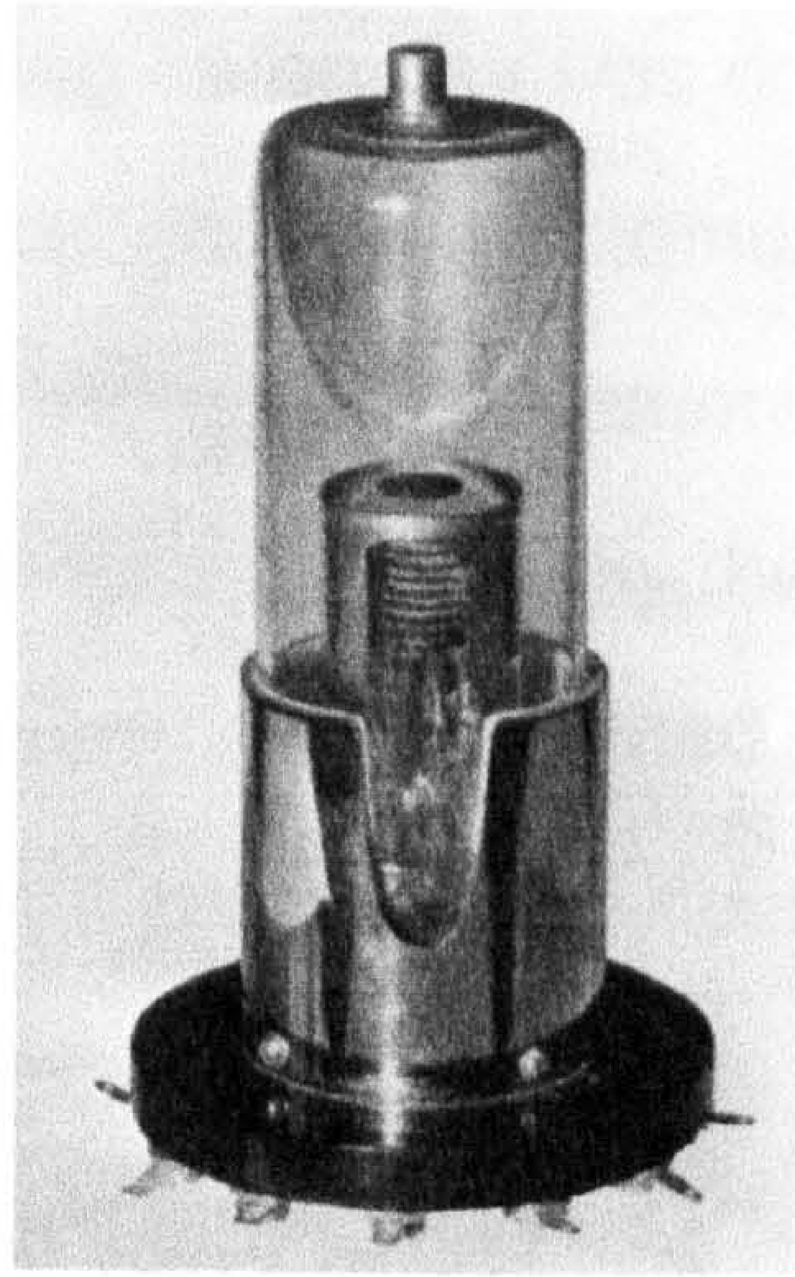


Figure 4.7: Baird photomultiplier

date; the intermediate film system was very dependent on a huge supply of water, sometimes running out of it and halting operations. The Farnsworth electron camera still in a developmental state in England, was presenting problems. It was used for a few programs but, due to low sensitivity (noise) and poor geometry, was soon withdrawn."

Tomes agreed that (noise) was a problem limiting the contrast range available from the tube, but disagreed with the suggestion that the geometry of the image was poor, in fact notes in his diary indicate that the electron camera often saved the day for Baird. [12]

" 8 October 1936: Baird's system operating today - the intermediate film broke down again. It was later O.K. Good electron camera picture."

Figure 4.6 shows the electron camera (image dissector) racks which contained the scan generators, line amplifiers, synchronising generators and monitor tube.

Sommer was delighted to discover that the Baird type MS phototubes (Figure 4.7) were to be used during the first official broadcast: [13]

"Baird used mechanical scanning and dissector one week and EMI the emitron the second week. The actual opening ceremony was done with the mechanical Baird system using - to my delight - my photomultipliers!"

But without an equally sensitive electronic television camera the intermediate film and spot-light scanners were struggling. Only the telecine and the occasional electron camera transmissions had performed well. Sommer [14] indicated that the Baird engineers were under no illusion from the start about who had the technical advantage.

"My colleagues and I were shocked when we saw the first test transmission from Alexandra Palace with the emitron (iconoscope) tube. Particularly for outdoor shoots, where the light cannot be controlled, the superiority was so obvious that we thought the BBC was very generous to let Baird Television broadcast alternate weeks."

In addition to the advantages exhibited by the iconoscope the main feature of Marconi-EMI's system was the use of interlaced scanning which reduced visible 25Hz picture flicker and enabled two sets of 202.5 lines (405 lines) to occupy the same bandwidth as Baird's 240 line sequential system. The emitron camera was the superior television scanner for outdoor and indoor use and the Baird telecine was the most efficient scanner for televising cinema films.

The following section is an analysis of the television broadcasting systems under test at the Alexandra Palace, 240 line sequential versus 405 line interlaced.

Analysis of Systems Resolution

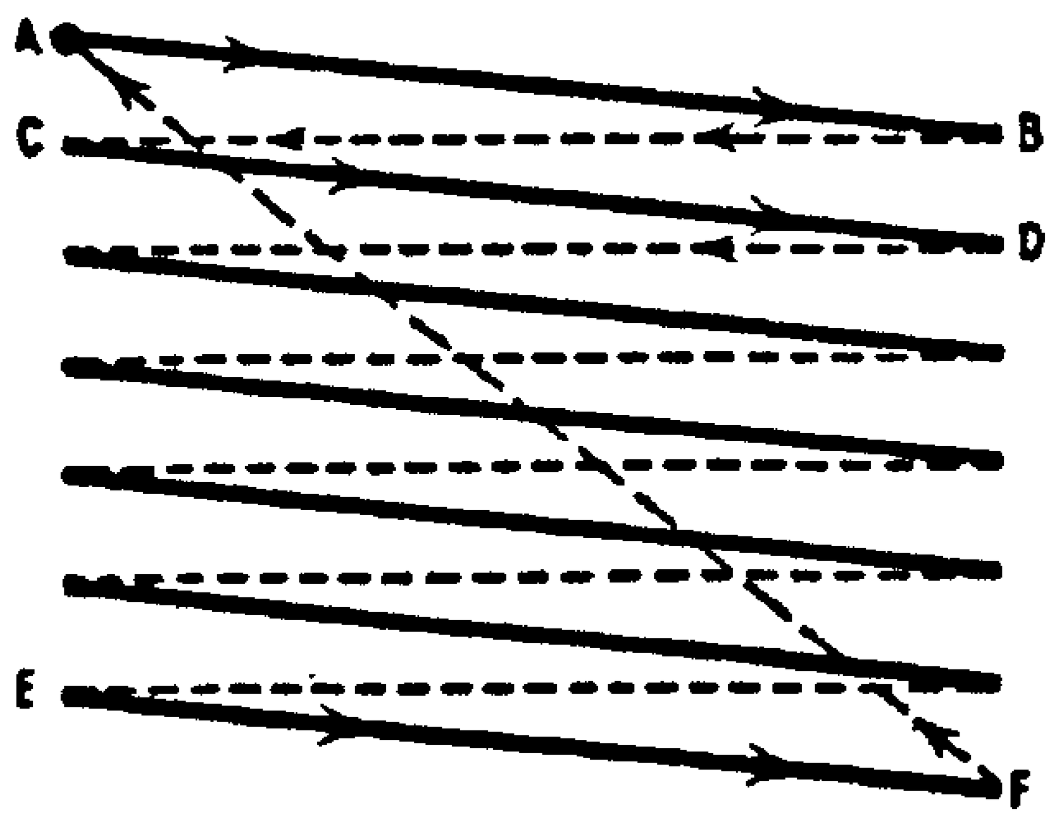


Figure 4.8: Sequential scanning.

Figure 4.8 illustrates the technique of sequential scanning by showing a simplified frame of only seven lines. Solid lines represent television scan lines and dotted lines signify line flyback. The cathode-ray spot commences its journey from 'A' and moves across to describe the line 'AB' on the fluorescent screen. The scanning spot is suppressed from visibility until it reaches point 'C'. This rapid but unseen scanning condition is known as 'line flyback'. The spot is then made visible again on the screen as it describes line 'CD'. These events are sequentially repeated until line 'EF' is traced on the screen. From point 'F' the spot is suppressed during the 'frame flyback' until it returns to point 'A' where it again becomes visible to begin a new frame. In reality there is only a single moving spot on the screen at any given time which is varied in brightness by the picture content. The frame containing a multiplicity of lines is apparent to the viewer as a complete image by the phenomena of 'persistence of vision'. This is the momentary optical retention of the moving spot on the human retina causing the perception of a number of visible lines. A television frame produced by this method is known as a sequential raster.

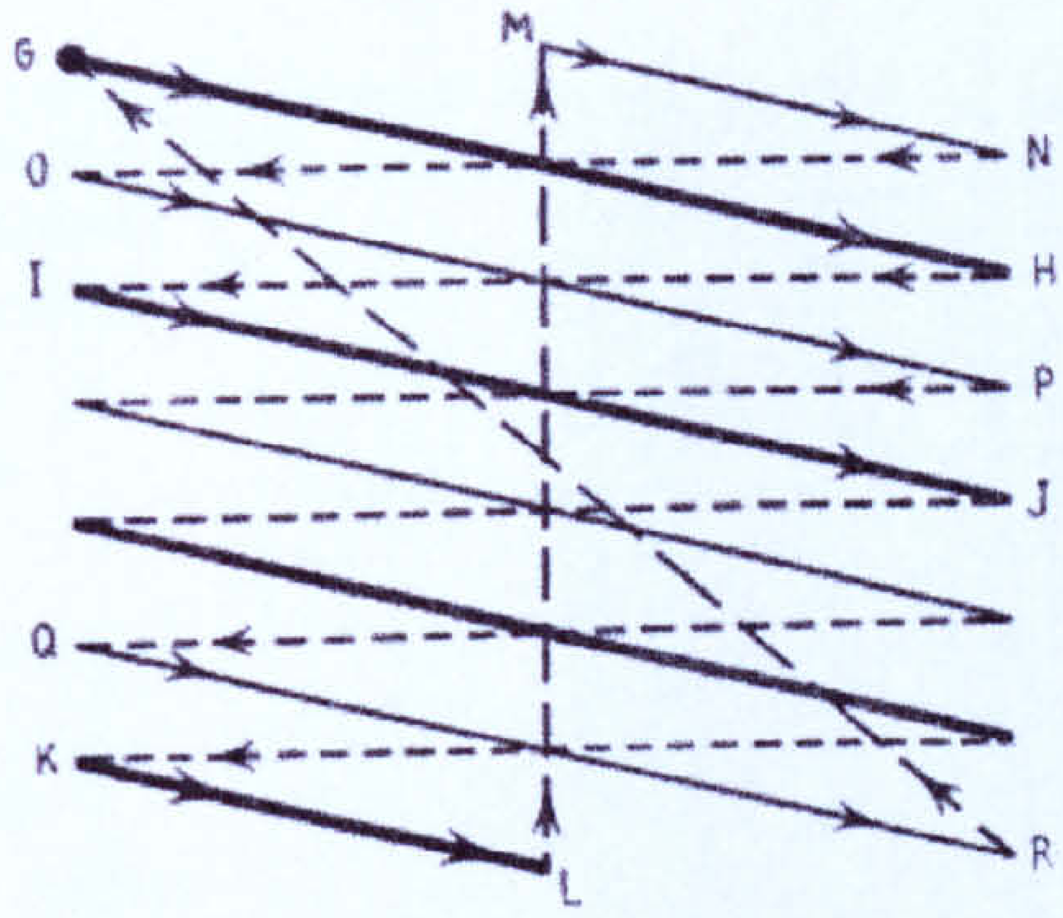


Figure 4.9: Interlaced scanning.

Miller explained: [15]

> "....... it is found that a picture frequency of 25 per second is insufficient for complete elimination of flicker with a bright picture. If the picture frequency is increased to 50 per second, flicker is no longer apparent, but the vision signal will require twice the frequency band."

In submitting additional information to the Television Advisory Committee's, Technical Sub-Committee on 8 March 1935, Baird Television wrote: [16]

> "The 240-line standard represented the 'economical and practical limit' which could be recommended for standardisation for at least three years....
>
> ....It would show a picture a long way ahead of what had been demonstrated by any system and would give ample definition, clearness and quality of all types of scenes as well as for close ups."

Figure 4.9 illustrates the Marconi-EMI pattern of interlaced scanning. The spot traces out a first set of parallel lines on the screen leaving a gap which is greater than that left by sequential scanning. The lines are numbered in the sequence 1...3....5...and so on. This first field has a repetition rate of 50 half frames (of 202.5 lines) per second and is known as the odd field. After the field flyback takes place another set of lines are

SPECIFICATION	Baird Television	Marconi-EMI
Number of lines (nominal)	240	405
Number of lines (effective)	220	385
Type of scanning	Sequential	Interlaced
Ratio - width; height	4:3	5:4
Field frequency	25	50
Frame frequency	25	25
Line frequency	6,000 Hz	10,125 Hz
Method of Modulation	DC AM	DC AM
Carrier limits : vision:	40 to 100%	30 to 100%
sync :	0 to 40%	0 to 30%
Number of line sync pulses	1 per line	1 per line
Portion of line occupied by sync pulses	10%	15%
Number of frame sync pulses	1 per frame	6 - 12 per frame
Portion of frame occupied by sync pulses	8.3%	5%
Maximum frequency (bandwidth)	2.0MHz	2.0MHz

Figure 4.10: Alexandra Palace System Specifications agreed with the BBC in 1935

scanned but this time they fall between the lines of the odd field. This is the even field and the lines may be considered as being numbered 2....4....6 and so on. Although it still takes 40 mS (equivalent to 25 frames per second) to complete one full frame of odd and even lines, the half frame repetition rate which is 50 frames per second effectively doubles the flicker frequency to a more acceptable level.

It would be expected that the image definition of the 405 line system should have been almost double that which was available from Baird's 240 line system. However, based on the following, it can be shown by simple calculation (Appendix 1) that the Baird sequential system of 25 frames per second, although likely to flicker on bright areas of the picture, was capable of yielding the highest image definition. The specifications of the Marconi-EMI interlaced system and the Baird Television sequential system agreed by the BBC [17] in 1935 are shown in Figure 4.10. The Baird Television and Marconi-EMI waveforms are shown respectively in Figures 4.11 and 4.12.

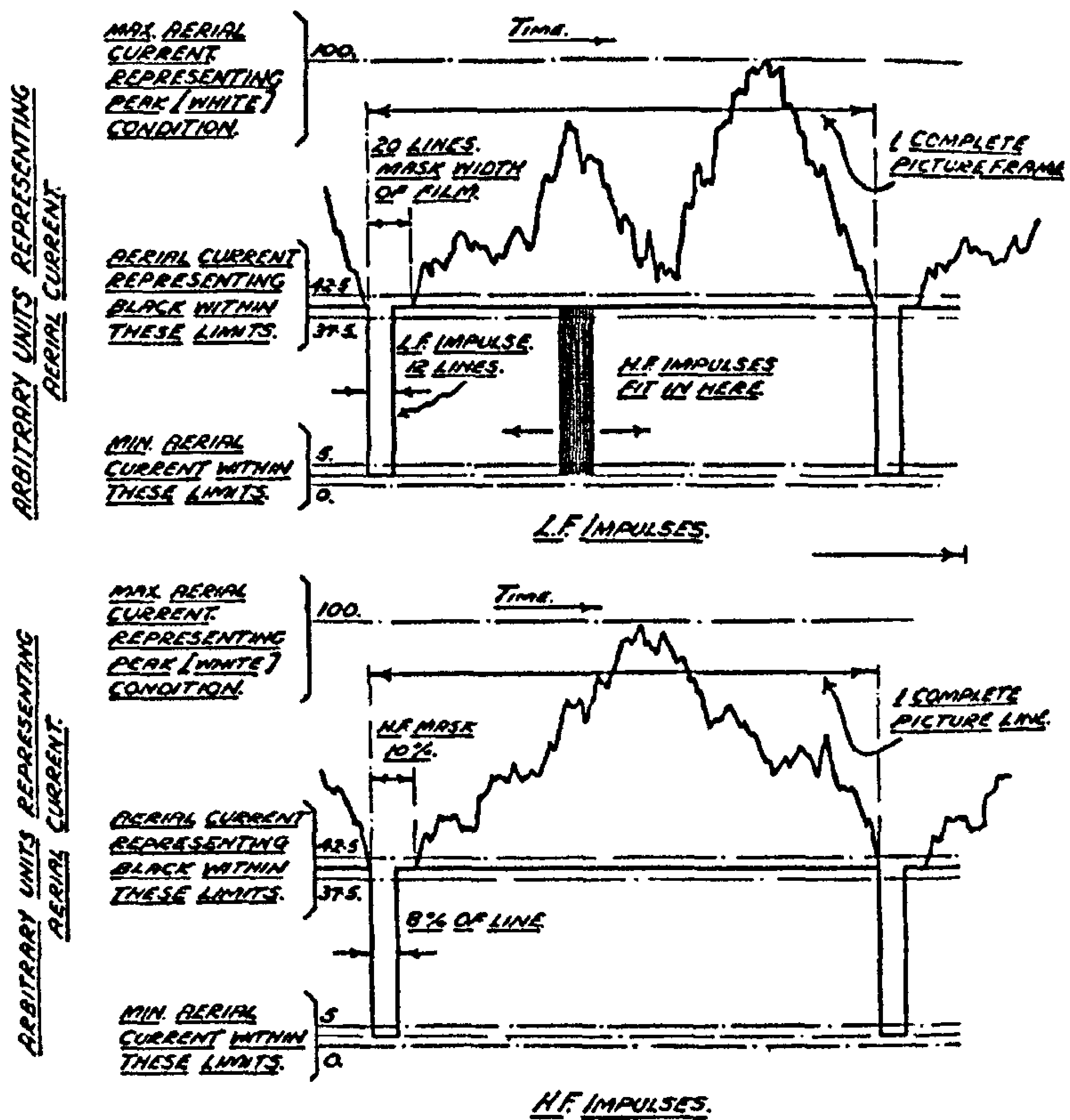


Figure 4.11: Baird Television 240 Line Sequential Waveforms

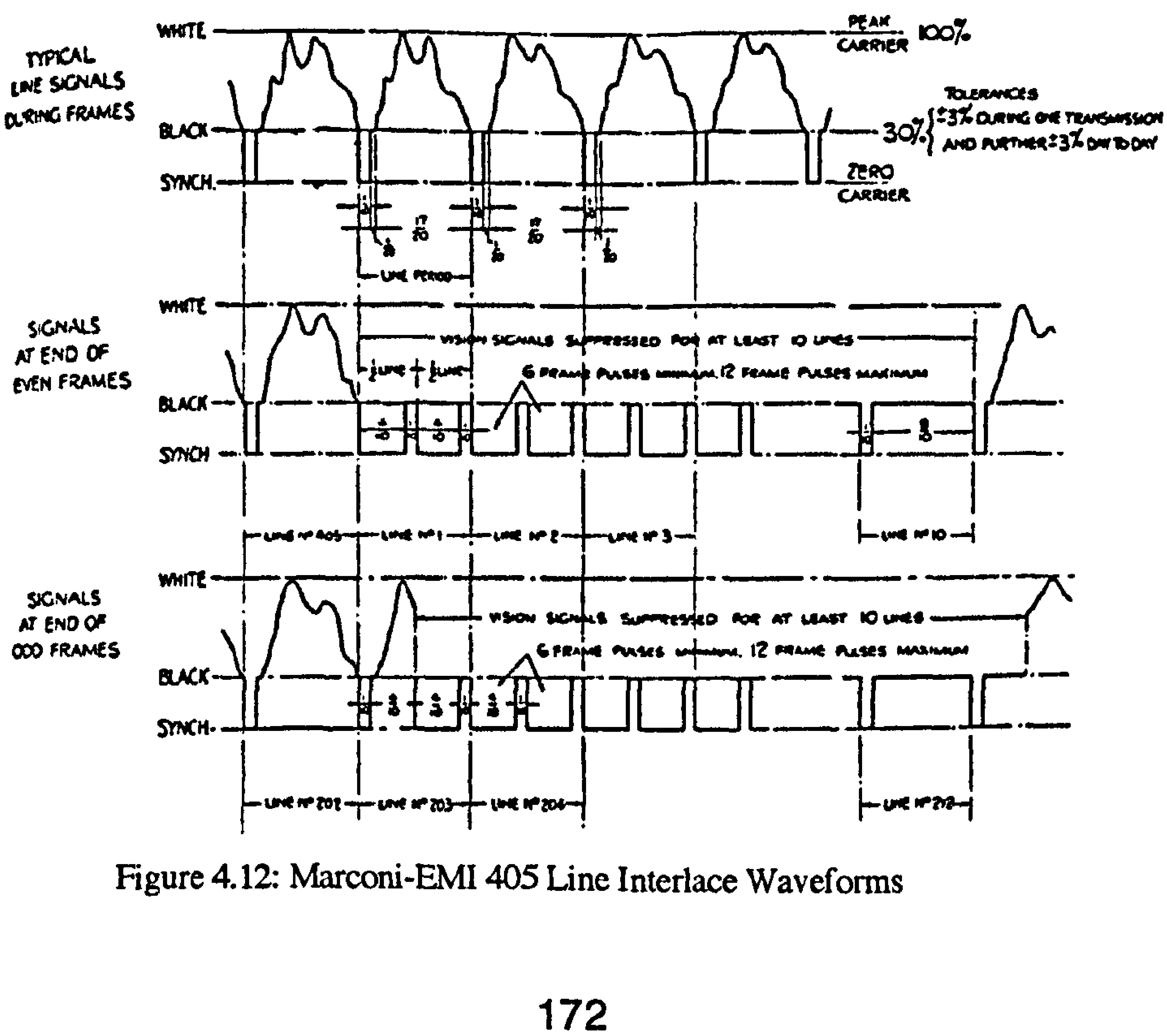


Figure 4.12: Marconi-EMI 405 Line Interlace Waveforms

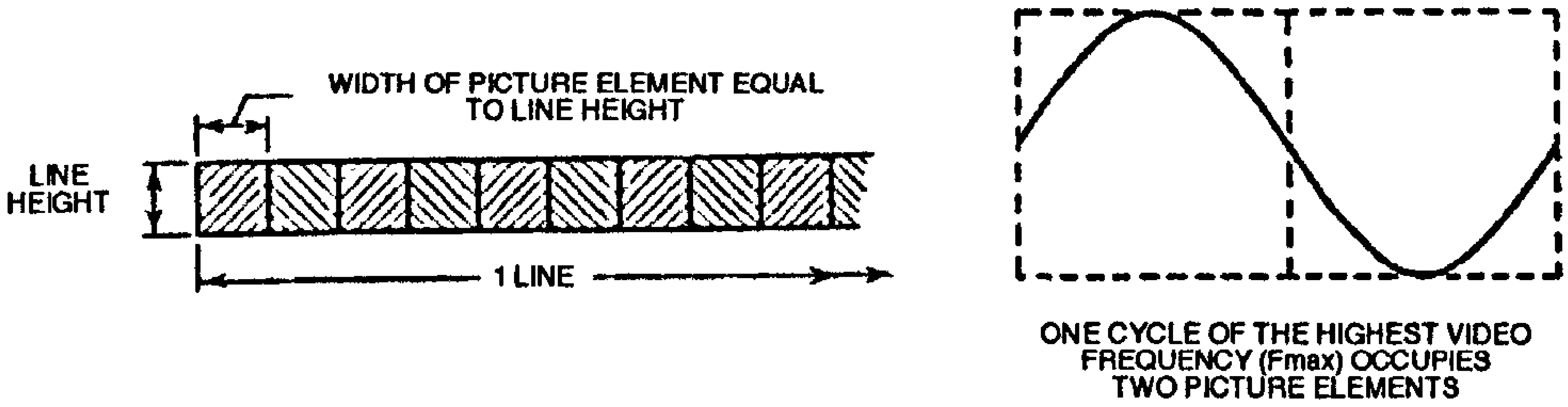


Figure 4.13: Relationship between picture elements (pixels) and horizontal resolution

Helt [18] described television image definition as:

> " The resolving power of a television system, or any part of that system, has been defined as a measure of its ability to delineate picture detail."

Helt continued: [19]

> "Vertical and horizontal resolution of the system must be considered separately. The vertical resolution is essentially a function of the number of lines comprising the scanning pattern, as well as upon the camera pick-up tube and the cathode-ray tube at the receiver. Horizontal resolution is principally a function of the width of the picture channel as well as of the shape and size of the two interlaced scanning spots."

The maximum number of changes from black to white which can occur along the length of a scan line in either a sequential or an interlaced television system is limited by the width of the picture channel. From 1935 the allocated channel width for Baird and Marconi to operate within was restricted to 2.0 MHz. The maximum number of changes which occur during a scan line are termed as horizontal picture elements or 'pixels.' Figure 4.13 illustrates that one cycle of the highest picture frequency occupies two picture elements. The definition of a reproduced television image depends on the number of lines per picture multiplied by the number of changes during a line. Therefore by calculating the products based on system specifications a fair comparison can be made.

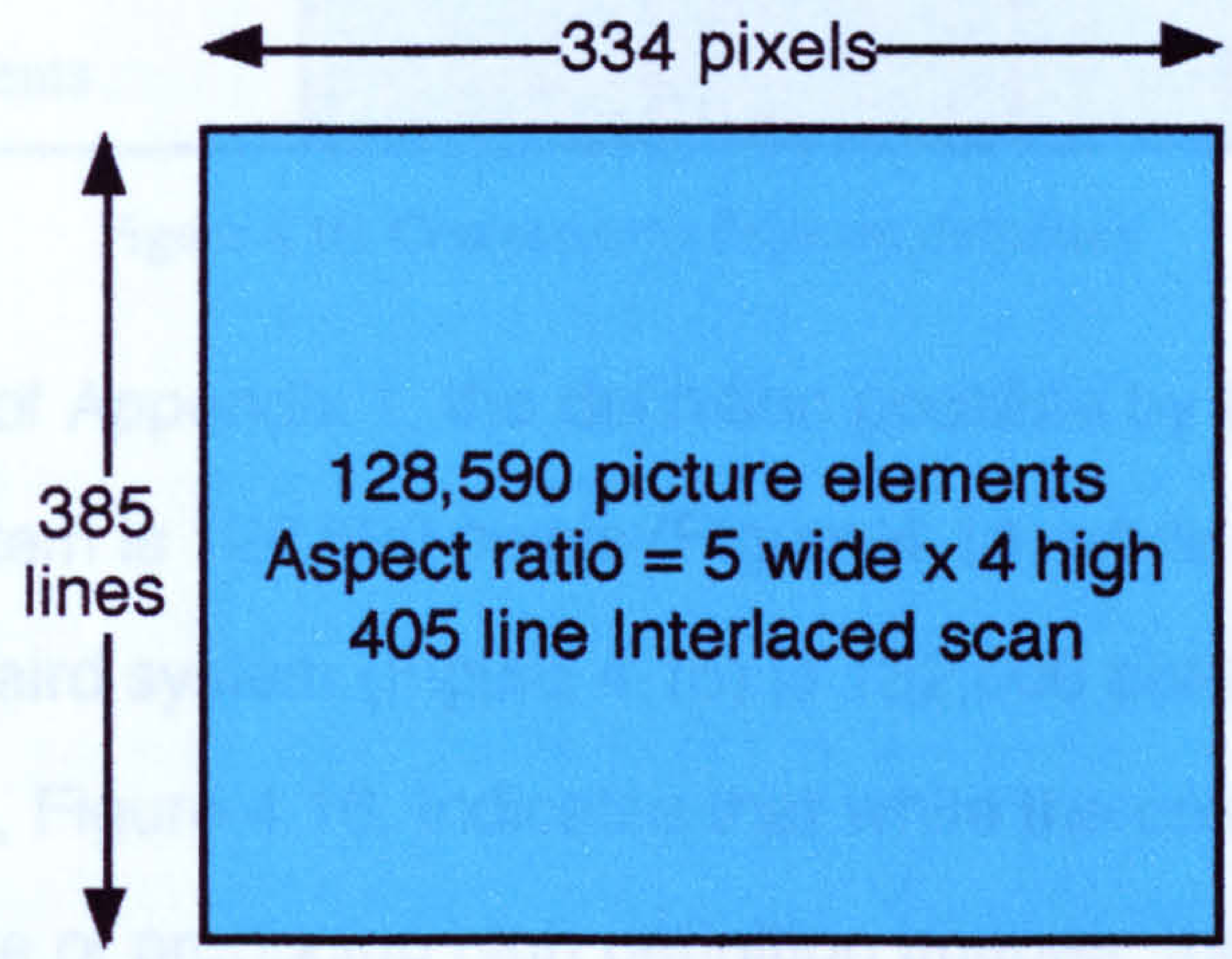


Figure 4.14: Marconi-EMI definition 334 x 385

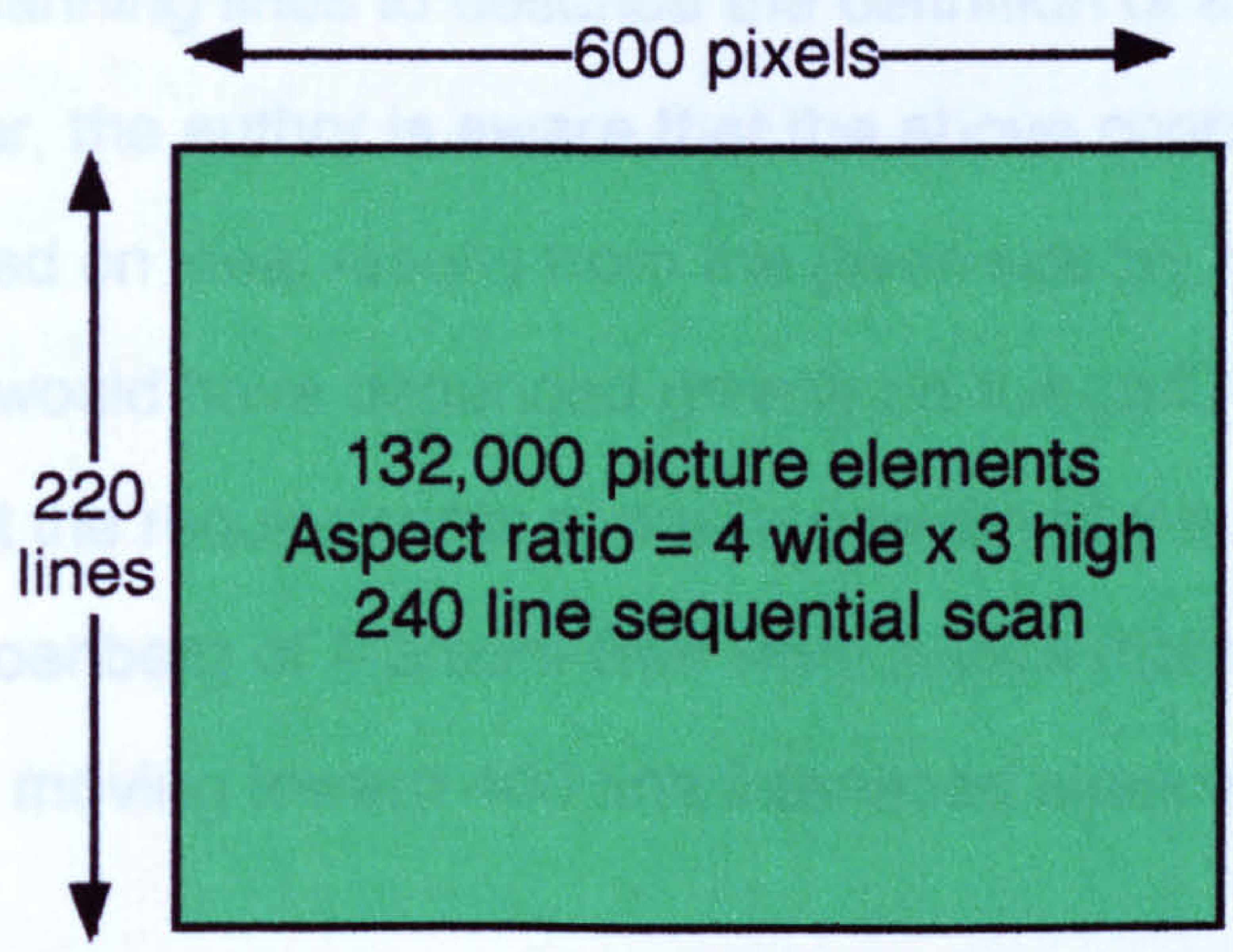


Figure 4.15: Baird Television definition 600 x 220

Specifications	Baird Television	Marconi-EMI
Bandwidth	2.0 MHz	2.0 MHz
Horizontal Definition	600 pixels	334 pixels
Vertical Definition	220 lines	405 lines
Picture Elements	132,000	128,590

Figure 4.16: Comparison of system definition

From the results of Appendix 1, the definition possible by the pre-war Marconi-EMI system is 128,590 pixels (Figure 4.14) while the definition possible by the Baird system (Figure 4.15) is 132,000 pixels. The system comparison table, Figure 4.16, indicates that while the competing systems were both capable of producing high definition images, the Baird system was potentially capable of producing 80 per cent greater horizontal definition and the highest image definition overall.

From this information it becomes apparent that it is deceptive to quote the number of scanning lines to describe the definition of a television system. However, the author is aware that the above conclusions are theoretically based on ideal results from the given specifications, and that practical results would have depended greatly on the ability of cameras or scanners to meet the requirements of the bandwidth of the systems. Blumlein and Shoenberg of Marconi-EMI were aware that there was a penalty to pay in moving toward 405 line interlaced scanning to reduce image flicker.

Burns indicated that: [20]

"They were aware in the initial stages the developed 240-line system might give more detail on 'early receivers of poor bandwidth'. During the period before the station became operational their transmitting apparatus was considerably improved and the receiver manufacturers designed good receivers so that 'tolerably good 405-line pictures were obtained'." Blumlein in 1938, considered that the 405-line system could be considerably improved in detail without exhausting the possibilities of the system."

While the above does not prove that Baird had a superior television system, it does show that a great deal of reasoning went into producing the best alternative to the interlacing technique. If good horizontal resolution had been recognised as the crucial feature instead of flicker on brighter images, then it may have been perceived that Baird had led the way with a possible 600 elements across a line. However, definition of the system was not to be the only deciding factor, flicker had been perceivably reduced by Marconi-EMI's interlacing techniques and the emitron had produced excellent studio and outdoor shots. The Baird Intermediate film was generally disliked by the performers and Baird's fortunes dwindled further when, on the evening of 30 November 1936, the Crystal Palace was engulfed in flames which spread to the Baird Laboratories and Studios.

Section 4.3

The Crystal Palace Fire

Figure 4.17: The Crystal Palace Fire

It was reported [21] that the fire which almost completely destroyed the Crystal Palace (Figure 4.17) on the night of November 30 1936, extended to the Baird Laboratories which occupied a considerable area of the south-west corner of the Palace: the whole of the laboratory equipment was destroyed. Investigations when the fire was put under control revealed that although the administrative offices, research department and studios had been entirely gutted, the production of television receivers and servicing departments had escaped almost unscathed.

The following are some of the reports about the Crystal Palace fire from Baird employees.

Dr Szegho: [22]

" I placed a few picture tubes in the gas fired exhaust ovens and went home to nearby Beckenham to grab a quick dinner and to return later to do the final processing and sealing-off of the tubes......

.... My anxiety that this the largest conflagration in recent times in London (up to the burning of the city by incendiary bomb attacks of Hitler) was caused by my gas ovens, in the vicinity of numerous oxygen tanks which the glassblowers used, was agonising. My relief, in proportion, was enormous when I met my laboratory assistants in the huge crowd which surrounded the Crystal Palace grounds. They assured me that the fire had started in a quite different wing of the Palace, and that they actually had time to enter our laboratories, turn off our ovens and were able to remove oxygen tanks and some personal equipment from my office."

Nuttall: [23]

"Although the fire started in quite a different area, the firemen were unable to prevent it spreading and it was quickly realised that the whole of the building would have to burn itself out. It was terrible to feel so helpless. We knew that these premises, still looking spick and span and containing much of our work, would soon be nothing but a pile of rubbish and there was nothing at all we could do to prevent it."

Tomes: [24]

"The fire moved so fast that I only had time to rescue our latest projection tube and the Baird cat, which was frightened. When we left the laboratories the fire was moving along, high above us. Any question of using the hoses was out of the question, it would have been like trying to extinguish a blaze with a fountain pen filler."

Figure 4.18: Remains of the Baird Studios and Laboratories after the fire

Sommer was dispatched by West to continue his work on photocells at Bolton-King's, Oxford Instruments where he remained until accommodation was found for him in new laboratories on the gallery of the Rotunda. Bolton-King was a photocell consultant retained on a stipend by Baird Television.

Sommer: [25]

> " We built a makeshift Lab in the 'Rotunda', an old building in the Crystal Palace grounds. Later we moved to a new building at Worsley Bridge Road, Lower Sydenham."

Tomes wrote: [26]

> "The Crystal Palace was destroyed by fire. The entire research facility of Baird's was wiped out. It was a major disaster for Baird Television Ltd. The only thing left was the School of Art building which was where the Baird television receivers were being developed and manufactured."

The remains of the Baird studio and laboratory facilities after the fire are shown in Figure 4.18.

Figure 4.19: The new Baird Television Factory at Lower Sydenham

While most of the Baird employees were still in shock and wondering about their future, Szegho seized the opportunity to make plans to equip a replacement cathode-ray tube development facility. On the day following the fire Tomes travelled to Szegho's home where they produced lists of the apparatus needed to restart their work. On the basis of their enthusiasm Captain West gave Szegho permission to begin purchasing apparatus. Tomes wrote in his personal diary: [27]

> "1 December 1936: Spent day at Szegho's jotting out lots of apparatus required to get restarted. Temporary labs to be fitted into the Rotunda building."

Initially a suitable temporary location was found in the School of Art building. This was a section of the Crystal Palace which was adjacent to the South Tower and had survived the fire. The building had originally been used by the Crystal Palace Company who ran schools of art, engineering and culture. [28] Many Baird workers lost their jobs or resigned, but the initiative of Szegho guaranteed the future of cathode-ray tube research. [29]

In February 1937, Samson's image dissector, Szegho's cathode-ray tube relocated to laboratories on the balcony of the Rotunda. [30] Sommer continued at Oxford Instruments until March 1937 before joining with Samson in the Rotunda. This temporary arrangement continued until September 1937 when Samson and Sommer moved to a new building (Figure 4.19) at Sydenham, followed in December 1937, by Szegho's cathode-ray tube research laboratory. Tomes remained at the laboratory in the Rotunda in control of a small department to produce experimental projection cathode-ray tubes for experimental theatre television. (Described in Chapter 5).

The next section describes the German company Fernseh and its links with Baird Television, Farnsworth and Nazi Germany.

Section 4.4

The German Connection

FERNSEH A.G.

Figure 4.20: The Fernseh Logo

Fernseh in Berlin was formed on 11 June 1929 by: Baird International Television; Zeiss Ikon; Bosch and Radio A. G. D. S. Loewe, as equal partners. [31] Soon after Hitler came to power in 1933 Baird Television was forced by the German Government to sell their one quarter share of Fernseh to Bosch and Zeiss.

Margaret Baird wrote: [32]

> "Hitler gave orders that our interest as a British concern must cease and that Fernseh must become wholly German. David Loewe, who had wanted us to take over the Loewe interest and gain control, had been expelled from Germany because he was a Jew."

Sydney Moseley indicated [33] that when he met David Loewe in London after the war he found him to be a broken man, afraid to talk or even to raise his voice beyond a whisper.

Moseley wrote: [34]

> " An estimable man, destroyed by personal hardship and lost pride."

J. L. Baird wrote: [35]

"Fortunately Major Church was able to visit Germany and negotiate a deal whereby we got a substantial cash payment for our share. If he had not done this and acted promptly, Hitler would as likely as not simply have confiscated the lot."

Tomes wrote: [36]

"..we had shipped on occasions, tubes to the Fernseh organisation in Germany. As they were likely to be used by the Nazis, Sommer insisted we chose sub-standard tubes with high noise and low multiplication."

Although the financial link of control by Baird Television was severed, it is now known that the technical link had remained open. Air Ministry files on Baird Television, released in 1972 at the British Public Records Office, London, indicate that Fernseh had been spying on Baird Television. Mr Hecht (Research and Development Instrument Laboratories, Air Ministry), who was accompanied by Wing Commander Archer (MI5), War Office, reported on a routine visit to Baird Television on 23 July 1936: [37]

"Information was also obtained from Captain West regarding the German position. There is a business agreement between Baird's and the German firm that each shall supply the other with all knowledge recently acquired. Recently, however, the Germans have taken all they could but have given away nothing. The German Government has complete control over all television developments which are kept secret.....

....Thus Baird's are on the point of discontinuing their business agreement unless the reciprocal facilities are given."

Szegho [38] confirmed that the reciprocal agreement continued until the onset of the second world war. By 1938 Fernseh had produced not only image dissector cameras and iconoscopes, but more interestingly, a replica of the projection tube developed by Szegho at Baird Television. [39]

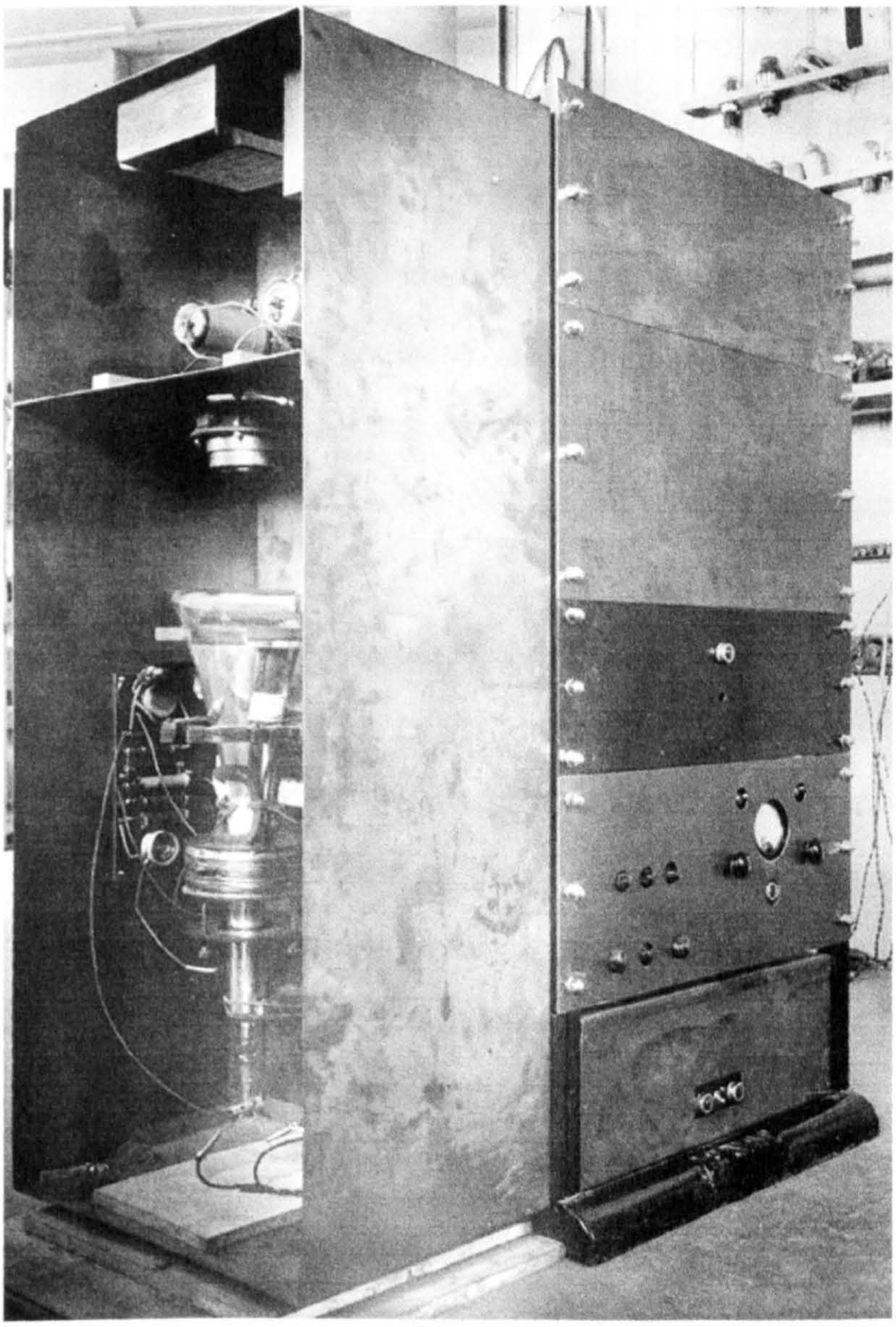


Figure 4.21: Baird Television Ltd
A High definition facsimile transmitter using cathode-ray tube scanning

Note: The above photograph and caption were
originally the property of Baird Television Ltd

According to Waddell and McArthur [40] there is considerable evidence to suggest that during the second world war both the British and the Germans used secret signalling by television. They also indicated that television was the forerunner of radar development and was being developed for aircraft surveillance purposes. A British Air Ministry report by Hecht [41] indicated that in 1936 Baird and EMI had contracts to supply apparatus for experimental television aerial reconnaissance work for the French and British Air Force respectively. Another Air Ministry report [42] revealed that Baird Television also demonstrated facsimile television to the Air Ministry as an aid to aerial reconnaissance. (Detailed in Chapter 6). Tomes recorded in his diary: [43]

> "Thursday 12 January 1939: Made good multiplier. Demo to BBC on new telecine and caption editor."

This apparatus is the basic requirement for the high definition scanning of documents or reconnaissance maps by the Admiralty for ship to shore communications. The cathode-ray tube had been developed to ensure that a minute spot could be produced and therefore guarantee the extremely high definition required by facsimile television. A photograph of the Baird Television high definition facsimile scanner is shown in Figure 4.21.

Farnsworth also had connections with Fernseh. Elma Farnsworth [44] reflected in the biographical account of her late husband that, in 1936, he had received a request from the Baird Company to assist with an important deadline for a BBC demonstration in London. The excursion was useful as the Farnsworth's intended to embark on a European vacation and visit Fernseh in Berlin to receive the royalty payments his company was due in respect of image dissector patents. By the middle of November 1936

Farnsworth completed his work at the Crystal Palace and travelled to Mentone in the French Riviera with his wife. Shortly after his arrival he received a telegram from Captain West.

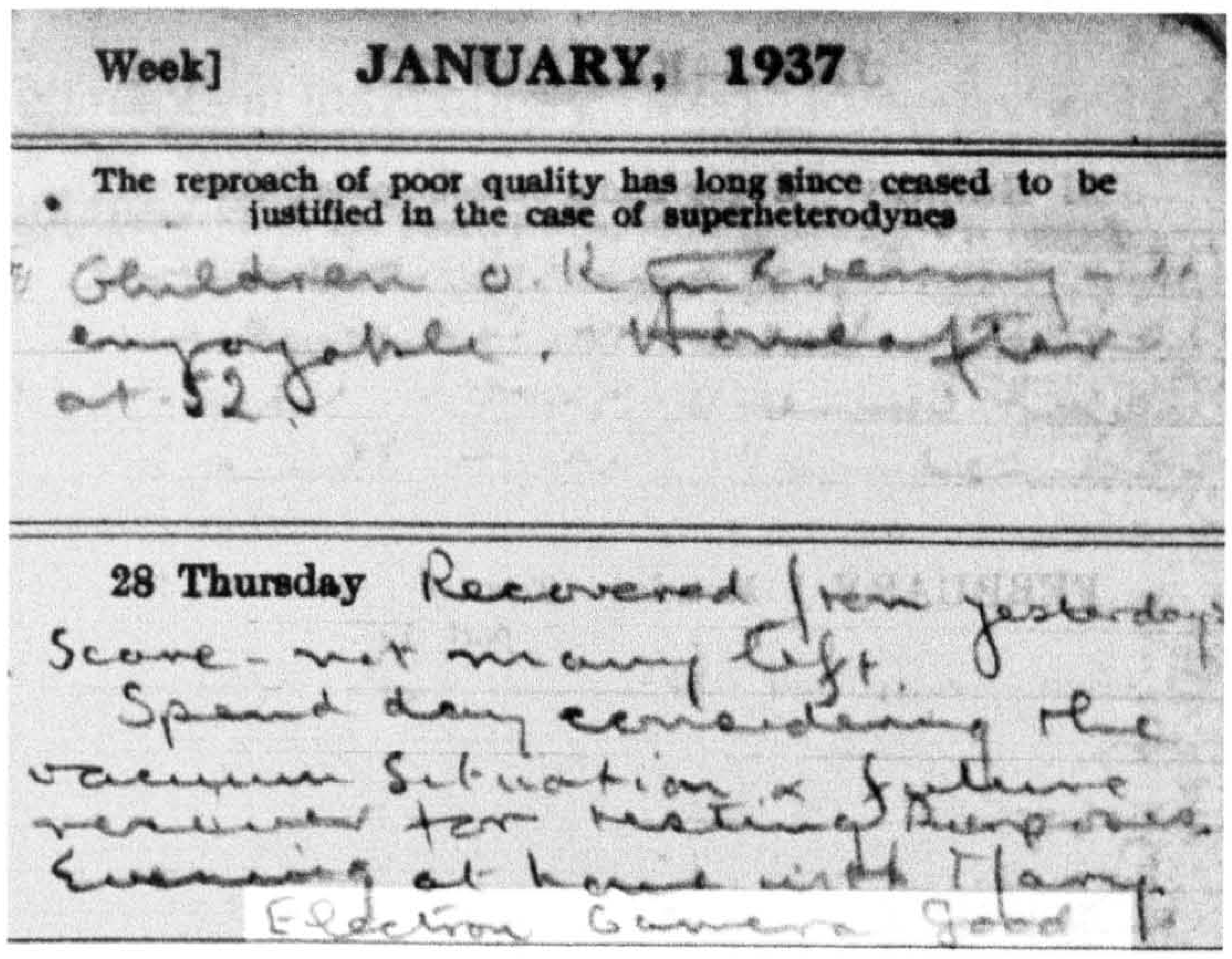
Elma Farnsworth wrote: [45]

> "The Crystal Palace had burned down, taking with it all Baird's equipment, along with all its hopes for a place on the English television scene, at least for the time being."

Farnsworth's returned to England just long enough to visit the mass of melted glass and twisted steel that was the ruin of the Crystal Palace.

> "Sifting through the rubble, Phil stumbled on a macabre souvenir of the tragedy, the charred, melted remains of one of his image dissectors. This discovery was a grim reminder of Baird's situation, but at this point, there was little Phil could do to help the company." [46]

Herbert [47] also found a molten image dissector in the rubble which added to the suggestion that Baird Television no longer had an electronic camera. Szegho [48] corrected this and explained that the Crystal Palace fire did not result in the destruction of the electron image camera. It had merely brought about the temporary destruction of the facility for making the tube. This research has revealed (Section 4.1 p.166) that a complete image dissector camera had remained in working operation at the Alexandra Palace. The replacement facility was in the care of Dr Samson in the Rotunda, as described in Section 4.3. (p. 181). Further evidence has been provided by Abramson and Tomes. Tomes [49] recorded, two months after the Crystal Palace fire; "Electron Camera Good," (Figure 4.22) with respect to the pictures he received from the Alexandra Palace. Abramson [50] reported that on 10 June 1937, Baird Television showed the latest electron image camera at the Television Exhibition at the London Science Museum.



Week] JANUARY, 1937

The reproach of poor quality has long since ceased to be justified in the case of superheterodynes

28 Thursday Recovered from yesterday's score - not many left. Spend day considering the vacuum situation & future requirements for testing purposes. Evening at home with Mary.

Electron Camera Good

Figure: 4.22 Evidence that the Image Dissector was still in use by Baird at Alexandra Palace after the Crystal Palace Fire

But, why did Farnsworth suggest that the Crystal Palace fire had destroyed the electron camera when the apparatus remained in operation at the BBC? The answer may never be known, but given that Hitler was making ready for a war, Fernseh was under Nazi control and known to be spying on Baird Television, it may have been designed to signal to Germany that Baird was no longer a consideration. Both countries were in the race to develop television for their armed services and a 1935 report in the 'The Times' [51] stated that German television research had been placed under the control of Air Minister General Goering because of its importance for the security of aircraft and for national defence. At that time, all television transmission apparatus in Germany was placed under strict regulations relating to military equipment. In a letter dated 30 April 1936 to H. E. Wimperis Director Scientific Research, Leedham wrote: [52]

"The Germans have obtained technical data and apparatus from America and England in respect of television cameras and have now made this apparatus and its development a State Secret. Any equipment specially designed in Britain is a State secret as decreed by Germany in respect of future developments in that country. Modified equipment is O.K. for sale to foreign countries."

Section 4.5

Farnsworth in Berlin

Figure 4.23: Farnsworth with Dr Goerz (right) in Berlin

Farnsworth had been due to receive a substantial financial figure in respect of image dissector camera royalties in 1936 but the Nazi regime presented a serious obstacle. Despite reservations and warnings from Captain West about the political situation in Germany, Farnsworth and his wife travelled to Fernseh in Berlin, at the end of 1936 to obtain the outstanding royalty funds. They were met at Berlin Airport by a car with two uniformed men who introduced themselves as 'courtesy drivers' and delivered them to the Eden Hotel. Captain West had been concerned for their safety and arrived in Berlin the next day. He was followed shortly by an unknown Baird director who was said to be *persona non grata* in Germany [53] and who had slipped in quietly.

Farnsworth [54] learned later that the drivers were Reichpost men reporting to German Intelligence. Dr Goerz, (Figure 4.23) the managing director of Fernseh, side stepped this by arranging for another driver. As they toured the Fernseh plant, there were many closed doors bearing the sign 'VERBOTEN'. Mrs Farnsworth [55] indicated that as Goerz was showing them the factory they were stopped by a soldier barring the door to the facility where they were developing Farnsworth's tube. Goerz spoke to the soldier who then allowed them to proceed on the basis that the visitor was the inventor of the tube. However, Farnsworth was unsuccessful in obtaining the funds due to him: [56]

> "Hitler had completely stopped the flow of Reichmarks out of Germany. They arranged the passage home but their exit visa's were cancelled. When they obtained new exit visa's these were also cancelled.

When this happened for a third time, Goerz took over and told them he would call in the evening and take them to the boat train. This train ran between Berlin and the seaport of Hamburg. They were smuggled on board by Goerz, Capt West and another, as yet unknown, Baird director.

On 5 February 1937 the Marconi-EMI system was chosen and the Baird system was rejected, however the British Air Ministry were investigating Baird's intermediate film system for use in aerial surveillance. (See Chapter 6). In an Air Ministry memo dated 17 April 1937, Hecht wrote:

> "....It will be seen that both call for intermediate film which is what our own War Office think is the proper way of doing television" [57]

As far as the commercial aspect of television was considered Baird Television had lost its place in broadcasting and would have to concentrate on receivers for home use and the possibilities of theatre television. [58]

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CHAPTER 5

Theatre and Domestic Television

Figure 5.1: Big-Screen Television Picture compared to a Living Model

List of Illustrations: Chapter 5

Section 5.1

The Birth of Theatre Television

A Brief History

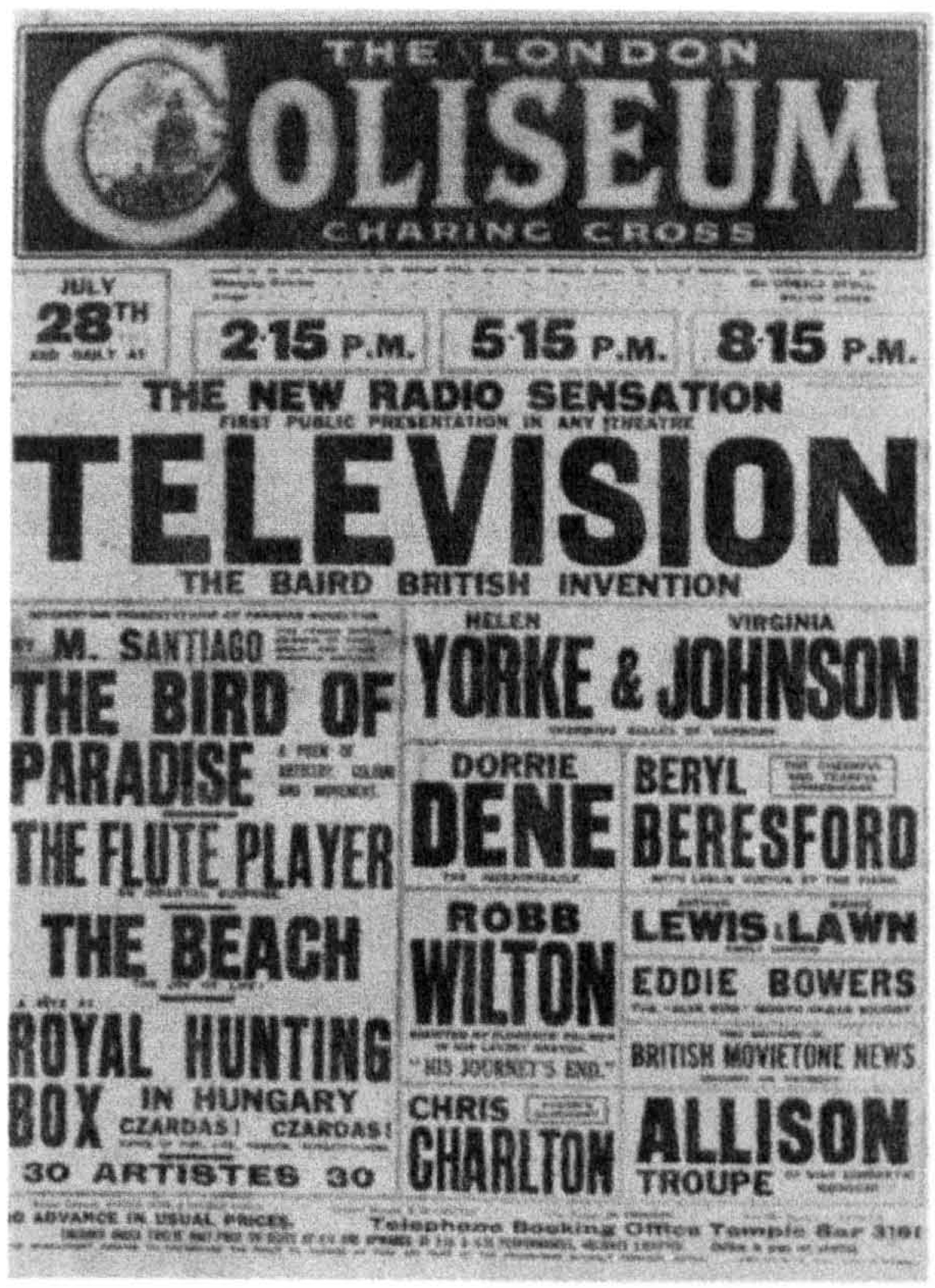


Figure 5.2: Coliseum Billing July 1930

The first showing of television to a paying theatre audience was carried out by John Logie Baird during July 1930 at the London Coliseum. (Figure 5.2). Baird recorded in his autobiographical notes [1] that theatre television had been the subject of his first issued patent: [2]

> "The first patent I took out described a television screen consisting of thousands of little lamps, something after the style of the (sic) certain electric publicity signs in Trafalgar Square where the lamps light up to form figures and letters."

222,604. Baird, J. L., and **Day, W. E. L.**
July 26, 1923.

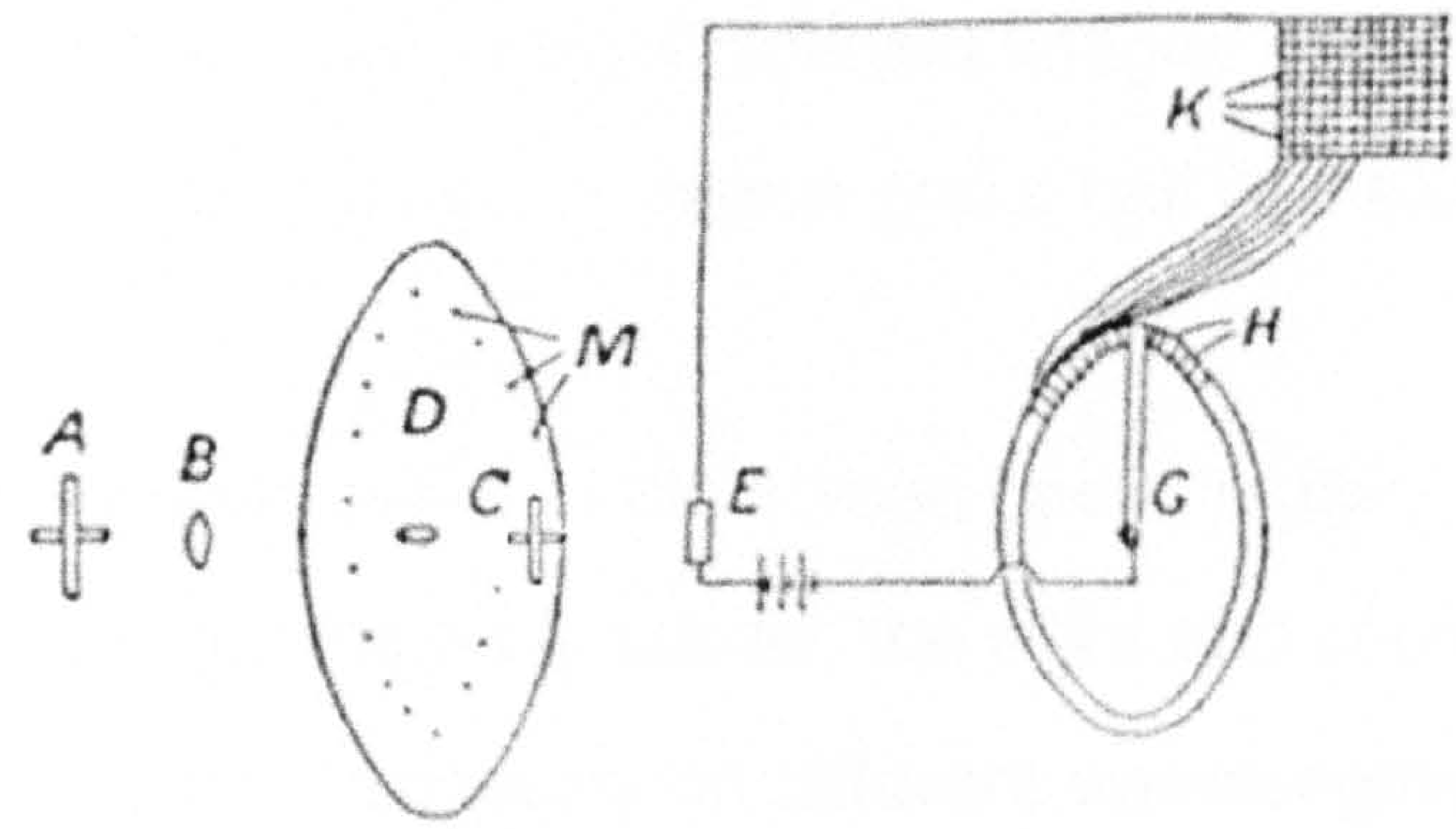


Figure 5.3: J.L.Baird's first issued patent - July 1923

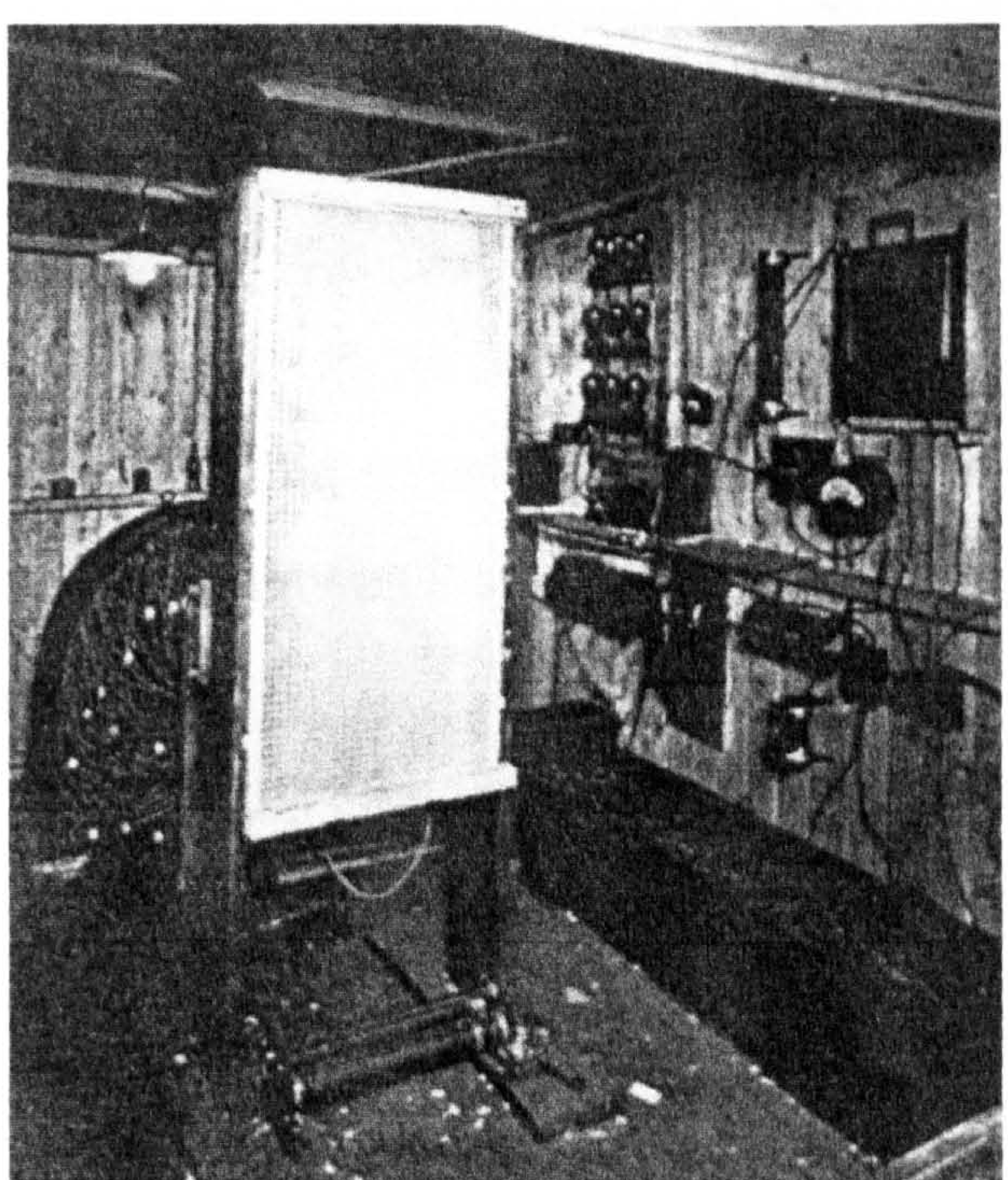


Figure 5.4: J.L.Baird's active screen

As illustrated in his patent, (Figure 5.3) Baird used an active screen which measured five by two feet. (Figure 5.4). A commutator was wired to the screen which rotated synchronously with the remote television scanner. This ensured that only the appropriate bulb would become active at precisely the correct time. This screen displayed images based on the Baird system of thirty lines at a rate of twelve and a half frames per second. Margaret Baird wrote: [3]

> "Although one newspaper said that the screen had a 'muslin' effect, the show compared well with the early talkies; the sight and sound in television, broadcast simultaneously on different wavelengths , were synchronised better than the early talkies."

These large screen presentations, with three daily performances, ran for three weeks and earned Baird Television fifteen hundred pounds. [4] Abramson [5] indicated that the lamps produced an afterglow effect which helped to create an image of greater brilliance with less flicker.

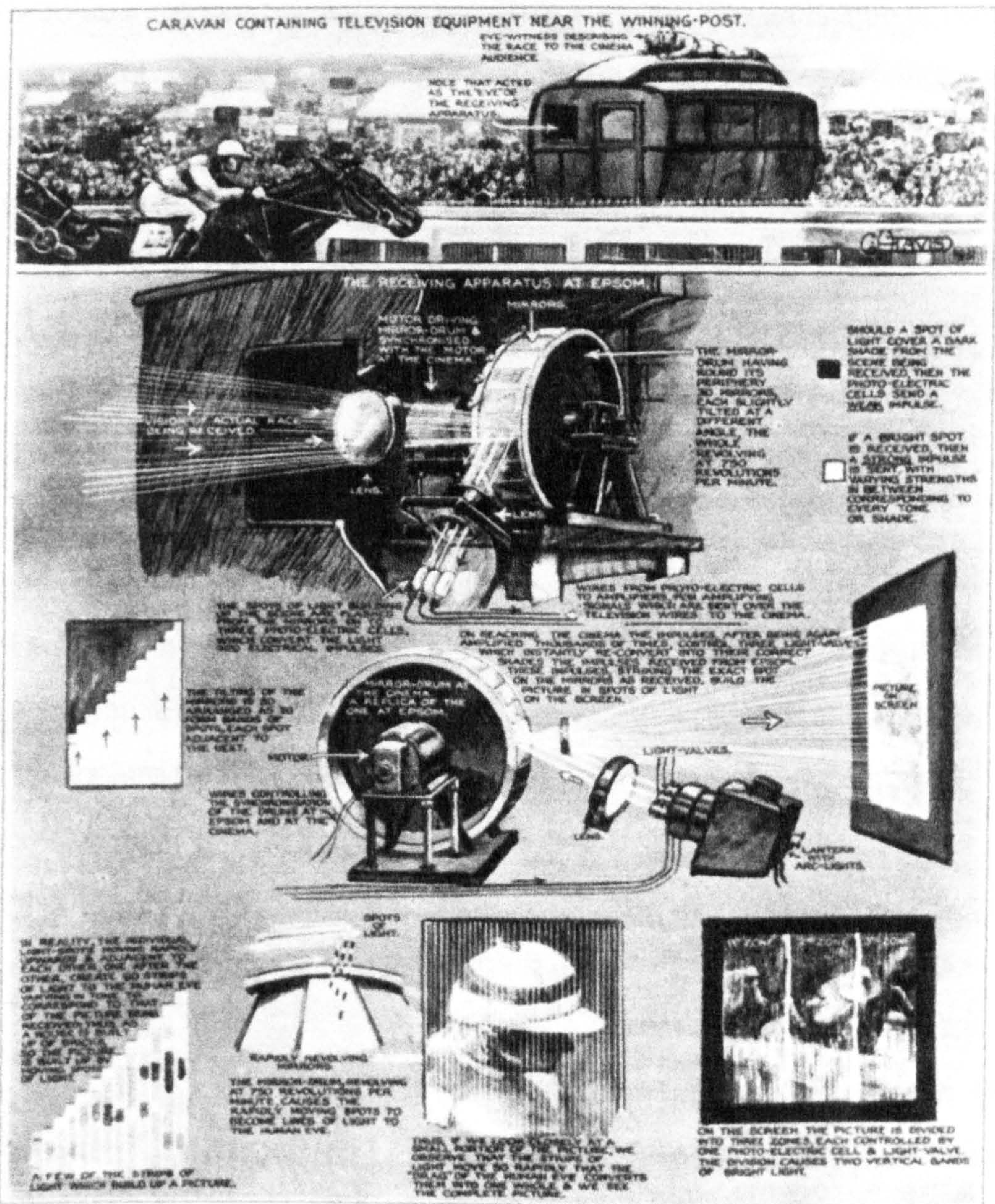
Miller wrote: [6]

> "The effect on the viewer, due to persistence of vision and a certain degree of afterglow on the tube screen, is that a complete set of lines is seen, though actually at any given instant there is only the single spot of light drawing the picture."

Any increase in the 'afterglow' of picture elements will assist persistence of vision by allowing extra time for the retinal storage of the image in the eye. By using filament lamps Baird had effectively produced a screen with a long afterglow. The storage effect was a by-product of the time taken for filament lamps, or picture elements, to cool from a hot condition. Therefore the viewer perceived less flicker on the active screen despite the applied low frame rate.

966 THE ILLUSTRATED LONDON NEWS June 11, 1932

HOW THE DERBY FINISH WAS SEEN BY A CINEMA AUDIENCE 14 MILES AWAY.



APRIL THE FIFTH'S WIN AT EPSOM TELEVISED IN MOVING-PICTURE FORM TO A SCREEN IN LONDON, ON WHICH IT WAS SEEN AS IT HAPPENED: HOW THE BAIRD TELEVISION SYSTEM WAS USED.

Figure 5.5: Illustration describing the method used by J. L. Baird to televise the Derby for the Metropole Theatre audience in 1932

On 1 June 1932, Baird surprised an unsuspecting audience at the London Metropole Theatre by presenting the finish of the Derby on three adjacent active television screens. This was transmitted from an outside broadcast caravan located at Epsom Downs from which a mirror drum picked-up three simultaneous side-by-side images. The technique of using a number of sections of an image to produce a larger composite image was known as 'Zone Television'. (Figure 5.5).

Abramson wrote: [7]

> "... a huge mirror drum with 30 mirrors was placed so that it could see the finish line. There were three sets of photocells and amplifiers so that three sets of signals were transmitted. One set, the centre set, was sent to the BBC, where it was transmitted on a wavelength of 261 metres for home consumption."

Baird wrote: [8]

> "To give a large picture at the Metropole, I had three pairs of telephone lines from Epsom race course and sent out three pictures side by side."

At the theatre the nine feet wide by six feet high screen produced bright television pictures with a definition of six thousand three hundred picture elements.

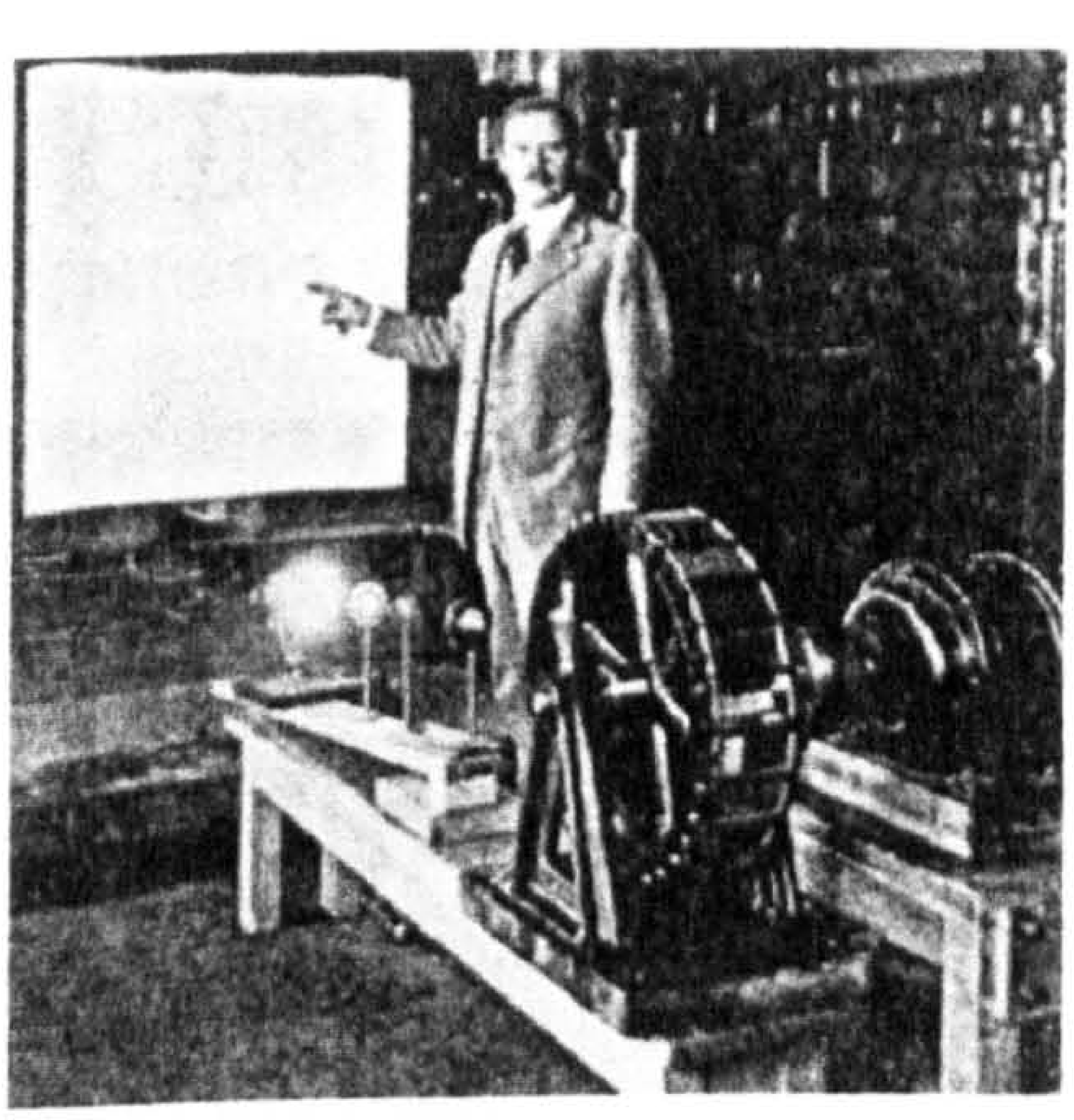


Figure 5.6: Alexanderson's Zone Television 1926

Although Baird was successful with 'Zone Television' he did not originate the concept. On 15 December 1926, Dr Alexanderson [9] of General Electric, demonstrated a multi-beam system (Figure 5.6) using the rotating mirror drum in reverse as the projector. Unlike Baird's system, this did not use active screens and the image quality was rather 'poor' [10]

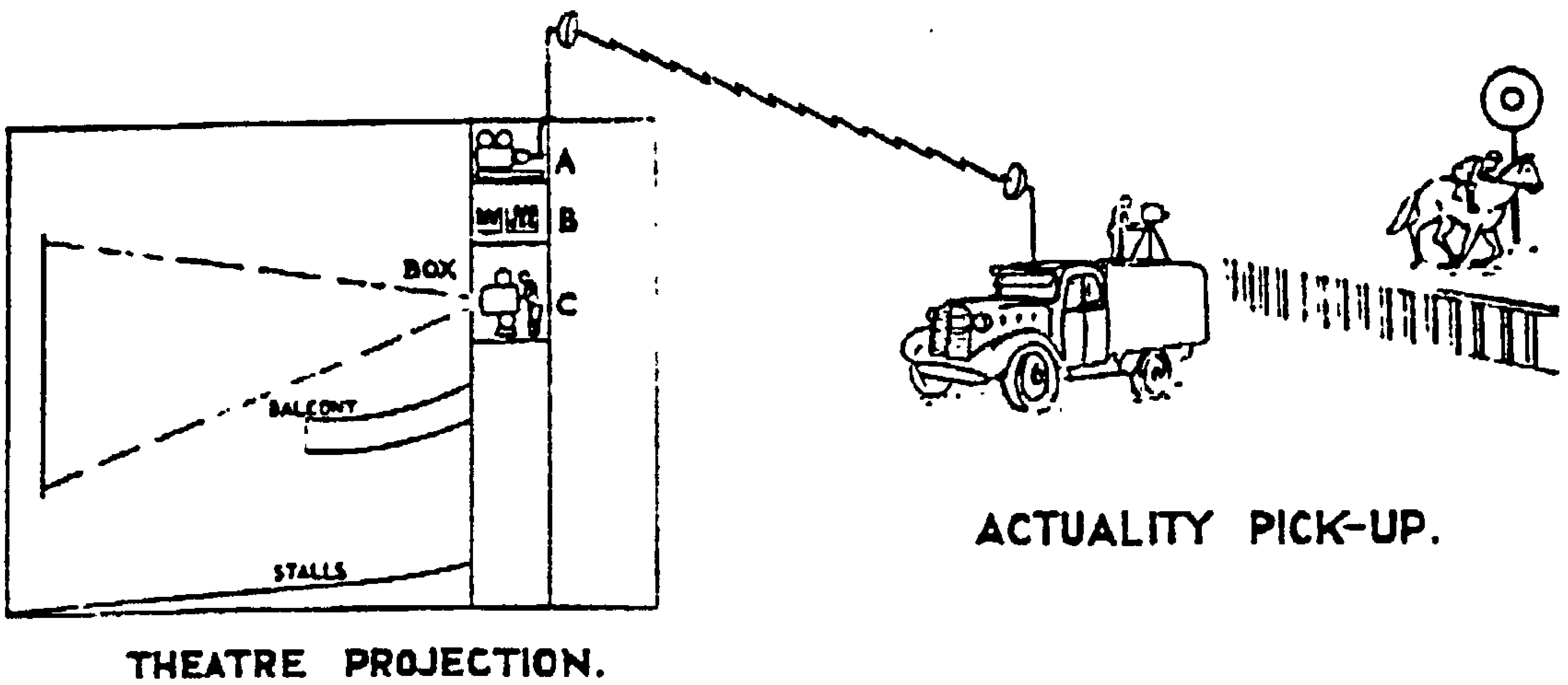


Figure 5.7: Intermediate Film Cinema Projection Baird Television 1935

In a paper by West [11] relating to the development of theatre television in England a version of the intermediate film system, (developed by Baird Television jointly with Fernseh AG in Berlin) was described for use as a theatre projector. With reference to Figure 5.7, a remote television image was sent by microwave link to the cinema where it was received and displayed on a small cathode-ray tube. A 35mm movie camera in the system photographed each television frame and after rapid development, fixing and drying, the film was projected on the large screen. The use of the standard auditorium projector enabled the processed film to provide the normal standard of brightness and fill the theatre screen. West [12] indicated that while the degree of definition was reasonably good, the method was expensive due to the high cost of film stock.

West wrote: [13]

> ".... the attempt by our associated company, Fernseh A G in Berlin, to use a continuous loop of film, which was cleaned and resensitized in a continuous process in the intermediate film projector, was not attended with success."

Abramson [14] reported that Fernseh demonstrated this system at the Berlin

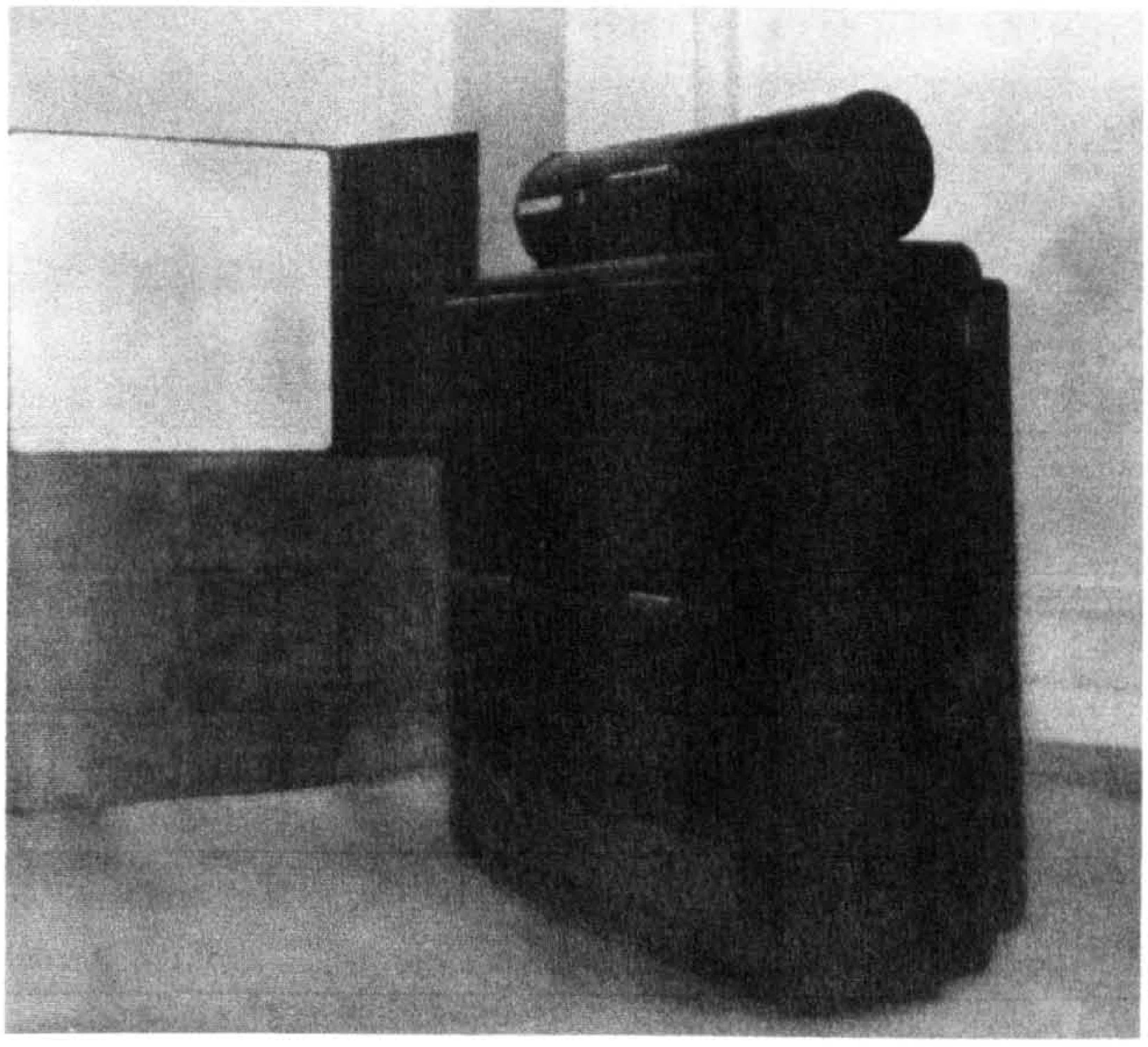


Figure 5.8: Szegho's first Projection CRT Unit

Radio Exhibition in August 1933, on a six feet wide by eight feet high screen using one-hundred and twenty lines.

Abramson indicated: [15]

> "the results were not very good, the image being 'thin' and marred by splashes and bubbles on the film."

At Baird Television in 1936 before the Crystal Palace Fire, Szegho and Tomes had experimented with projection cathode-ray tubes. Szegho recalled some of his first thoughts on large screen television: [16]

> "I tried to reduce to practice a pet idea of Farnsworth and excite by the electron stream a heat screen made out of the Nerst gas mantle material, cerium oxide. The beam density, however was not sufficient to bring an area large enough to incandescent. I reverted to the simple scheme of utilising intense fluorescence of a screen in a 5 inch tube bombarded by approximately 30 kV electrons."

On 26 July 1936 Szegho and Tomes developed their first flat faced cathode-ray tube and projection unit. (Figure 5.8). The images were projected on a 6 feet wide cine screen using a highly efficient projection lenses. [17]

Tomes wrote: [18]

> "Captain West immediately saw the tremendous potential there was for having big-screen television in cinemas. He encouraged us to increase the brilliance of the pictures, which meant using higher voltages, but this brought about many problems which had to be overcome."

The next section describes the formation of Cinema Television Ltd, a company which operated from within Baird Television and which was owned by Gaumont British.

Section 5.2

Cinema Television Ltd

By early 1937 the future of the Baird Company had become uncertain. Compounded with the problem of renewing apparatus and facilities lost during the Crystal Palace fire, the company had been forced to shed two hundred jobs. The situation grew worse when EMI were chosen to supply transmission apparatus for the BBC with the result that public confidence slumped. [19]

Television receiver production was not resumed at Baird Television in the aftermath of the fire but was contracted-out to Baird's sister company 'Bush Radio' which was also part of the Gaumont British chain. With the exception of cathode-ray tube manufacturing and television receiver circuit design (which were less affected by the fire); cathode-ray tube development, electronic camera and photomultiplier development departments were undergoing a transitionary period.

Tomes wrote: [20]

> "The shares plummeted and the future looked really bleak. Baird 15 inch receivers gave excellent pictures but were too expensive. Production had to be re-tooled to make smaller 10 inch and 12 inch receivers. The only bright spot on the horizon was the great promise shown by our big-screen projection work, in which I was deeply involved."

Szegho [21] was concerned that the experimental projection tubes had a tendency to become unstable causing the picture to flutter at varying frequencies. The phenomena occurred because the projection tubes had

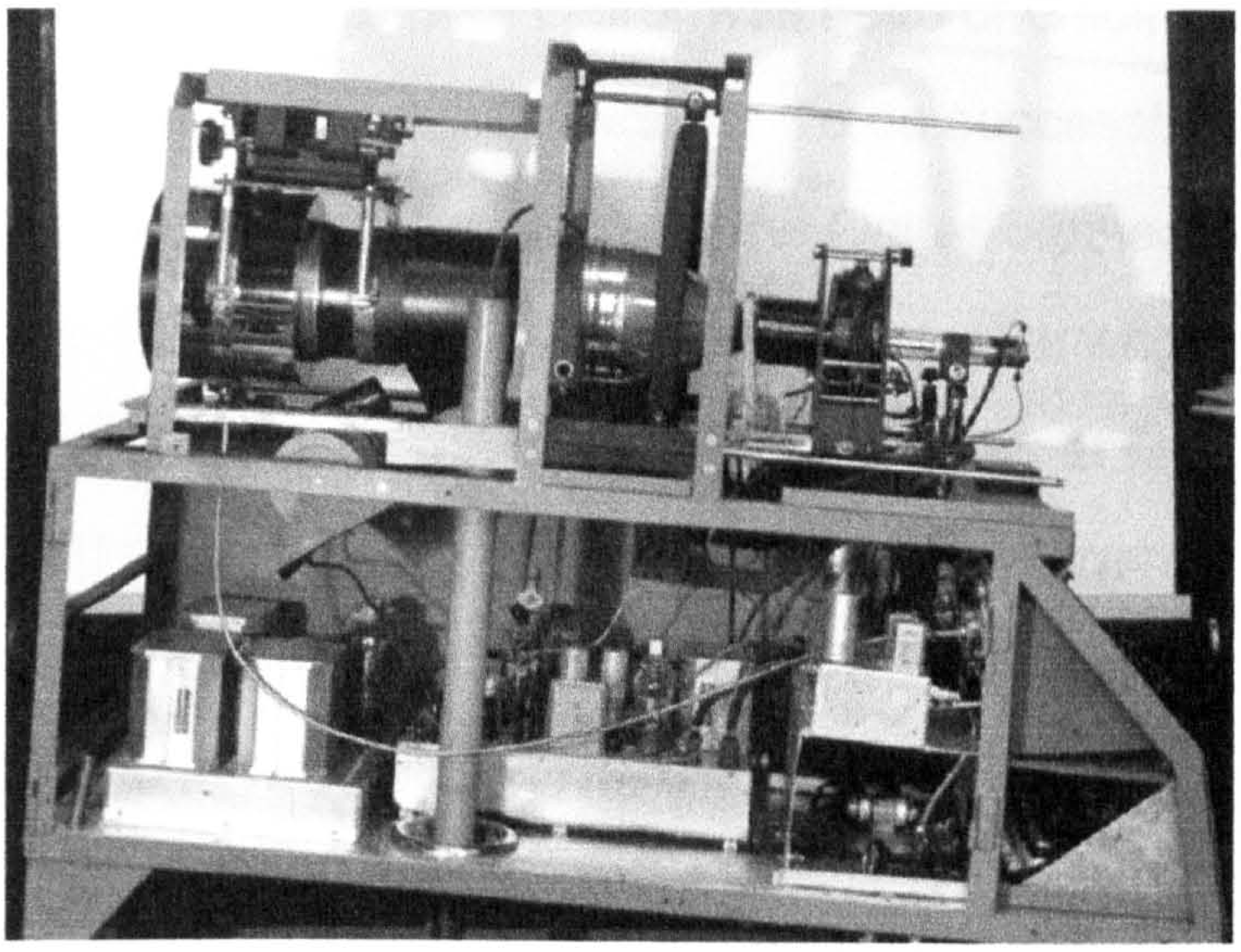


Figure 5.9: In-line cathode-ray tube television projector chassis

electrically insulated fluorescent screens which were continuously bombarded with electrons. [22] It was discovered that if the anode voltage was raised above a certain value the screen would continue to charge up negatively until a point was reached when the screen would suddenly discharge down the side-wall. This produced a momentary electrical field which interfered with the deflection of the scan causing the picture to flutter usually at one of the corners of the picture. Tomes [23] recalled that one tube, Number 205, seemed to have a charmed life and could be safely operated up to 27,000 volts without any fear of flutter.

Tomes wrote: [24]

> "Some tubes were better than others and one particular tube was completely free from the effect. The solution was of course to make the screen conductive, but it took several months to solve that problem."

On the 8 July 1937, Szegho and Tomes gave a demonstration to the Baird board of directors. The Ostrer brothers, Mark and Isadore, requested that experimental equipment (Figure 5.9) be installed in Film House at

Wardour Street in London. Isadore Ostrer was head of Gaumont British and the principle shareholder of Baird Television. To be successful with theatre television, West hoped to gain support from the Ostrer brothers who also controlled the chain of British Gaumont cinemas. West arranged for a demonstration of theatre television to the Ostrer brothers at Film House on 11 November 1937. The event to be screened was the 'Armistice Day' celebrations broadcast by the BBC from Whitehall. The Ostrers were impressed and enthused about installing the system in their cinemas. [25]

Although working separately from the Company, J. L. Baird was also intent on promoting theatre television with the Ostrers: [26]

> "It seemed to me that now being out of the BBC, we should concentrate on television for the cinema, and should work hand-in-glove with Gaumont British, installing screens in their cinemas and working towards the establishment of a broadcasting company independent of the BBC for the supply of television programmes to cinemas."

Baird [27] promoted the idea of theatre television with Isadore Ostrer who responded positively by forming a new Gaumont British company, 'Cinema Television' which would virtually control Baird Television.

This critical step taken by J. L. Baird guaranteed the continued support from Gaumont British and led to the reorganisation of Baird Television with John Logie Baird as president.

Section 5.3

Higher Definition Theatre Television

Figure 5.10: Projection in the Tatler Theatre, London, 1938

On 8 December 1937 a 405-line large screen demonstration was given by Baird Television at the Palais Theatre, Bromley, Kent. Abramson [28] indicated that the projected picture was some eight feet by six feet and was of a regular programme of the BBC.

Tomes wrote: [29]

> "Capt West appointed an engineer to take over projection demonstrations which relieved Szegho and myself of much time consuming work."

Early in 1938, a dual television projector (Figure 5.10) was installed in the Tatler Newsreel Theatre in London. A single projection unit is shown in Figure 5.11 and a detailed illustration of the component layout of the chassis is shown in Figure 5.12 .

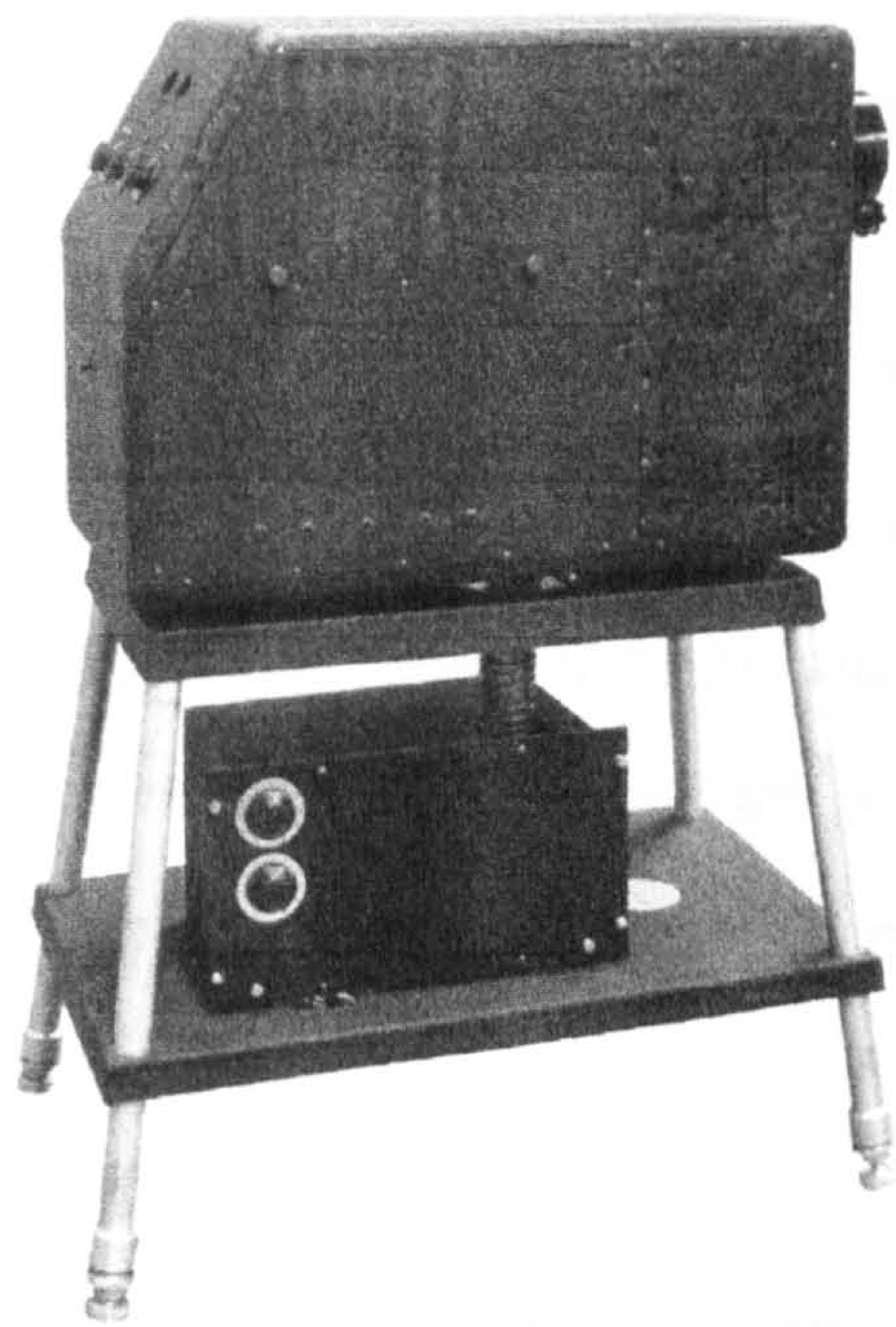


Figure 5.11: Baird Projection Unit for reproducing television pictures on a large screen in cinemas and large halls.

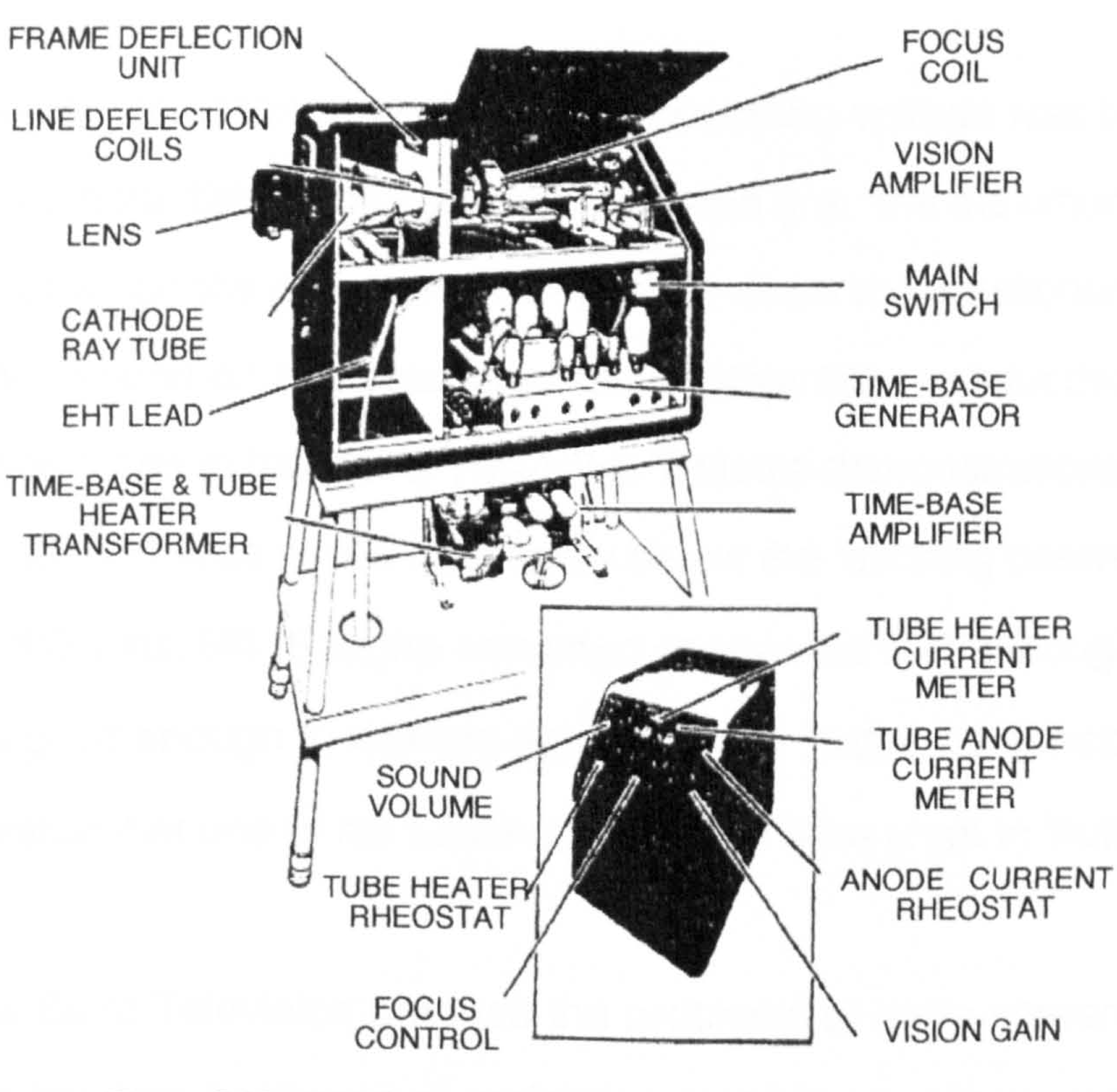


Figure 5.12: 1938 Baird cathode-ray tube projector for the 10 x 17 1/2 feet screen in the Tatler Theatre, London.

West described the apparatus: [30]

> "It housed a cathode-ray tube operating on 30,000 volts, and reproduced an intensely bright picture (3 x 4 inches in size) on the screen of the cathode-ray tube, which was projected by an f/2.5 lens on to a screen 10 x 7 1/2 feet. The illumination on the theatre screen was of the order of 1/4 foot-candle, and the brightness, using a semi reflecting screen material, of the order of 1/2 foot-lambert; *(=1/2 lumen/sqft)* and demonstrations were given of various actuality programs transmitted on the 405-line basis by the BBC." Note: Author's italics.

The problem which Szegho and Tomes described as 'flutter' was related to the 'sticking potential' which occurred in most non conductive screen cathode-ray tubes when they operated above a certain voltage. McConnell: [31]

> "In the earlier projection tubes the useful operating voltage was limited by the 'sticking potential' of the fluorescent screen (i.e. the maximum potential at which the screen would stabilize when the equilibrium conditions depend on secondary emission rather than conductivity)."

The projection tubes in the Tatler Newsreel Theatre demonstrations were operated at 22,000 volts which was safely below the 'sticking potential,' of around 27,000 volts. [32] Szegho remained concerned that although the picture was good enough to warrant equipping the Tatler, he considered it to be intolerable that one of his tubes could at any time erupt in 'flutter'. [33]

While Baird Television pursued the problems of large-screen television in theatres by means of projection cathode-ray tubes, John Logie Baird spectacularly continued to promote alternative methods.

Section 5.4

J. L. Baird's Theatre Television

There were two distinctly different Baird theatre television projects, one operated from Baird Television Ltd (Cinema Television) under the direction of Captain A. G. D. West, based on the 405-line line format, while the other was based on John Logie Baird's private colour television work. Herbert [34] indicated that from 1933, J. L. Baird worked from his private laboratory in a converted stable adjoining his house at Crescent Wood Road in Sydenham. There he established his own staff and workshop facilities.

J. L. Baird and A. G. D. West moved in different directions in the development of television. Baird's personal interest lay in the area of research and development of theatre, colour and stereoscopic television, while West's main concern was to make Baird Television profitable through the marketing and sale of current products. Despite this Baird and West seem to have got on well together and met for dinner occasionally during the war years. [35]

From 1934, J. L. Baird made use of the 'South Tower' of the Crystal Palace and had access to Baird Television research specialists.
Tomes wrote: [36]

"Baird rarely visited the Crystal Palace and I can only remember his coming to our laboratory twice and one of these visits was the occasion of his birthday. He confined himself to developing mechanical television systems and from time to time gave demonstrations of his work in theatres in London and in private shows to the press."

Szegho concurred: [37]

" Mr Baird was president of the company at least up to the beginning of World War II, but he remained in the background. During the seven years I was with Baird Ltd, J. L. Baird paid only three or four visits to my lab."

J. L. Baird thought highly of Sommer's work on photomultipliers and visited him more frequently: [38]

"I was very fond of him as a human being - two qualities that I never see in print were his delightful sense of humour and his shrewd judgment of people when he discussed my colleagues."

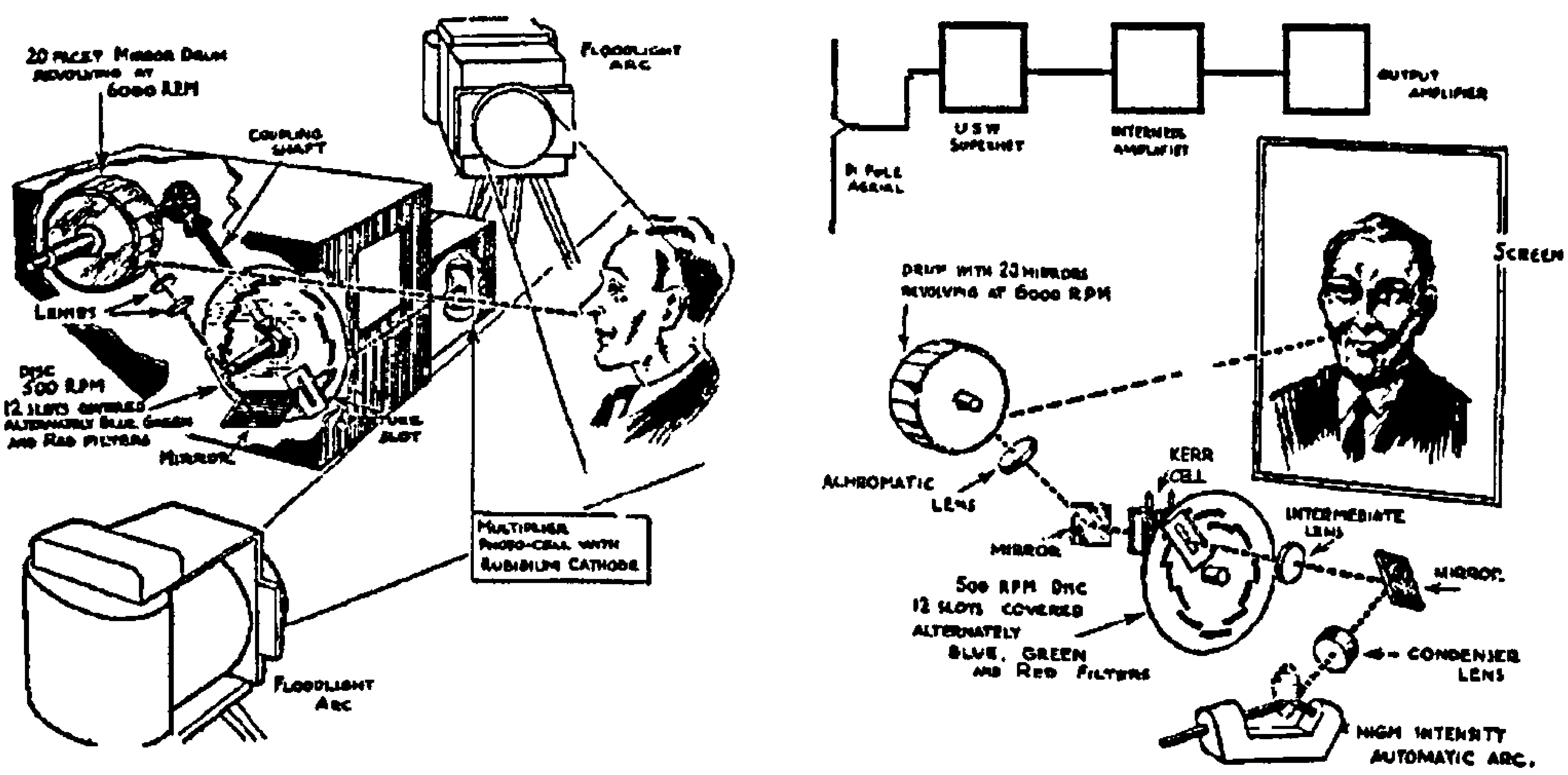
Baird offered Sommer a position at his private laboratory: [39]

"I did not think it would be wise to leave the relatively secure employment of Baird Television to join him full-time, but I continued to help him with his colour TV project."

Herbert [40] described J. L. Baird's advanced work on theatre television:

"Following the successful demonstration of interlaced, 120-line monochrome television picture on a 8 by 6½ feet screen at the Dominion Theatre, Tottenham Court Road. London, in December 1936, Baird ambitiously set out to establish yet another first."

Baird gave a press preview of colour television in December 1937, which he repeated on 4 February 1938, to an amazed and unsuspecting audience at the Dominion Theatre. The pictures transmitted from the Crystal Palace, South Tower, were projected on a 12 by 9 feet screen. Herbert [41] described Baird's process as comprising of a drum carrying 20 small mirrors rotating at 6,000 rpm and reflecting sections of the scene upon a revolving



Colour Transmitter Colour Receiver

Figure 5.13: The process used by Baird to collect and project the 120-line colour images

disc with 12 slots. Each slot was fitted alternately with blue/green and red colour filters. The vertical slices comprising the televised image were then reflected onto the rubidium cathode of one of Sommer's multiplier photocells. This arrangement provided a 2 colour 120-line picture which was reproduced in the cinema with a similar arrangement involving a 150 Watt arc lamp in conjunction with a Kerr cell to reproduce the required variations in light intensity. (Figure 5.13).

West wrote: [42]

> "Looking back at that demonstration, in which a two-colour process was employed in providing a 120-line interlaced picture, we find that the results were remarkable, considering the 'state of the art' at that time."

At Baird Television, Szegho had identified methods for overcoming the problem of 'flutter' and was entertaining plans to produce bigger and brighter projected cathode-ray tube images.

Section 5.5

Pipeshaped Projection Tubes

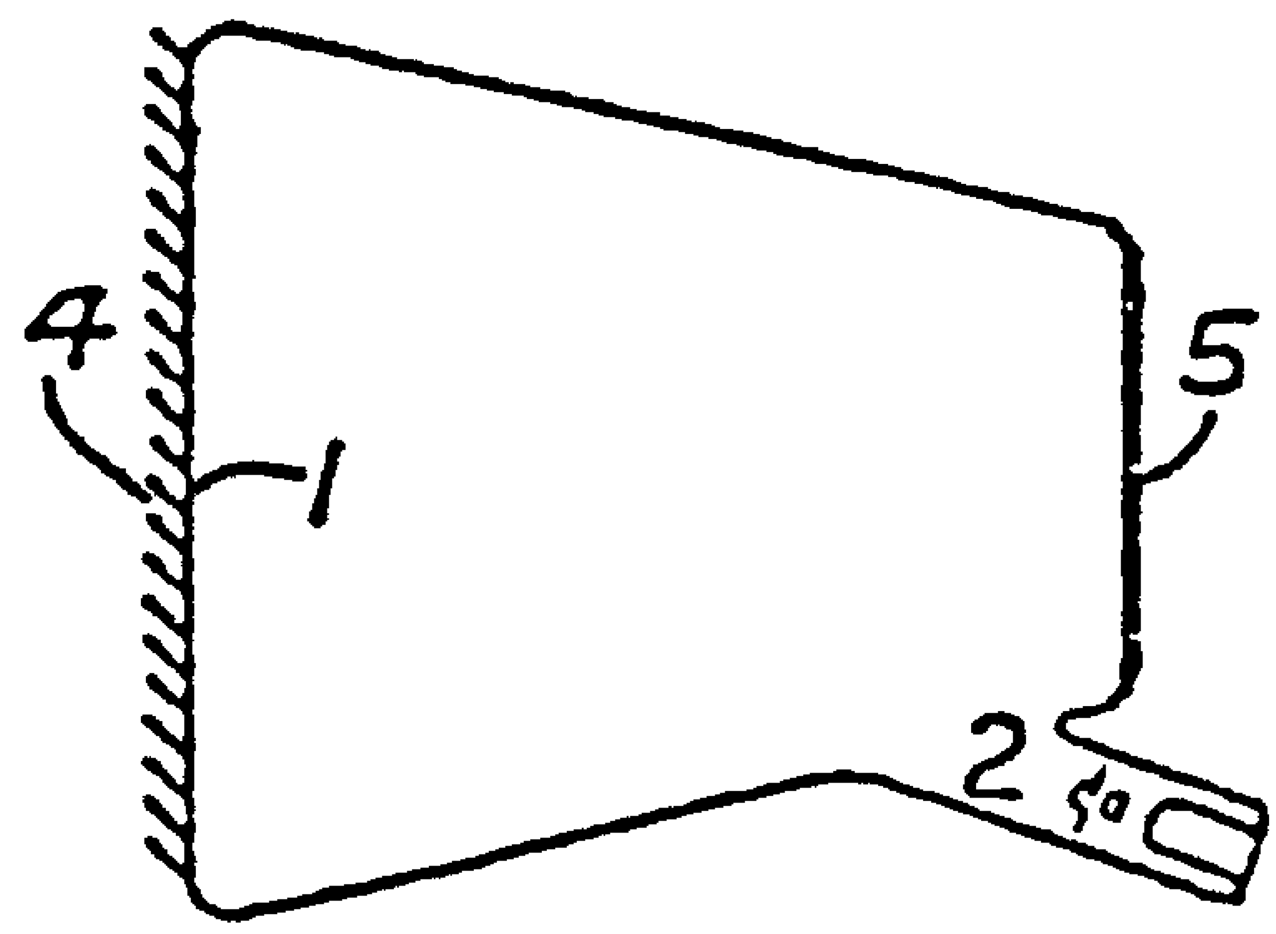


Figure 5.14: British Patent 496,778
Szegho and Tomes/Baird Television
1937

The key to solving the problems associated with flutter may be found in an invention which Szegho and Tomes jointly patented [43] with Baird Television on 4 June 1937. With reference to Figure 5.14: A luminescent screen (1) is formed on the back wall of the tube (4) which has a reflective metallic backing of silver or a similar material. The image passes through the front of the tube (5) which is clear and may be parallel to the screen. The gun (2) is displaced to the side of the tube.

Szegho recalled that flutter in projection cathode-ray tubes had also been a problem in Germany: [44]

> "Fernseh took the bull by the horns. They made a front-surface projection tube in which the fluorescent material is deposited on metal and viewed by the projection lens from the side bombarded by electrons."

It is almost certain that Szegho exchanged notes with Moller of Fernseh as part of a long standing reciprocal arrangement. This was despite an earlier

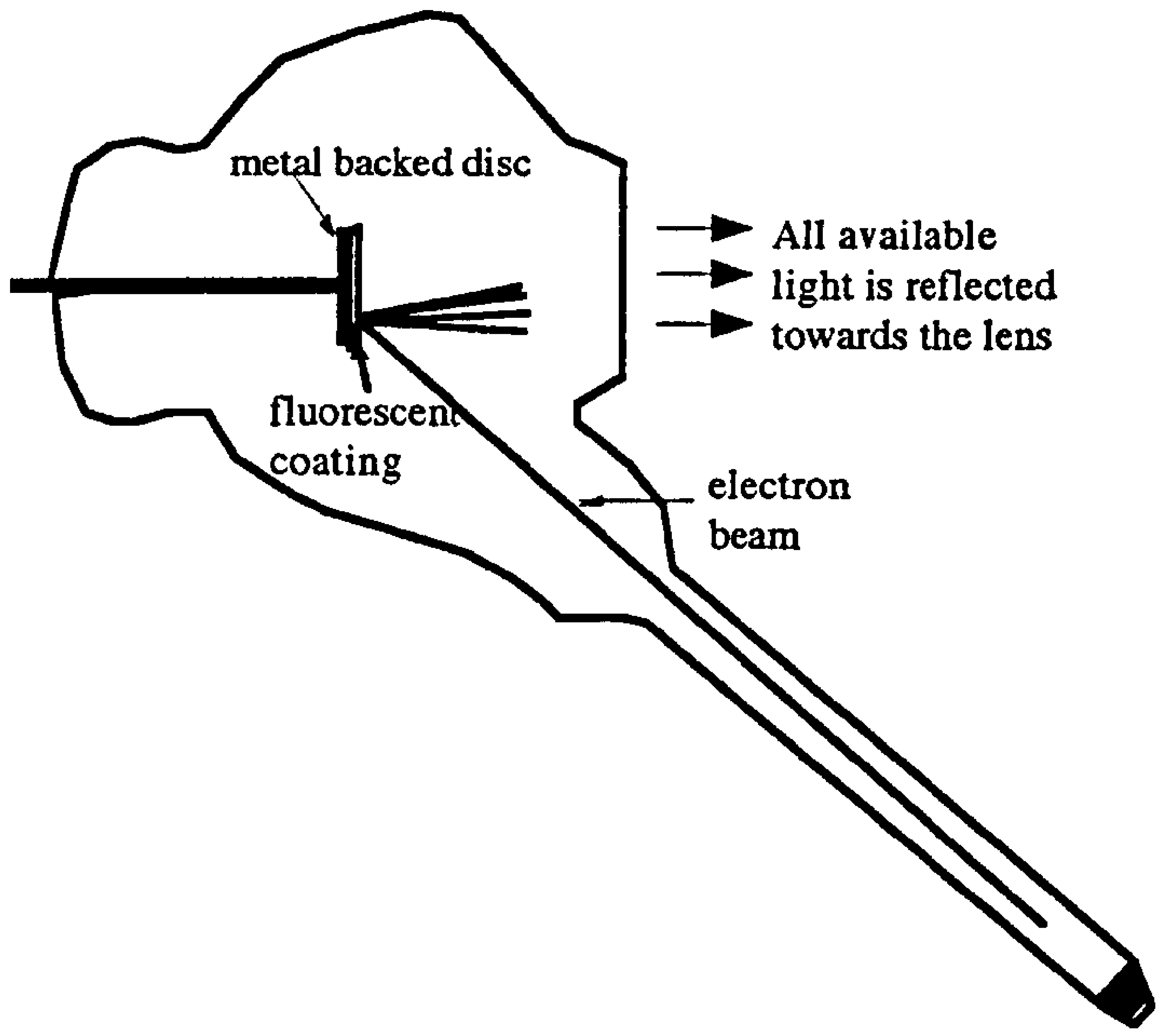


Figure 5.15: Front-surface metal-backed-screen projection cathode-ray tube

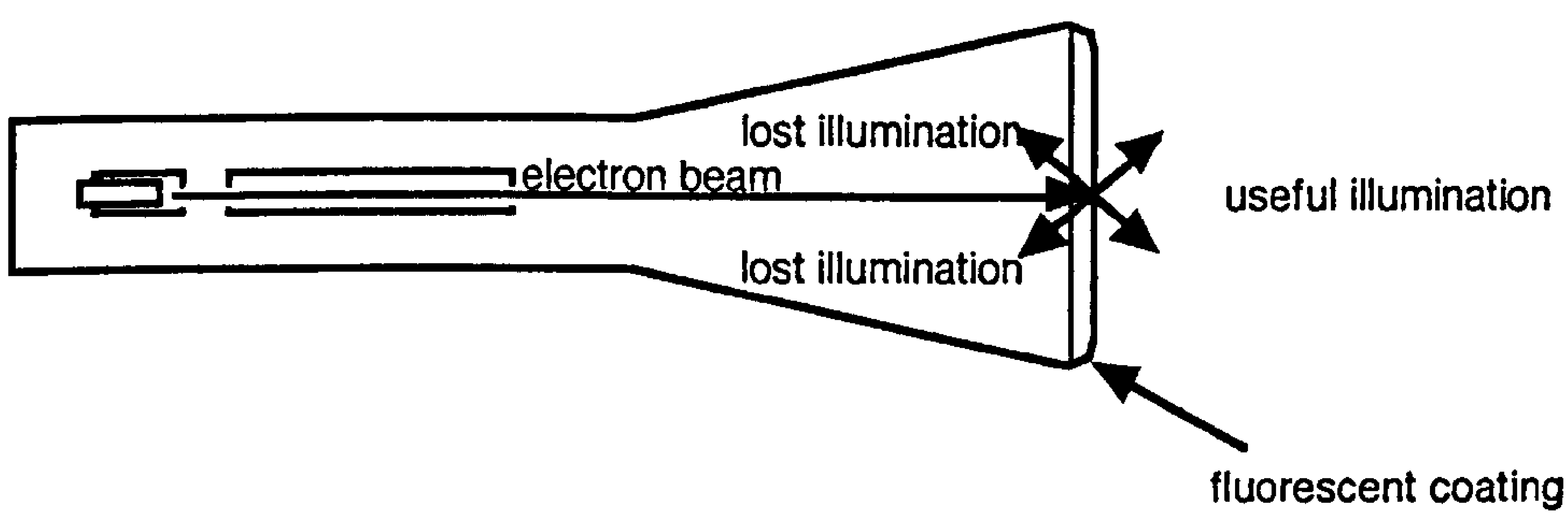


Figure 5.16: Conventional non-metallised screen in-line cathode-ray tube

acknowledgement by the British Air Ministry in 1936, (see Section 4.4, page 185) that such arrangements should be discontinued. The Fernseh projection tube (Figure 5.15) which was based on the Szegho/Tomes front-surface tube patent, was free from 'flutter' and could produce higher illumination than conventional in-line cathode-ray tubes. The reasons were twofold: First, the screen was conductive and therefore became stable at higher voltages, producing brighter images, and secondly the screen was more efficient due to the metal backing plate which reflected the image in the direction of the lens. Figure 5.16, illustrates a non-metallised, in-line projection tube showing loss of screen illumination due to light scatter.

Salaries had been frozen at Baird television since December 1937 which prompted Tomes to review his position: [45]

> "I always believed that regular salary increases were tangible evidence of progress in a company and, when at Bairds all salaries were frozen, it was time for me to be concerned."

Tomes made plans to accept an appointment with the BBC at Alexandra Palace. In an attempt to discourage this, West gave Tomes control of a department on the balcony of the Rotunda to work, independently from Szegho, with Johnston the glassblower. His remit was to develop and produce six inch projection tubes for scanning photographs, captions, text, and cinema film. These tubes had 'highly actinic' screens, which means that the blue colour of the fluorescent screen matched the sensitivity of photographic film.

Tomes decided to accept the job offer at the BBC where he was due to commence work on 23 May 1938. His last job with Baird Television was to produce a blue recording tube with a six inch screen for Banfield who worked on intermediate film cameras: [46]

> "It was a special, highly hush, hush venture, something to do with airborne TV for the French Air Ministry."

(The project with the Baird Television and the French Government is described in Chapter 6.)

The BBC did not take advantage of Tomes' skills and for seven months he was given inappropriate tasks including: television cameraman; studio lighting engineer; and working on transmitters at Daventry. When Capt West learned that Tomes was disillusioned by the BBC an interview was arranged which resulted in his return to Baird Television at Sydenham on 21 November 1938.

Tomes wrote: [47]

> "I was working in the photoelectric research laboratory, which was headed by Dr Samson. The original idea was that I would make iconoscopes, but it was decided that instead, Dr Sommer would teach me how to make photomultipliers, which would release him to concentrate on photoelectric surfaces."

Tomes and Szegho now moved in different directions within the Baird factory at Sydenham. Chapter 6 will deal with the parallel contributions of Dr Samson, Dr Sommer and Tomes in the Baird photoelectric research laboratory. The next section describes Szegho's development and application of pipeshaped tubes.

Section 5.6

Projection Tubes and Projectors

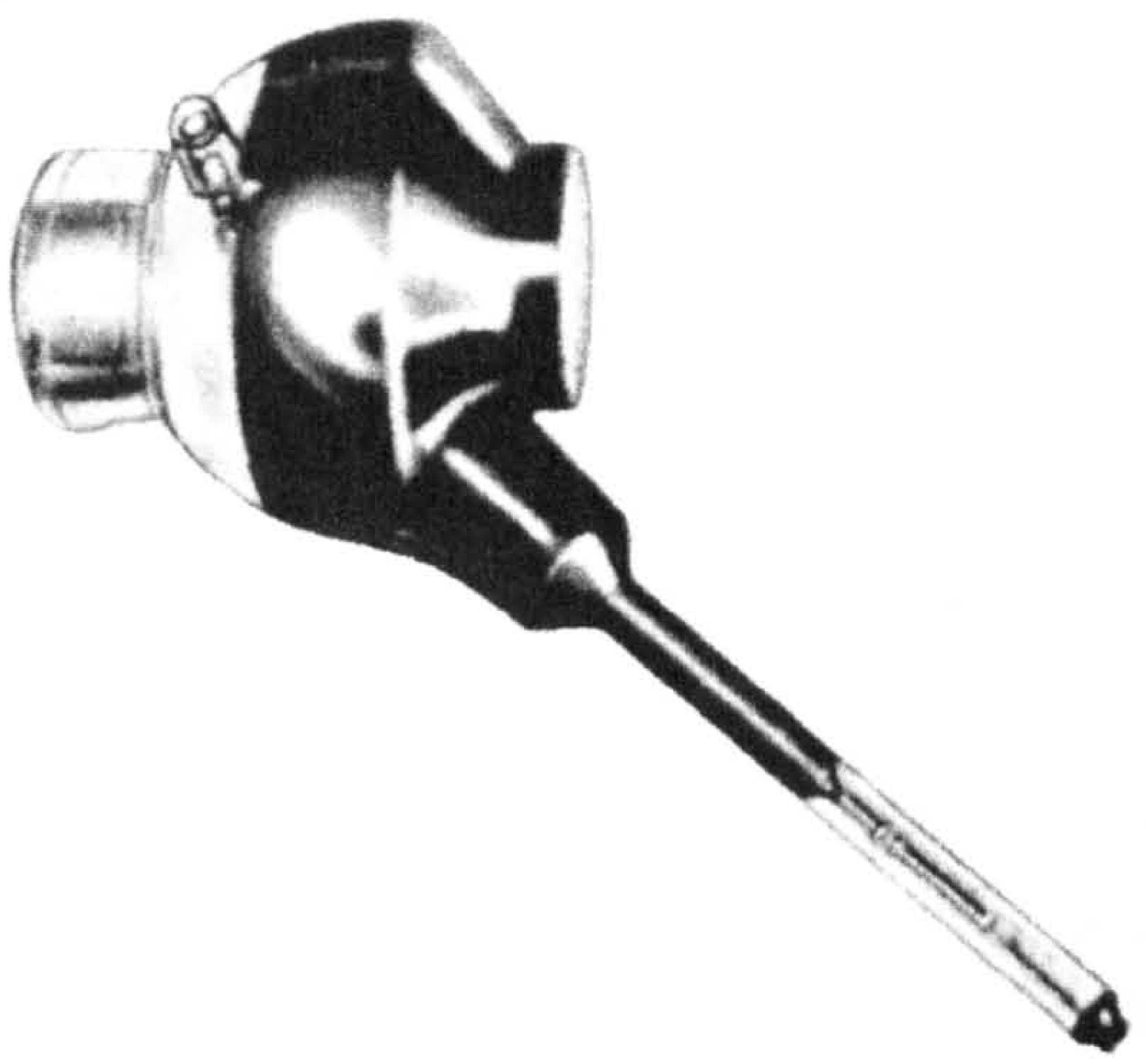


Figure 5.17: Fernseh Pipeshaped Projection Tube

Figure 5.18: Dr Szegho holding a Baird Pipeshaped Projection Tube

With the Ostrer brothers committed to theatre television, Szegho began a programme to produce front surface projection tubes. Figure 5.17 shows the 1938 front-surface cathode-ray tube [48] made by Fernseh. [49] Naturally this is very similar to the Baird tube shown in Figure 5.18. The Baird Television Company drawing (Figure 5.19) illustrates precisely the shape of the British tube. It should be noted that previously published literature relating to this family of Baird pipeshaped projection tubes often identifies them as 'teapot tubes'. [50] Tomes recalled [51] that Szegho and his assistant Wingent (who formed the enormous bulb on a glass lathe), had produced the first pipeshaped tube on 28 January 1938.

Szegho wrote: [52]

> "The tubes I designed were large, had a 16 inch diameter and with the neck at 30°, resembled a large tobacco pipe, hence the name "pipeshaped" tube. The fluorescent screen in it was of 7" diameter, the

Figure 5.19

Detail drawing of the 13½ inch

Baird Projection Bulb

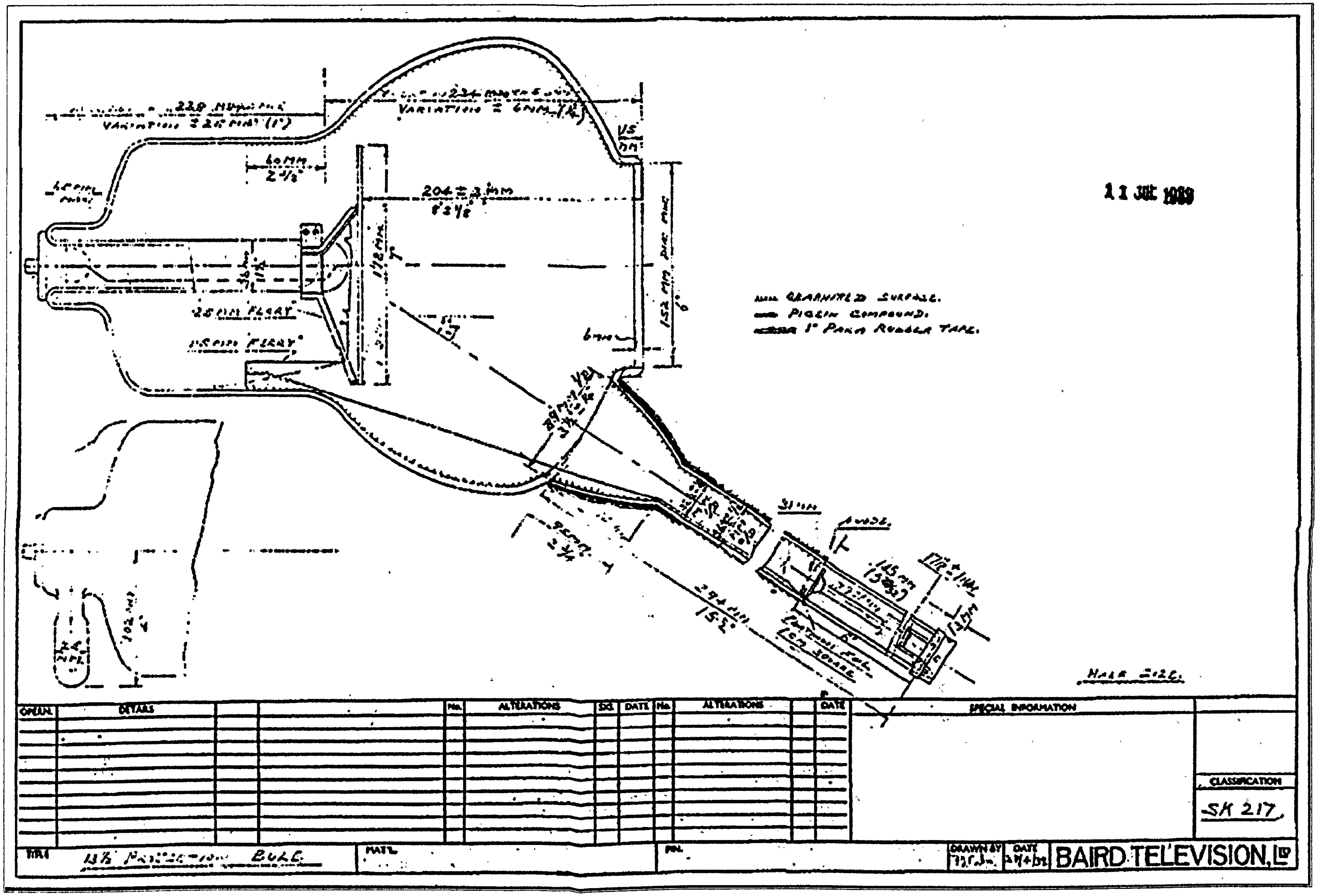


Figure 5.19: Detail drawing of the Baird13$^1/_2$ inch Projection Bulb

tube was operated at 50 kV."

Although off-axis-front-surface scanning solved flutter it introduced new problems which had to be resolved.

McConnell reported: [53]

"The fact that the axis of the electron beam was not normal to the screen made it difficult to avoid electron-optical aberrations and shape distortions, especially where high beam currents were concerned."

This image error known as 'Keystone' distortion, which also occurred in electronic cameras of the iconoscope family, was corrected to an acceptable level by the Baird engineers. However, with tubes functioning at about 50,000 volts their useful operating life required careful consideration. The cinema application was based on a 2 hour programme which indicated that in a dual projector unit each tube had to operate for at least 1 hour.

Szegho wrote: [54]

"The main problem hence was with avoiding dielectric puncturing of the glass, especially in the vicinity of the deflection coils. I experimented with water cooling of the fluorescent screen deposited on an aluminium disc, but this proved to be superfluous. The life of the tube was limited by the life of the very hot filament and by raster burning. It varied between 1-200 hours, quite sufficient for a theatre."

The special glass envelopes for the pipeshaped tubes were developed cooperatively with the glass company 'Chance Brothers' who also helped design the bulb for a Baird 22 inch direct view television tube. With the small deflection angle this was an enormous bulb (Figure 5.20) which required great wall strength when under the pressure of a vacuum. Tomes [55] noted in his diary that on 1 July 1937 he had a 22 inch tube on the pumps, later it was recorded that as few as six 22 inch tubes were made. [56]

5.20: Szegho's 22 inch Baird Cathode-ray Tube

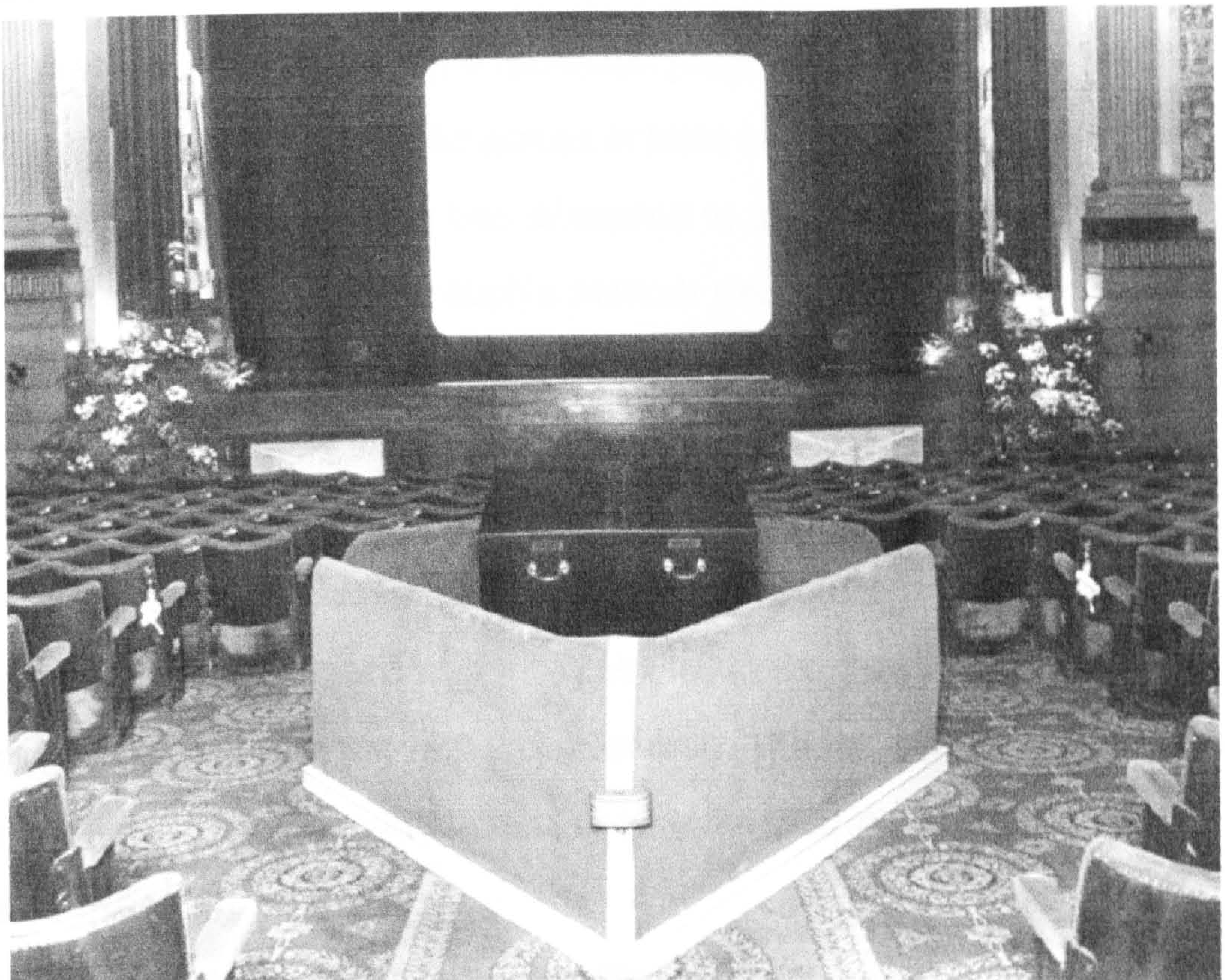


Figure 5.21: Baird Television double Projector
Marble Arch Pavilion in London

In February 1939, a Baird projector (Figure 5.21) using pipeshaped tubes [57] was installed in the Marble Arch Pavilion, London. Szegho [58] indicated that the projection lens (Figure 5.22) was designed by Dr Warmisham of Taylor, Taylor and Hobson - a Gaumont British optical firm. Bell wrote: [59]

"In the Baird equipment each projector unit is of the twin type; that is to say, it employs two cathode-ray tubes, which are kept in service continuously when the apparatus is being used, so that in the event of a breakdown of any part of the equipment change-over is instantaneous and the performance not interfered with."

Everything except the lens was duplicated. The Baird Television Ltd document, 'Specification of Large Screen Television Projection Apparatus for use in Cinematograph Theatres' indicates: [60]

"In practice when projecting a television programme, both tubes are in operation, the lens being slid across in front of the tube which has been selected for use. Negative bias is applied to the control electrode of the other, or 'stand-by', tube in such a manner that its picture is 'blacked-out'."

The twin projector unit is shown in Figure 5.23 with a single lens, and Figure 5.24 shows a rear view of the controls and pipeshaped cathode-ray-tubes.

Figure 5.25 shows one of the twin 60,000 volt high tension units, which were installed in two separate cubicles in the theatre and positioned as close as possible to the twin projector unit. The cubicles were fabricated from angle iron and expanded metal or wire mesh and the whole structure was earthed.

According to the Baird Television specifications: [61]

"Each high tension unit, two of which are supplied with the equipment,

Figure 5.22: 12 1/2 inch, Taylor, Taylor & Hobson Projection lens

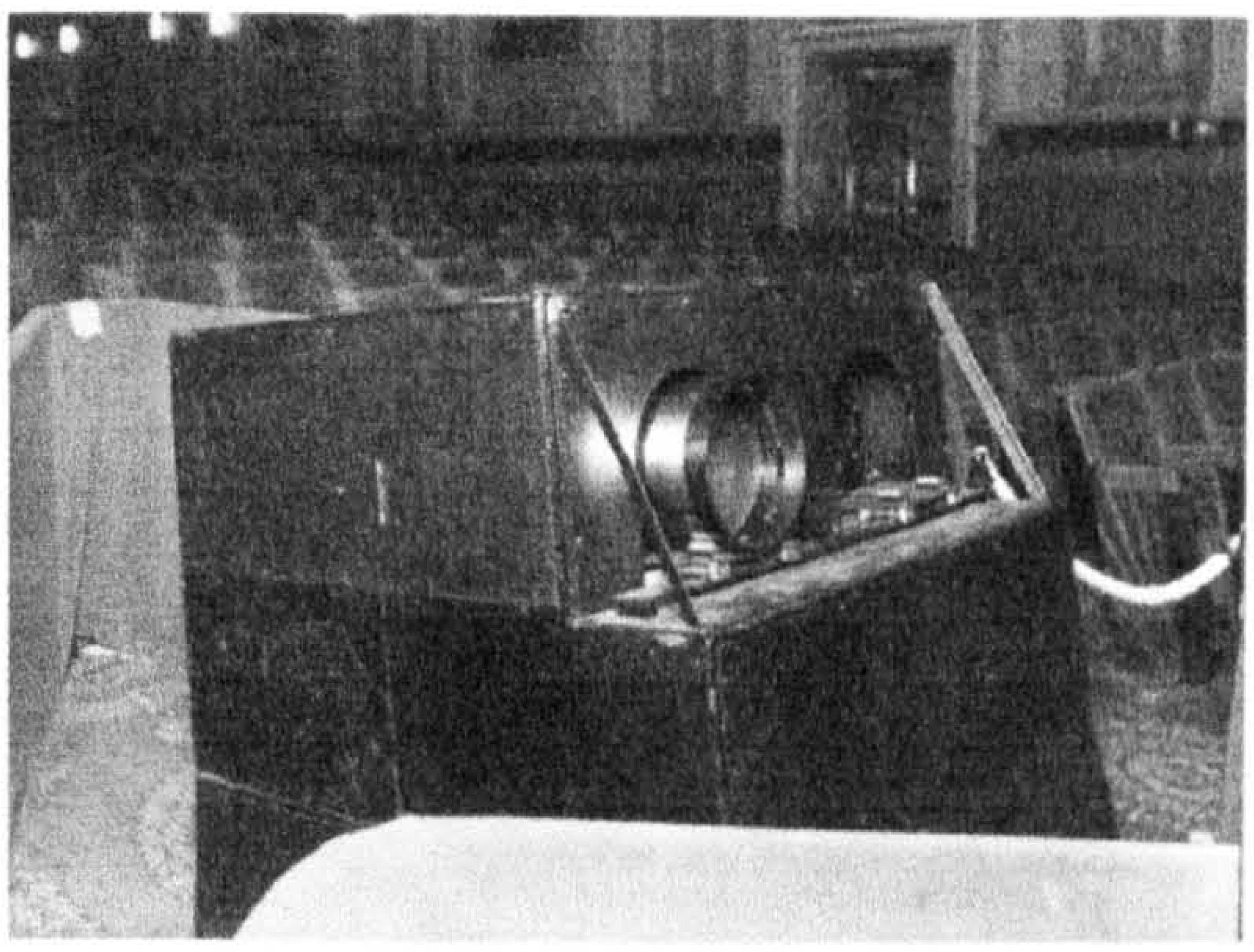


Figure 5.23: Front view of the Baird Television double projector at the Marble Arch Pavilion, London.

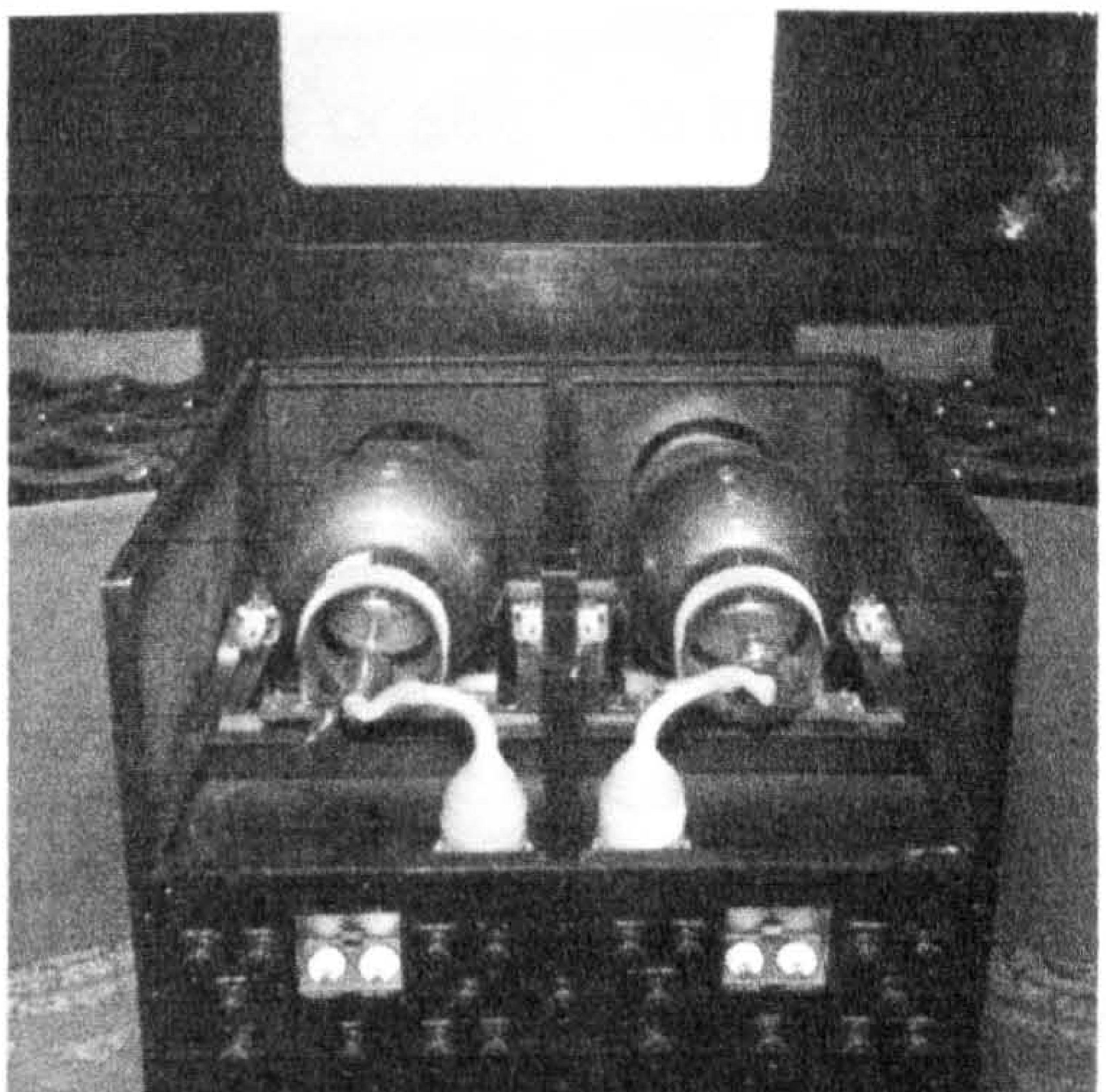


Figure 5.24: Baird twin cathode-ray tube projector at the Marble Arch Pavilion, London. (Rear view of controls and cathode-ray-tubes.)

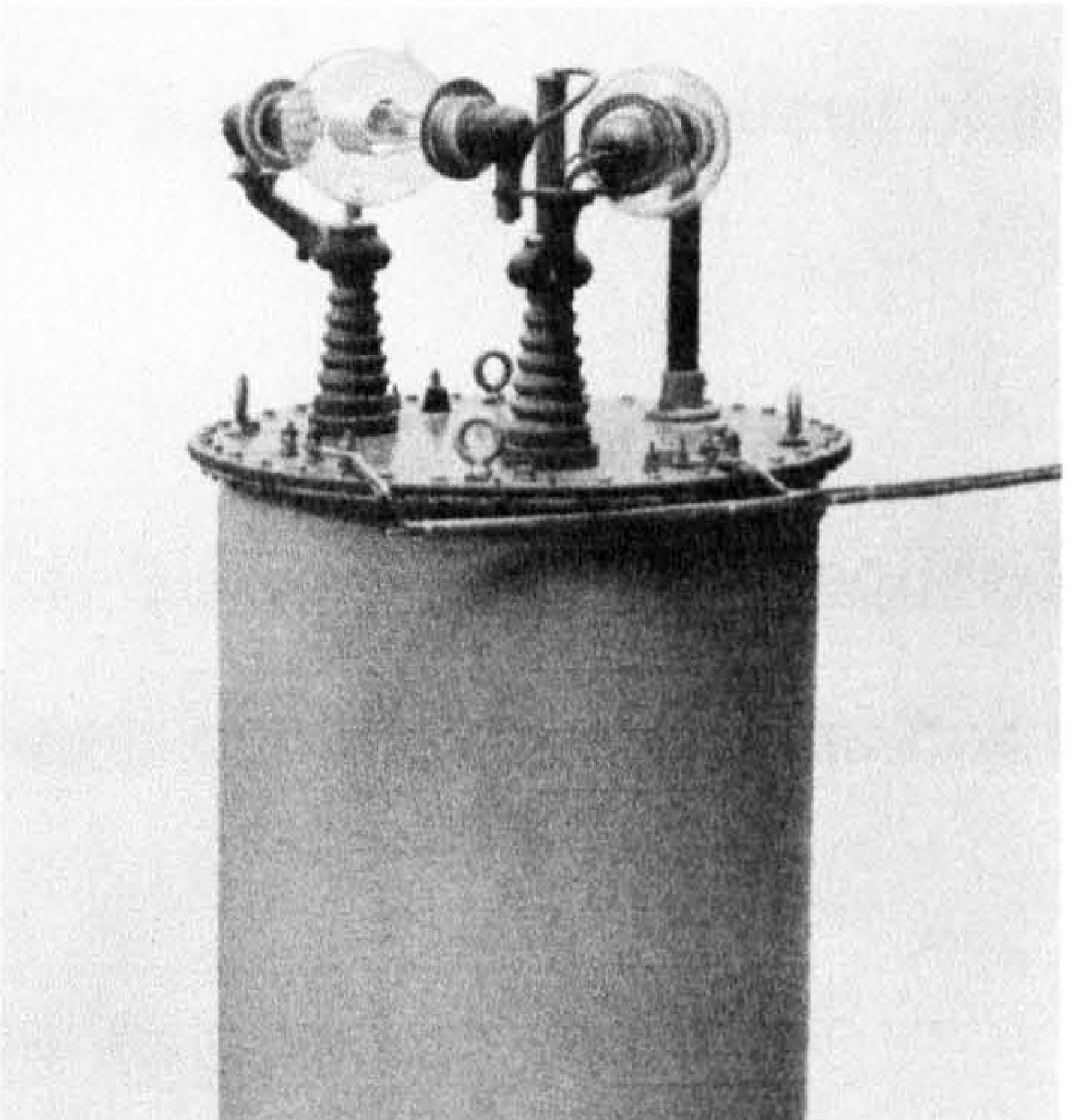


Figure 5.25: One of a pair of 60,000 volt high-tension units. These were installed in twin cubicles at the Marble Arch Pavilion, London.

consists essentially of a welded steel tank, 1.00 metre high by 0.625 metre diameter with a circular cover made of high grade insulating material."

Inside the tank and immersed in oil, the unit consisted of: the high tension transformer; two highly insulated transformers for feeding the filaments of the rectifier valves; four high voltage smoothing condensers connected in series parallel, each having a capacity of 0.05 mfd; and a centre tapped 'bleeding" resistance of 60 megohms connected across the bank of condensers. Supported in triangular formation by insulating pillars on top of the tank were the two half-wave rectifier valves. The positive output from the rectifier was taken directly from a terminal connected to the filament of one of the valves, situated at at the top of its insulated supporting pillar. The negative output was earthed, and also connected directly to the tank and to the iron cores of all of the transformers. The Baird Television circuit of the unit is shown in Figure 5.26.

In the interest of public safety the Baird specifications [62] required that each cubicle door had a special lock and key designed to interlock with the switch panels.

"1. To switch on the high tension unit the appropriate door key must be inserted in a socket in the switch panel.
2. Once the high tension unit has been switched on the key cannot be removed from the switch panel.
3. To remove the key it is necessary to switch off the H.T. unit, and to earth the positive output terminal mechanically.
4. Having removed the key from the switch, it is impossible to remove the earth connection or to switch on the H.T. unit.

5. Having inserted the key in the lock of the cubicle door and opened this door it is impossible to remove the key again until the door has been re-closed and locked."

The flexible high tension cable which connected to the twin projector was similar to that used for X-ray work, and consisted of stranded copper conductors insulated with rubber to withstand 100,000 volts, enclosed in an earthed sleeve of woven copper braid and covered with a cotton braiding.

Figure 5.27 indicates the general design and dimensions of the television screen supplied with the Baird Television projection equipment. The screen was made of canvas with a specially designed silvered surface. The Baird specifications indicated: [63]

"The particular finish which we use for this is the result of prolonged research, and we have proved that it provides the best possible compromise between intrinsic brilliance and evenness of illumination when viewed from all parts of the theatre."

Further information relating to the Baird Theatre Television Specifications can be located in Appendix 2.

The main part of the Baird industry was directed towards cathode-ray tube production and television receiver design and development. The RadiOlympia exhibition in London on 25 August 1938 gave Baird Television the opportunity to display their impressive range of television receivers. Since the Crystal Palace fire all Baird television receivers were assembled by Bush Radio.

Figure 5.26

The Circuit of the 60,000 volt

High Tension Unit

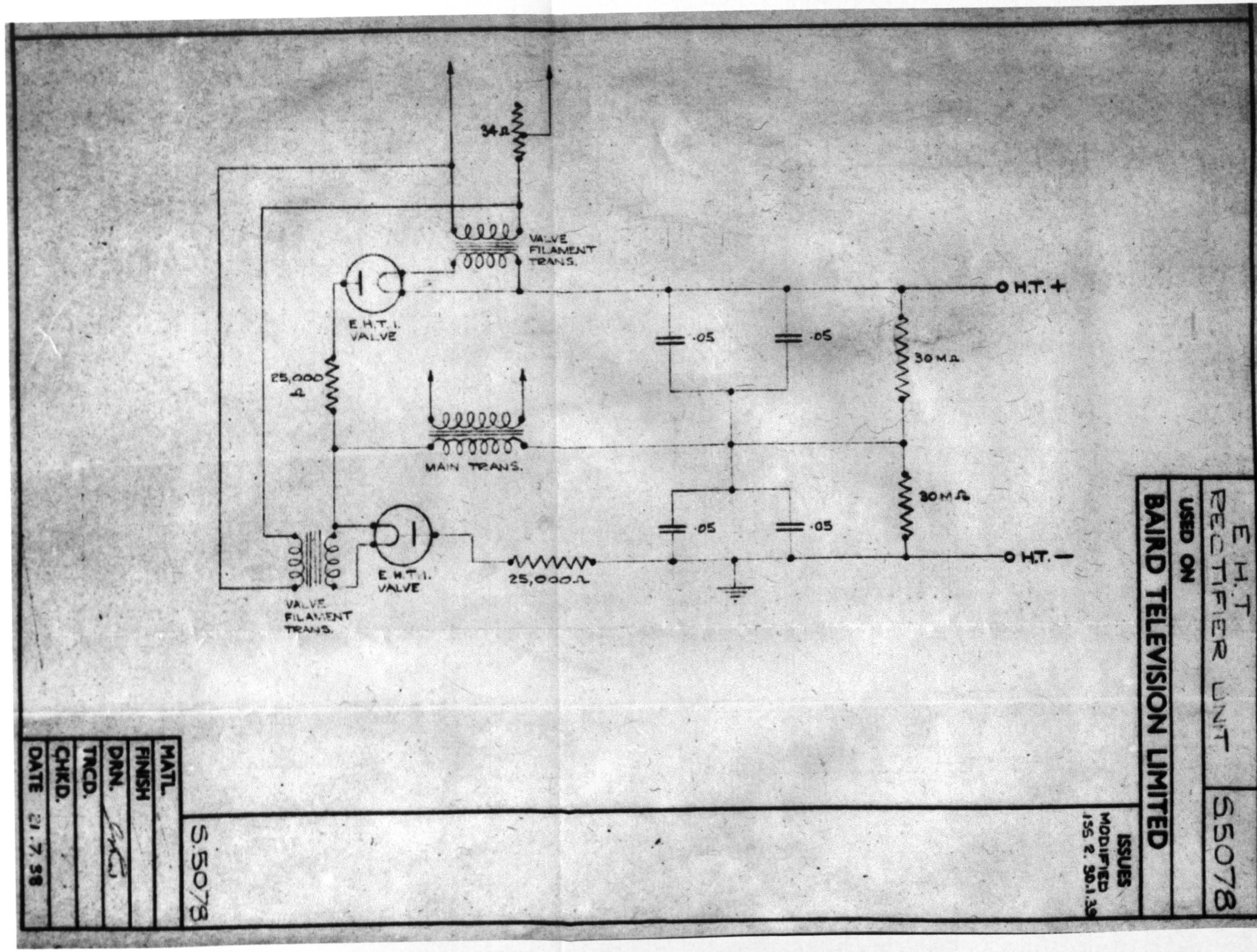


Figure 5.26: The 60,000 volt Rectifier Circuit

Figure 5.27

The Baird Theatre Television Screen

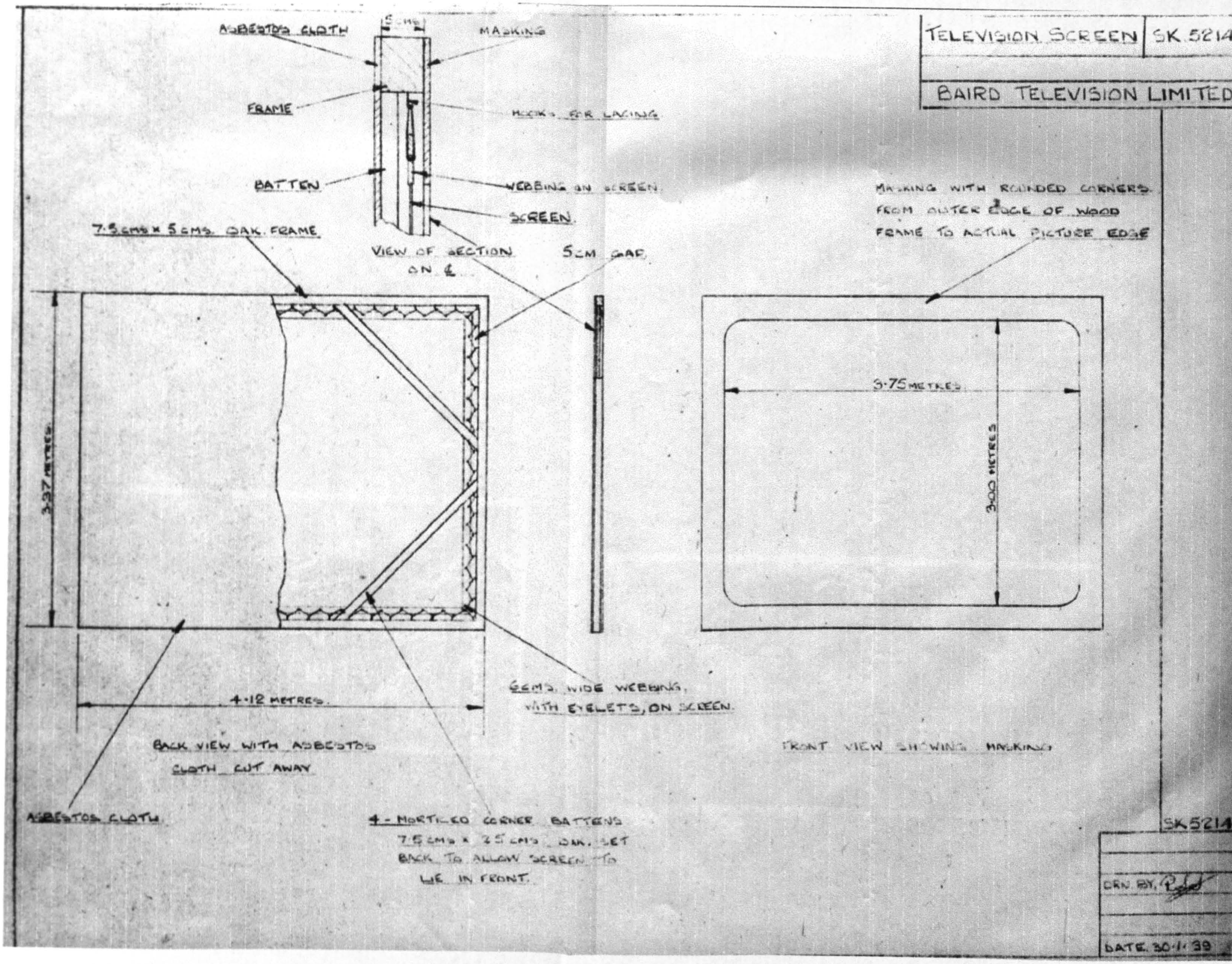


Figure 5.27: The Design and Dimensions of the Baird Theatre Television Projection Screen

Section 5.7

RadiOlympia 1938

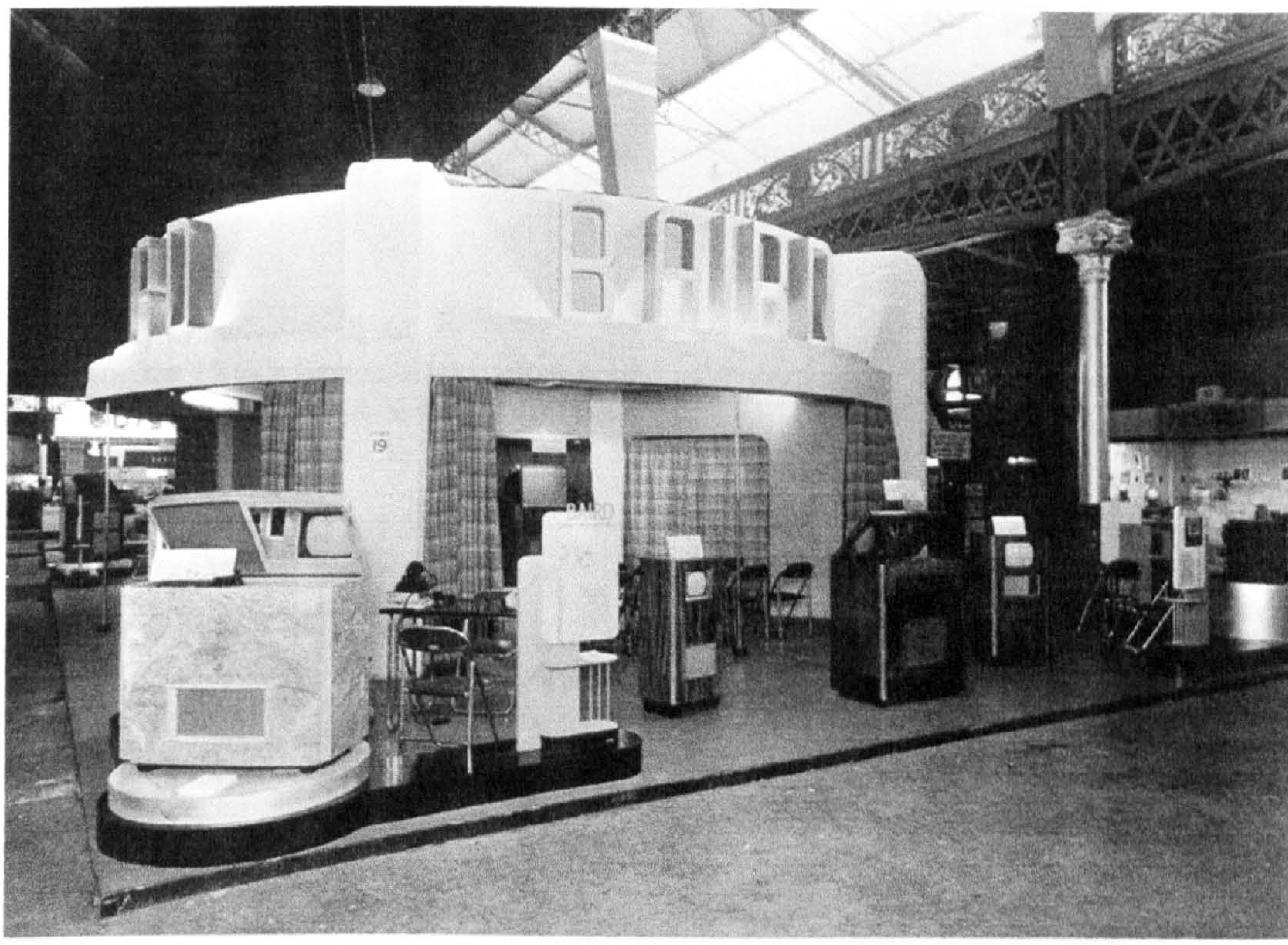


Figure 5.28: Baird Television 'Stand 19' RadiOlympia 1938

The television receivers which had been displayed on the 'Baird Stand' (Figure 5.28) from 25 August 1938 RadiOlympia exhibition were impressive and comprehensively catalogued. [64] The Baird 1938-39 catalogue is reproduced in Appendix 3. The receivers ranged from the modest 'T.20 Table Model' with its 9 inch cathovisor tube costing 35 Guineas (Figure 5. 29), to the elaborate 'T.14 Radiogram Model' (Figure 5. 30 and Figure 3.31) retailing at 120 Guineas.

Bennett-Levy described the Baird T.14: [65]

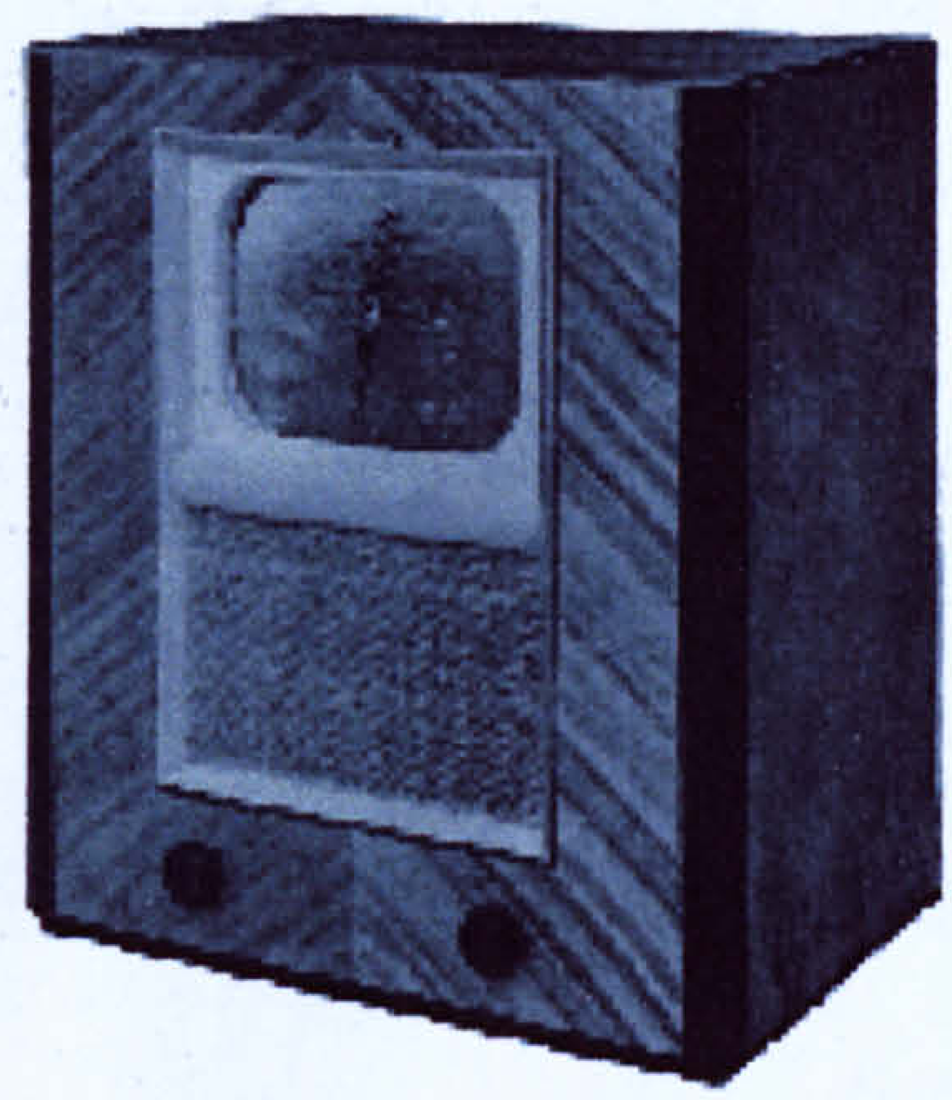
> "Screen 15 inch, Gramophone with Collaro autochanger. Bush radio and drinks cabinet, finished in oak."

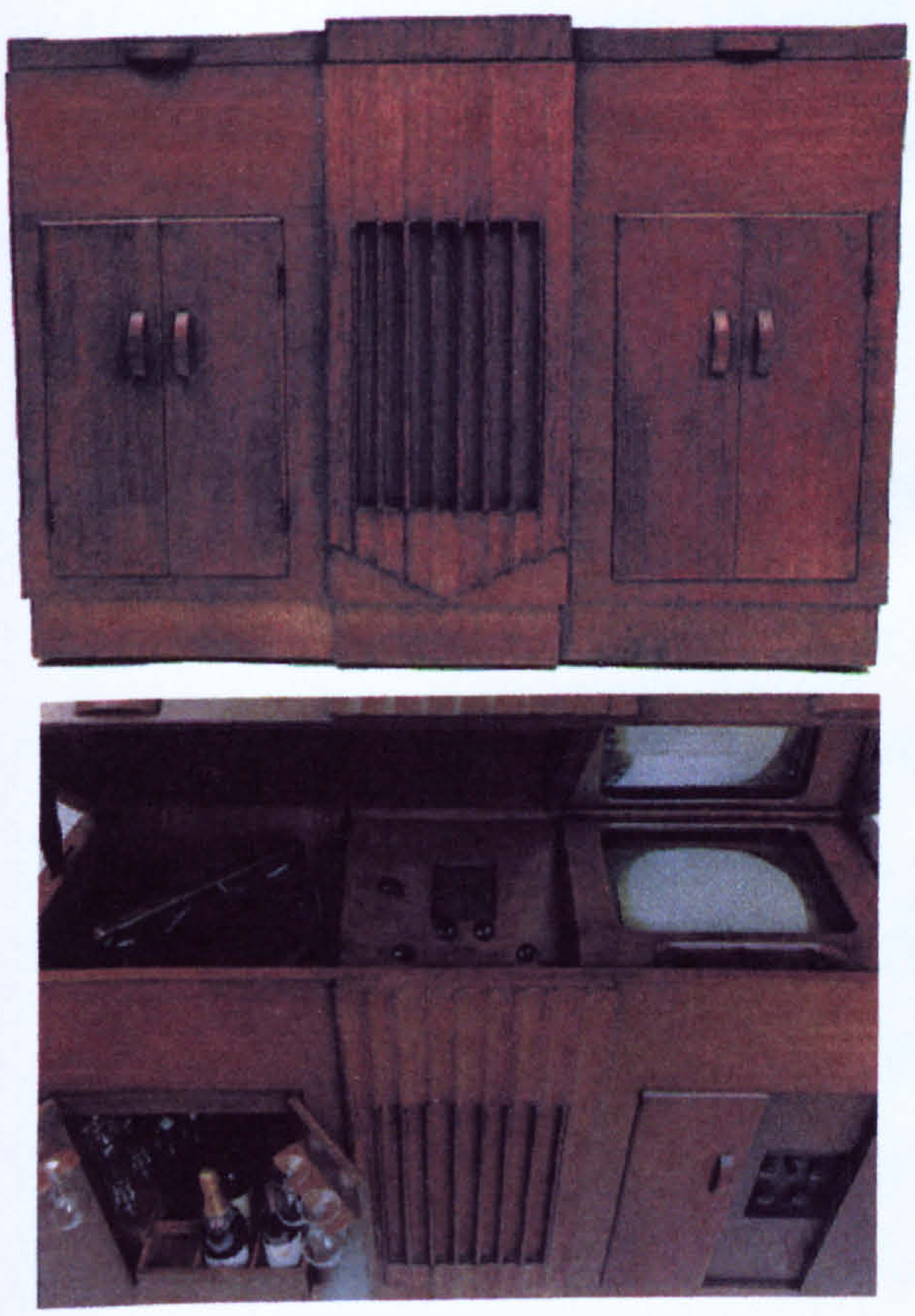
Right: Figure 5.29: T.20 Baird Table Model

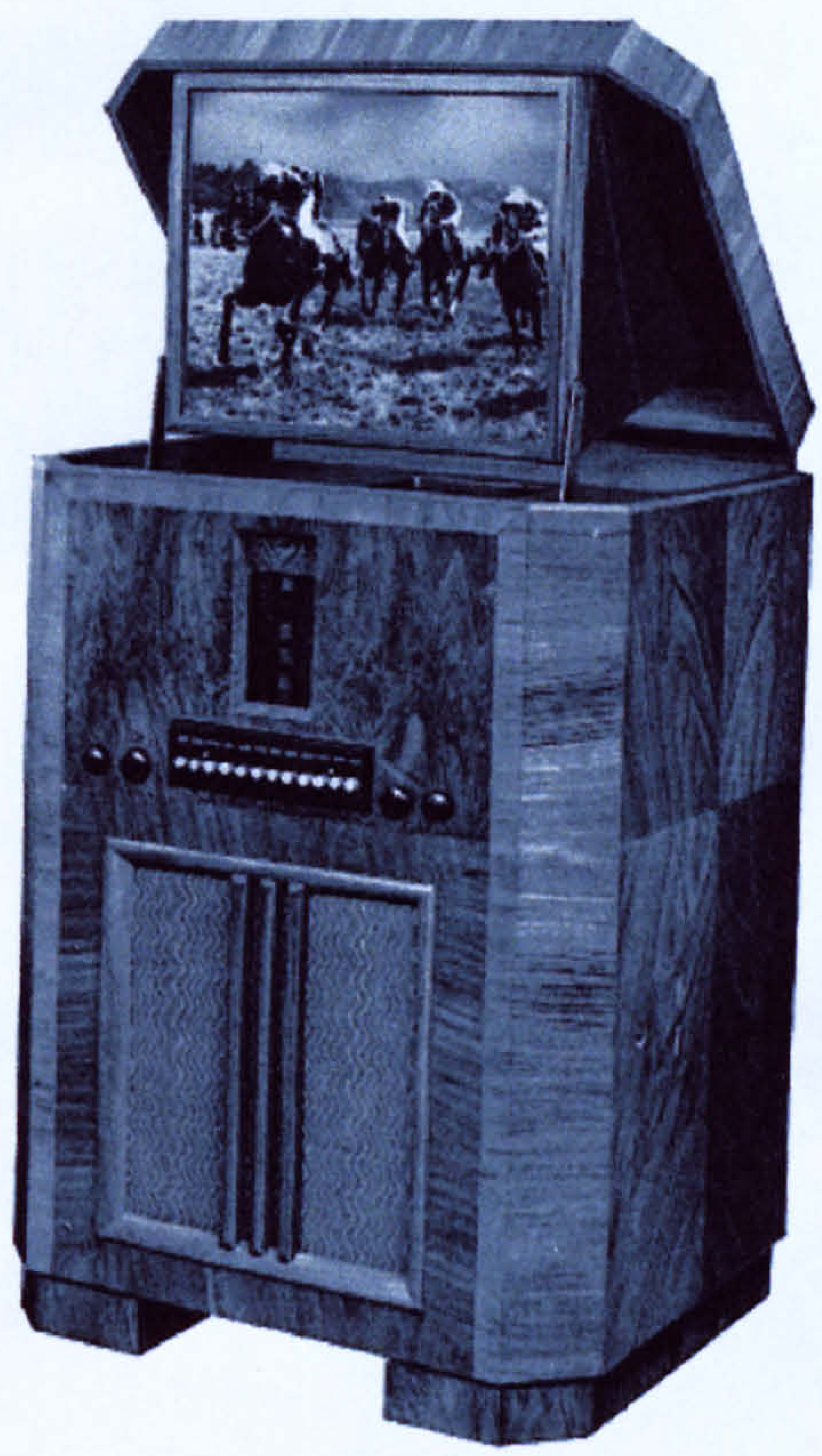
Below left: Figure 5.30: T.14
Gramophone Model with lid and cabinet doors closed.

Lower Left: Figure 5.31: T.14
Showing the 15 inch Screen, Gramophone with Collaro Autochanger, Bush radio and Cellarette.

Lower Right: Figure 5.32: T.19
Luxury Projection Model designed primarily for installation in Hotels and Clubs.







Also exhibited was the 'T.19 Luxury Projection Model.' (Figure 5.32). This was the highest priced television receiver in the Baird catalogue costing 150 Guineas. The specification [66] indicated that a Baird projection tube mounted vertically in the cabinet projected the picture through the lens which focused the picture onto a mirror set in the lid. From there the picture was thrown directly onto the rear of the viewing screen.

Although Baird Television were unique in their method of advanced cathode-ray tube projectors another system for displaying large screen television had been perfected and was shown on a neighbouring Stand at RadiOlympia.

Section 5.8

Scophony Ltd

Figure 5.33: Scophony Stand at RadiOlympia 1938

The Scophony Company displayed apparatus for theatre television at RadiOlympia in 1938. (Figure 5.33).

Abramson [67] indicated that Solomon Sagall, the founder of Scophony, had been interested in the work of the Hungarian television pioneer, Denes Von Mihaly as far back as 1929. Sagall's main interest was in novel methods of optical-mechanical television as a means of producing large screen images. According to Singleton, [68] Baird Television and Scophony had been financially linked since 1933. The Gaumont British Company had virtually owned, with the Ostrer brothers acting as bankers, both Baird Television and Scophony. Stockholders in Scophony had included: Gaumont British; Ferranti Electric; and Oscar Deutsch of the Odeon Theatre Chain.

Singleton continued: [69]

"The financial interest by Gaumont British in Scophony continued until 1936 when, on the formation of a public company they appear to have withdrawn and the cinema interest were taken over by Odeon Cinemas."

The Scophony scheme relied on a mechanical/electro-optical scanning receiver which used a light source modulated by a novel device known as the Jeffree ultrasonic light cell.

Abramson wrote: [70]

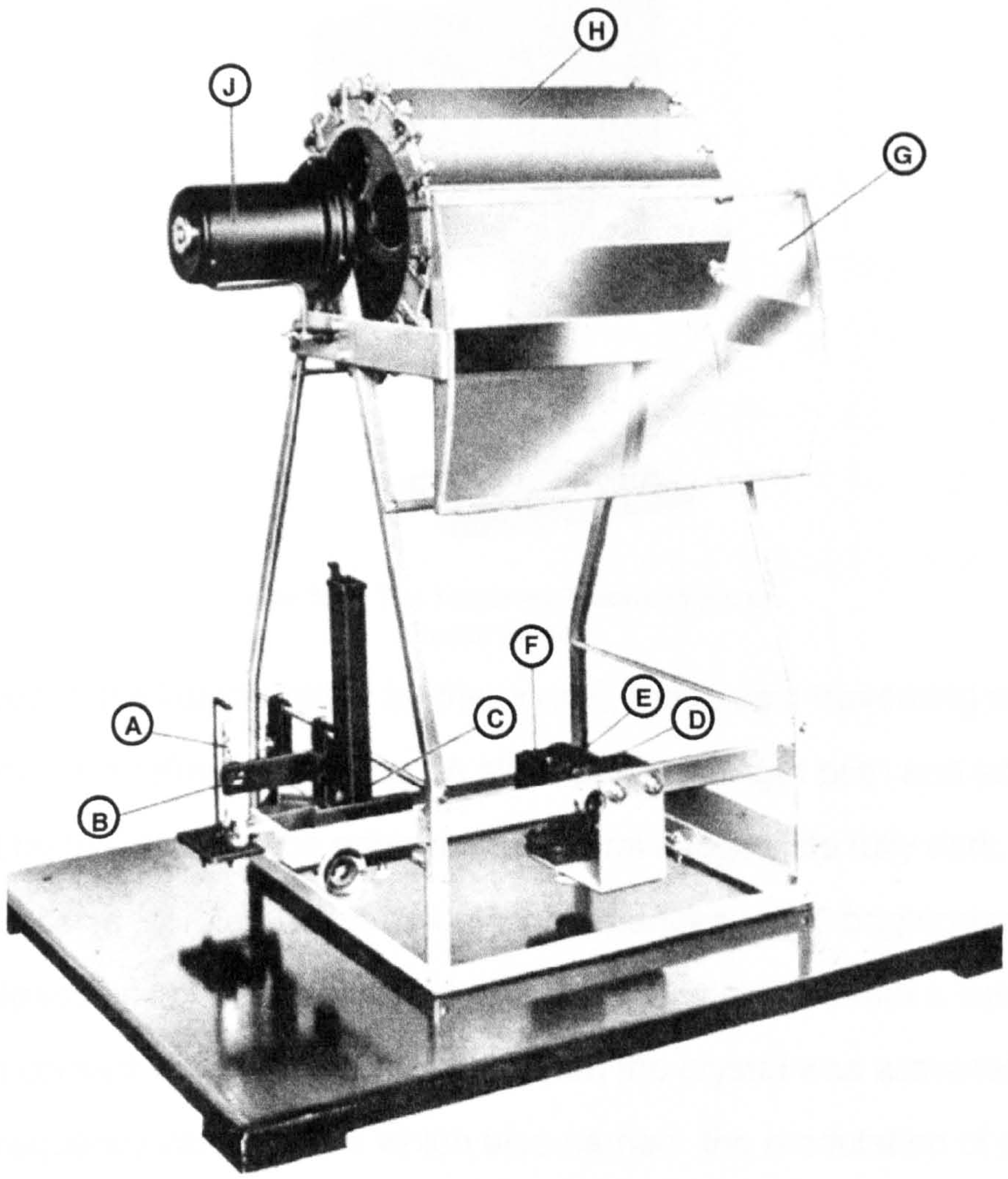
"On March 3, 1934, J. H. Jeffree of Scophony, Ltd., London, applied for a patent for an electro-optical light valve. It was comprised of a medium traversed by high frequency mechanical waves so that the medium acted as a diffraction grating upon reflected light."

Jeffree's invention [71] depended on an effect discovered in 1932 called the Debye effect, which showed that by passing light through a liquid transversed by sound waves, diffraction effects similar to those produced by diffraction gratings could be observed. Previous methods used by Scophony for light modulation had involved the Kerr cell which resulted in light loss producing low contrast pictures. Singleton wrote: [72]

"The ultrasonic cell based on the Debye-sears effect solved this problem, in that a complete line of a picture could be shown simultaneously on the screen, giving some hundred times the light than with a single spot element."

Singleton described the operation of the light cell: [73]

"The principle of the device is based on the traversing compression



A.	High pressure mercury lamp	B.	Projection lens for the horizontal plane
B.	Optical stop	G.	Projection lens for the vertical plane
C.	Light control	H.	Slow speed scanner
D.	High speed scanner	J.	Slow speed scanner motor
E.	High speed scanner motor		

Figure 5.34: The Scophony ultrasonic cell system for back-projection, 405-line home television.

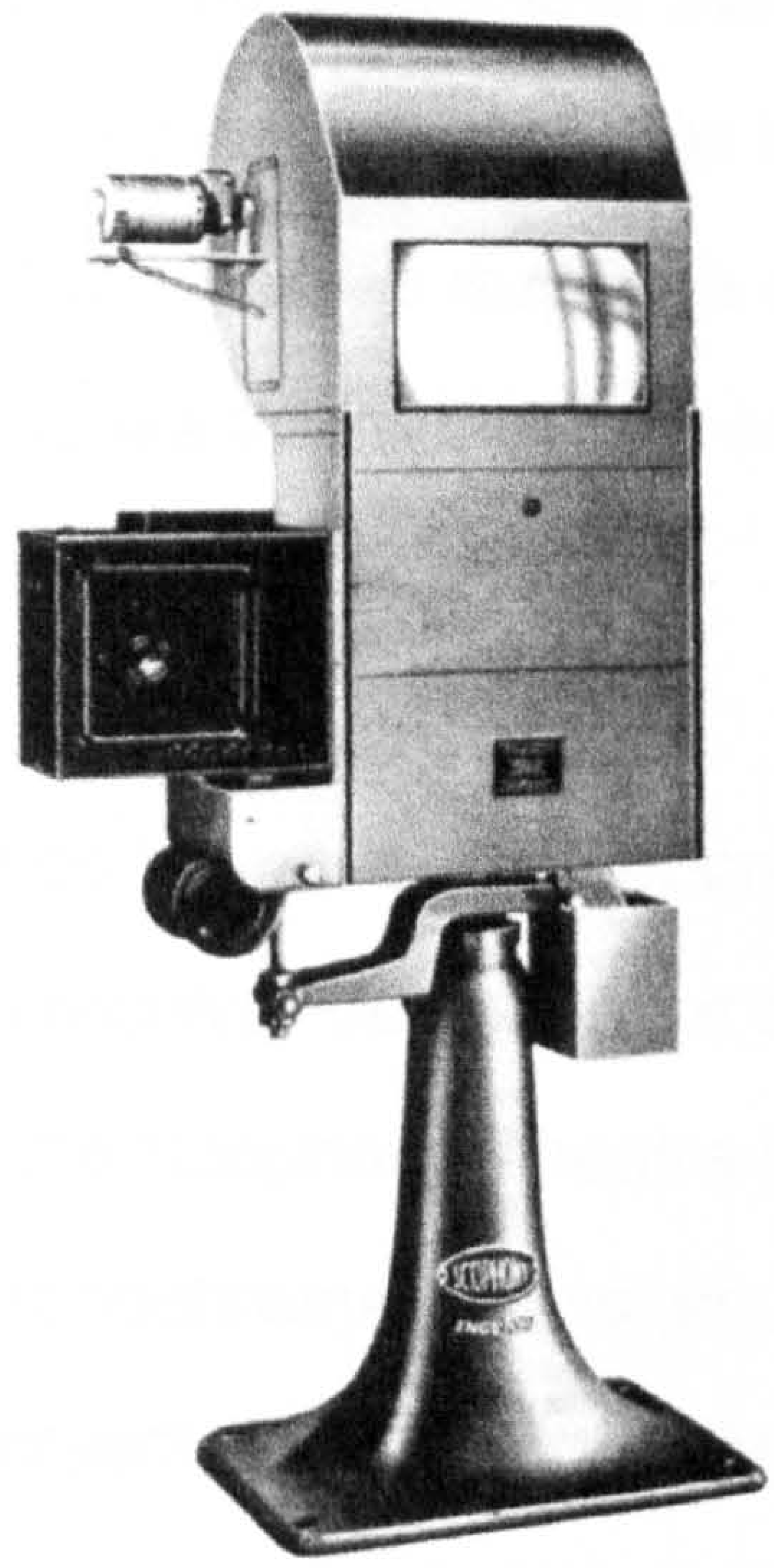


Figure 5.35: The Scophony Theatre Projector
(Junior Model)

waves in the liquid excited by the crystal, these said traversing waves acting as a refraction grating. A slit is put in the light path and adjusted so that by the interference pattern, the central image gets fully dark, which darkness according to the modulation, changes to full brightness."

The ultrasonic light cell consisted of a glass vessel filled with a liquid which was in contact with a quartz crystal. When the crystal was activated by a high frequency carrier wave which also carried the modulation of a television signal, ultrasonic sound waves representing the modulation were produced in the vessel.

Singleton indicated: [74]

"If the modulation was applied to the quartz crystal nothing was seen on the screen until the scanner, which was between the screen and the light control, was rotated at such a speed that it followed the speed of the ultrasonic waves in the liquid exactly. The modulation stored in the ultrasonic waves then became visible and stationary on the screen. A large number of scanning spots could thus be used simultaneously. In apparatus designed for 405 lines, part of a whole line of the picture (representing something like 200 elements) was used simultaneously. This meant a 200-fold increase in light"

Figure 5.34 illustrates the various component parts of a Scophony back-projection television receiver designed for domestic application. This system was also used in the Scophony Theatre Projector (Figure 5.35) to project brilliant 405 line monochrome television pictures on to a cinema screen. This led to the screening of the Boon Danahar fight in London by Scophony in the Odeon Cinemas, in direct competition with the Baird Television Company and the Gaumont Cinemas.

Section 5.9

The Boon Danahar Screening

Figure 5.36: A Crowd of 3,000 people stormed the New Monseigneur and the adjoining Marble Arch Pavilion Theatre in London

The Baird Television company equipped the Tatler and the Marble Arch Pavilion with television projectors to screen the Boon-Danahar middle lightweight title fight, which was scheduled to be broadcast by the BBC from Harringay Arena on 23 February 1939. [75] In direct competition the Scophony company equipped the theatre immediately next to the Pavilion, the New Monseigneur News Theatre, with their projection apparatus.

On the day before the screening the Daily Express reported on circumstances leading to the rights for the BBC to show the event: [76]

"..the BBC's with a yearly income of £3,000,000, gives only £300,000 to television. Of this sum only £75 is available for the rights to televise the

Boon-Danahar fight. The promoters turned the offer down."

The Daily Express reported: [77]

> "Then the big film interests (in this case Gaumont British) stepped in and said, 'We will pay the promoters a large sum if we can show the fight in our cinemas.' And the promoters said, ' Fine-in that case the BBC can televise and we won't charge them a penny.' And the BBC against their better instincts, were forced to agree."

The Evening Standard concurred: [78]

> "Triangular agreements between the BBC., promoters of events and cinema proprietors will assure sufficient money to stage spectaculars hitherto beyond the British purse."

Szegho's pipeshaped cathode-ray tubes were used to project the television images of the fight on a 12 feet by 15 feet screen to a paying audience of 1290 people at the Marble Arch Pavilion. At the New Monseigneur News Theatre, Scophony had a screen 6 feet by 5 feet which although smaller was reported [79] to be adequate for the size of hall.

With reference to the Baird equipment West later wrote: [80]

> "... we well remember a red-letter day in large-screen projection in February, 1939, when a much publicised boxing match (the Boon Danahar fight) was reproduced to an excited and enthusiastic audience who had paid up to two guineas (ten dollars at that time) for their seats in this theatre for this particular event. The audience stood up and cheered on the conclusion of this fight, which fortunately went the full distance. Not a single person asked for his money back!"

The newspapers carried the story for days after the event. Campbell Dixon of the Daily Telegraph and Morning Post reported: [81]

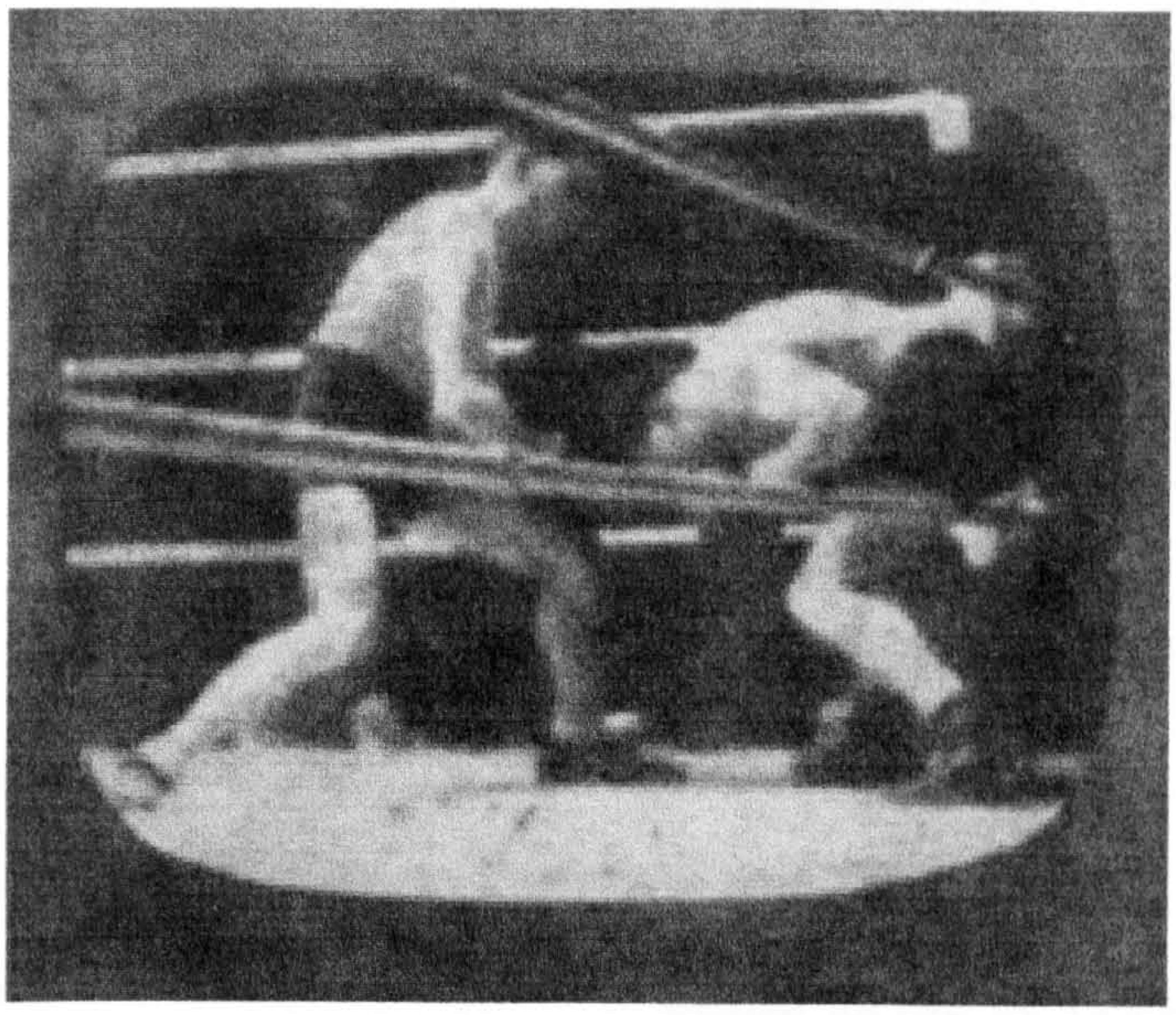


Figure 5.37: How the event looked on
Baird Television's Big Screen

"I deliberately stood at the back of the Marble Arch Pavilion, and even from there I could follow the contest blow by blow, which kept the audience of 2,000 jumping with excitement and at the end lifted them cheering to their feet."

Eric Boon the holder, defeated Arthur Danahar in their contest for the British lightweight boxing championship after the referee stopped the fight in the fourteenth round. [82]

The Television Advisory Committee, watched the large screen transmission by the Baird system at the Marble Arch Pavilion with the Director General of the BBC, F. W. Ogilvie. [83] Burns [84] indicated that the BBC had been aware of the progress and interest being shown in television for the cinema and had been concerned about the plans and pretensions of Baird Television and Scophony Ltd. As a direct result of the successful screening of the Boon and Danahar British lightweight boxing championship, Isadore Ostrer decided to order twelve sets of Theatre

Television equipment for installation in the larger London theatres.

By September 1939 the following theatres had been equipped: [85]

Marble Arch Pavilion	1290 seats
New Victoria Cinema	2564 seats
Gaumont, Haymarket	1382 seats
Gaumont, Lewisham	3047 seats
Tatler Theatre	650 seats

Scophony and the Odeon chain of cinemas also had plans. After further events at the New Monseigneur and the Odeon, Leicester Square, Oscar Deutsch announced that he was going to equip all his 60 Odeon theatres in the London area with Scophony large screen television. [86] It will become evident in the next chapter that European events overshadowed the realisation of these arrangements.

The next chapter describes the parallel electronic imaging contributions of the Baird Photoelectric Laboratories leading on to the implications of the second world war.

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CHAPTER 6

An Industry at War

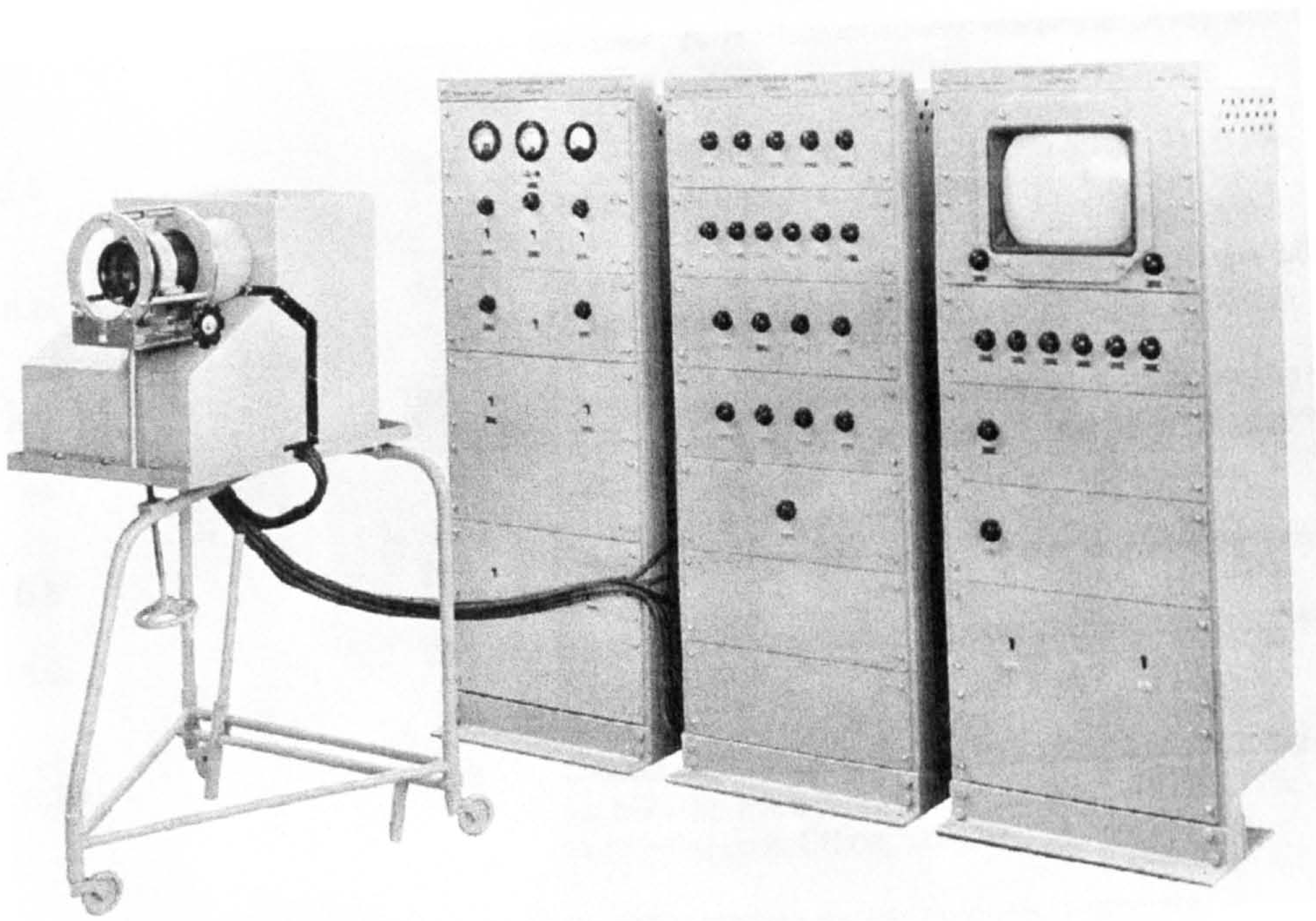

Figure 6.1: The Baird Iconoscope 1938

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Section 6.1

Photocathode Development 1938 -1939

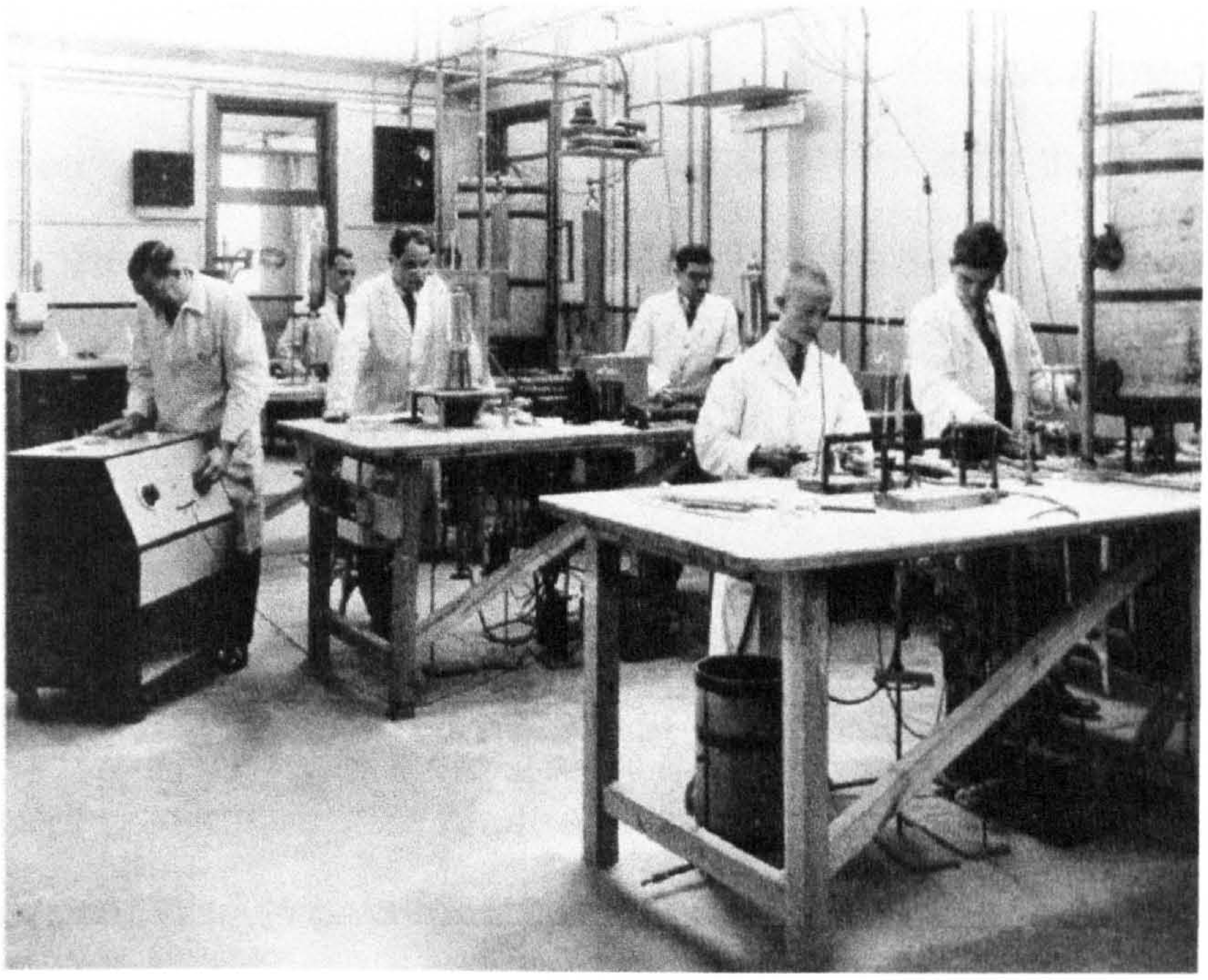


Figure 6.2: Baird Photoelectric Laboratory, Sydenham 1938.
Centre row from left to right: Dr Samson, Dr Sommer and Tomes.

Dr Sommer was hired by Baird Television on 1 January 1936 to make photomultipliers with 'S-1' silver-oxygen-caesium (Ag-O-Cs) photoemissive cathodes and mesh dynodes, (as described in section 3.5, p.149) and to work with Dr Samson on the development of the image dissector camera. [1]

Sommer [2] indicated that S-1, which was the only photocathode material available for television camera tubes during most of the nineteen thirties had its peak in the infrared.

Sommer wrote: [3]

"One interesting point about photocathodes: The S-1 a natural for night vision tubes, was really most unsuitable for TV because of its non-panchromatic response curve. Performers always had to use heavy make-up and tongues always looked like white paper."

Sommer occasionally produced two or three, 10 inch, four stage photomultipliers for J. L. Baird who used them in his private laboratory at Crescent Wood Road, Sydenham. To capture colour television images Baird required a photomultiplier tube with a spread towards the blue response for the development of colour television. [4] Initially Sommer introduced Rubidium into the process and produced Silver-Rubidium-Caesium-Oxide, (Ag-Rb-Cs-O), photosurfaces which slightly improved the blue balance but with low efficiency. Although the results were rather modest, Sommer patented the process on 26 July 1937. [5]

A major breakthrough in photoemissive surfaces was made by Sommer at Baird Television after a visit to his laboratories by a German scientist on 1 November 1938. Tomes recalled that while awaiting his return to Baird Television from the BBC, he was called upon during his days off to assist Dr Sommer in the fabrication of photocells at Baird Television. On one occasion he was asked by Lance to join Sommer for the day to meet Heimann a German scientist who was visiting from Berlin. Tomes initially thought that Heimann worked for Fernseh and wrote: [6]

"Baird Television Ltd had a reciprocal interchange of information with Fernseh AG in Germany and, no doubt, Heimann had been sent to glean information on Sommer's latest research."

However, Sommer [7] indicated that Heimann had been with the German Post Office and later (possibly before his visit to England) had started up his own Company in Weisbaden. Sommer [8] recalled that Heimann told them that Gorlich at Zeiss in Jena had invented a new cathode consisting of an

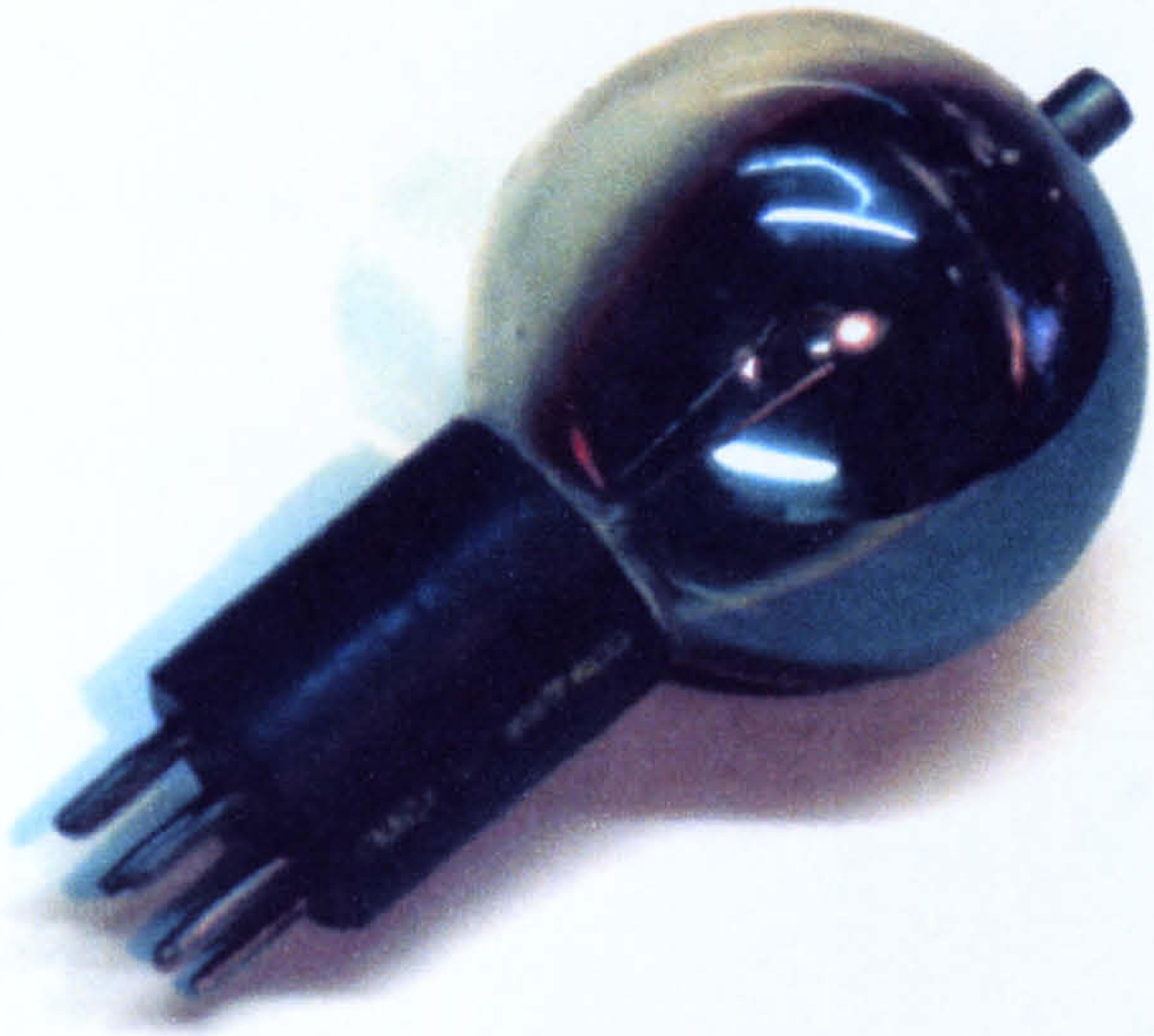


Figure 6.3: Example of a Baird caesium-antimony (Cs_3Sb) photocell developed by Dr Sommer in 1938.

alloy of caesium (Cs) and antimony (Sb) for making transparent photoelectric cathodes. Heimann showed Sommer and Tomes how thin layers of antimony could be sensitised with caesium to enable the production of a unique transparent photosurface which could be used in experimental television camera tubes. Tomes [9] indicated that prior to this the use of antimony in photocells was unknown to them.

After Heimann's visit Sommer experimented with thin films of caesium-antimony (Cs-Sb) but in the process he accidentally produced a thick layer resulting in an unexpected breakthrough. In fabricating the thick Cs-Sb layer, Sommer had discovered a photosurface which was highly photosensitive and had a marked response to daylight.

> "The knowledge brought to us that day was to cost the Germans dearly, for variations of this cathode were widely used in missiles during the war against the Nazis." [10]

Figure 6.3 is an example of a Baird caesium-antimony photocell patented by Sommer [11] and later designated S-11. Elated with this discovery, Sommer focused on working progressively through the other elements in the periodic chart to produce a photosurface with a wider response curve. Sommer recalled: [12]

> "I had two incentives to continue: Baird's requirements for his colour system and some odd requirement by Woolwich Arsenal to improve their evaluation of gun flashes."

He first tried unsuccessfully to combine the red sensitive Ag-O-Cs cathode with the blue sensitive Cs-Sb cathode.

Sommer wrote: [13]

> "Without any scientific justification I made a 'Friday Afternoon Experiment' and replaced Sb by its neighbour in the Periodic System, ie, Bi.
> By sheer luck I obtained a good panchromatic response in this first experiment and, naturally, continued with the experiments and immediately applied for a patent in G.B. and in U.S.A."

This surface comprised: caesium (Cs); silver-oxide (Ag-O); and Bismuth (Bi) and the process was patented [14] on 20 July 1939. This was the world's first panchromatic photosurface, later to be designated 'S-10'. Tomes recalled [15] that over the next few months Sommer launched into what was to become his lifelong study of photoemissive materials.

Both the Cs-Sb, S-11, and the (Bi-Ag-O-Cs) cathode,'S-10' were important patents. The S-1 cathode was replaced by the S-11 cathode in most of Baird applications including photomultipliers, (except in applications where infrared sensitivity was required). The S-10 was an outstanding achievement which produced good colour balance in black and white

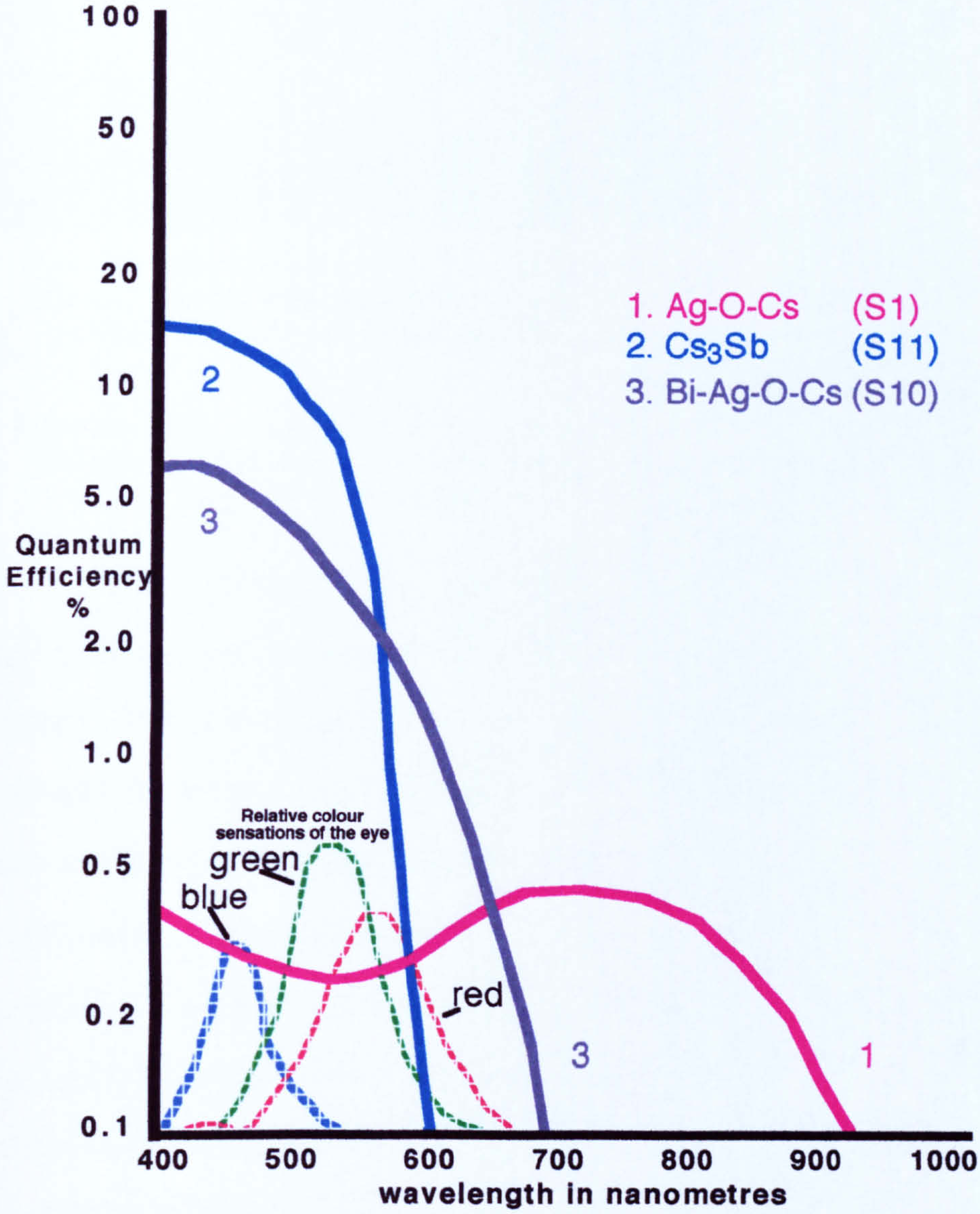


Figure 6.4: Spectral response curves of
Ag-O-Cs, Cs_3Sb, and Bi-Ag-O-Cs cathodes

television and was the only cathode available when colour television began in America in the 1950's. [16] The S-10 cathode was later used universally in the RCA image Orthicon, the standard camera tube used in commercial television after the end of the second world war. Baird Television has never been given any credit for either of these unique developments upon which the entire monochrome and colour television industry was based.

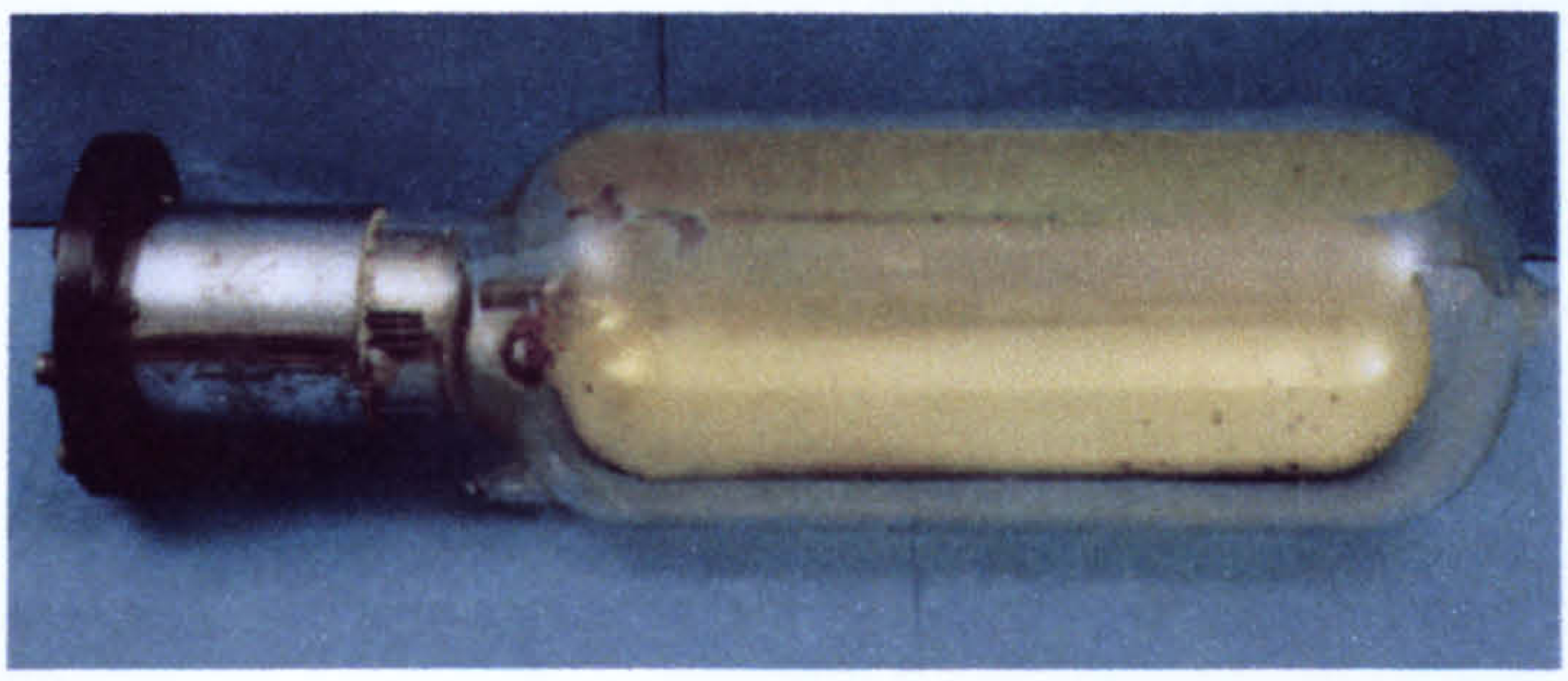


Figure 6.5: (above) An example of a Baird Multiplier Photocell Type ML with an S-1 cathode (Ag-O-Cs) Predominantly red and infrared sensitive

Figure 6.6: (right) An example of the Baird Multiplier Photocell Type MA with the S-11 cathode (Cs-Sb) Daylight-blue sensitive

In 1938, experts making silver oxide-caesiated cathodes, could expect to achieve an average of 20 microamps per lumen. Tubes were acceptable with a lower limit of 15 and the maximum was likely to be 30 microamps per lumen. With the advent of the thick film caesium-antimony cathodes, figures of between 80 and 140 microamps were possible. Tomes [17] indicated that when using the Cs-Sb cathodes, tubes with less than 20 were considered to be rejects. Figure 6.4 compares the sensitivity and colour responses of the three cathodes: S-1; S-10 and S-11. The colour sensitivity curves of the eye, superimposed on the graphs in Figure 6.4 serve only to show the relationship between (wavelength and colour) and photosurface material characteristic.

Prior to the discovery of the S-11 caesium-antimony cathode, Baird photomultipliers type ML and MS were fabricated with S-1 cathodes. (Figure 6.5).

Tomes wrote: [18]

"27 December 1938: Back at work, I noted that Sommer had made a

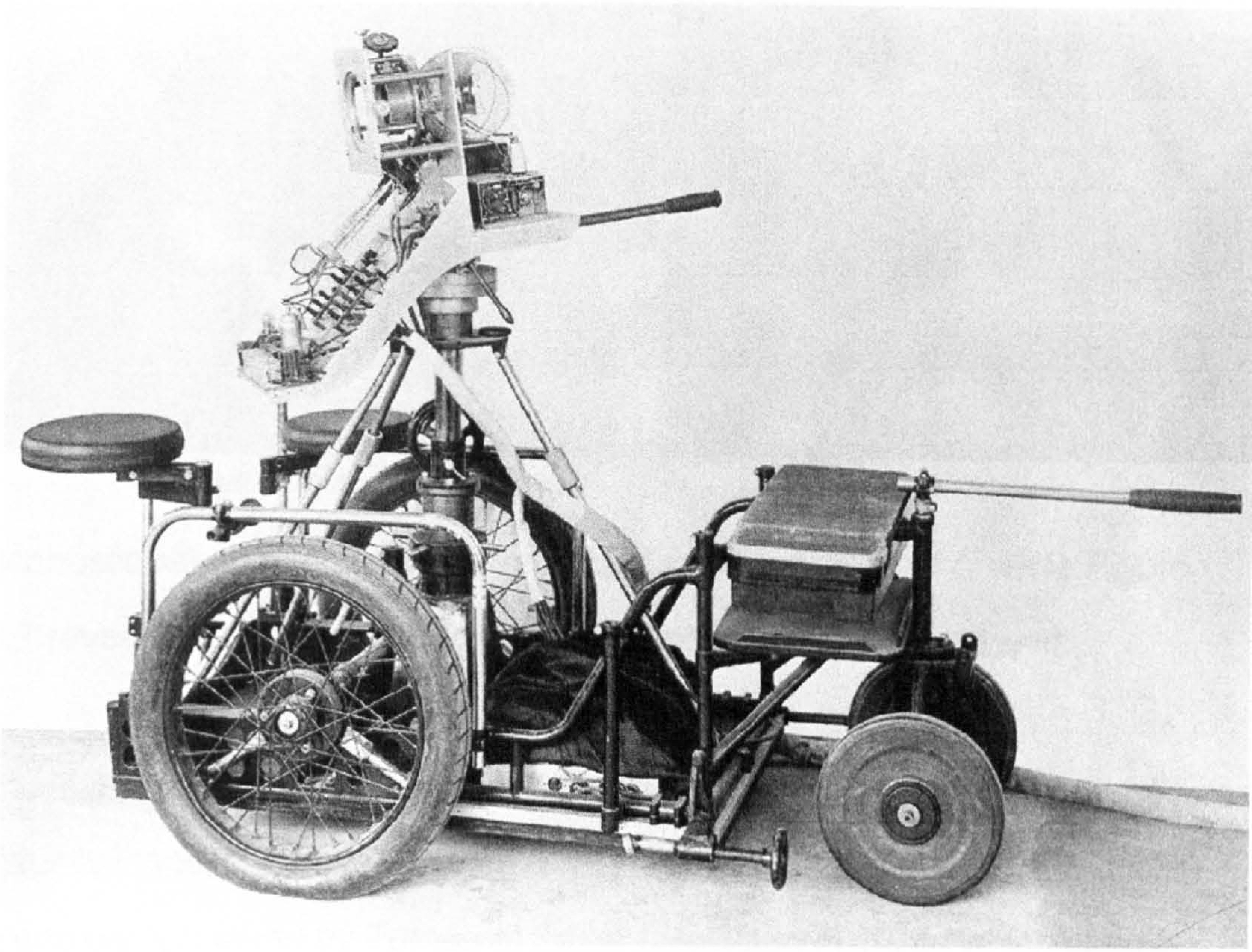


Figure 6.7: Portable storage camera with the cover removed to reveal the Baird iconoscope tub

stable multiplier using his improved caesium-antimony technique."

Figure 6.6 shows an example of a daylight, or blue sensitive type MA Photomultiplier Cell.

Tomes recorded in his diary: [19]

"29 December 1938: Baird's all day making MA cell - quite good."

Dr Samson greatly enhanced the sensitivity of the Baird Electron camera using Sommer's photosurfaces but the results were never good enough to compete with the iconoscopes storage effect. Capt West suggested that Samson develop iconoscopes and Tomes was asked to make one tube every day from June 1939. [20] Figure 6.1, at the beginning of this section, shows the Baird general purpose storage camera

Figure 6.8: Baird iconoscope tube

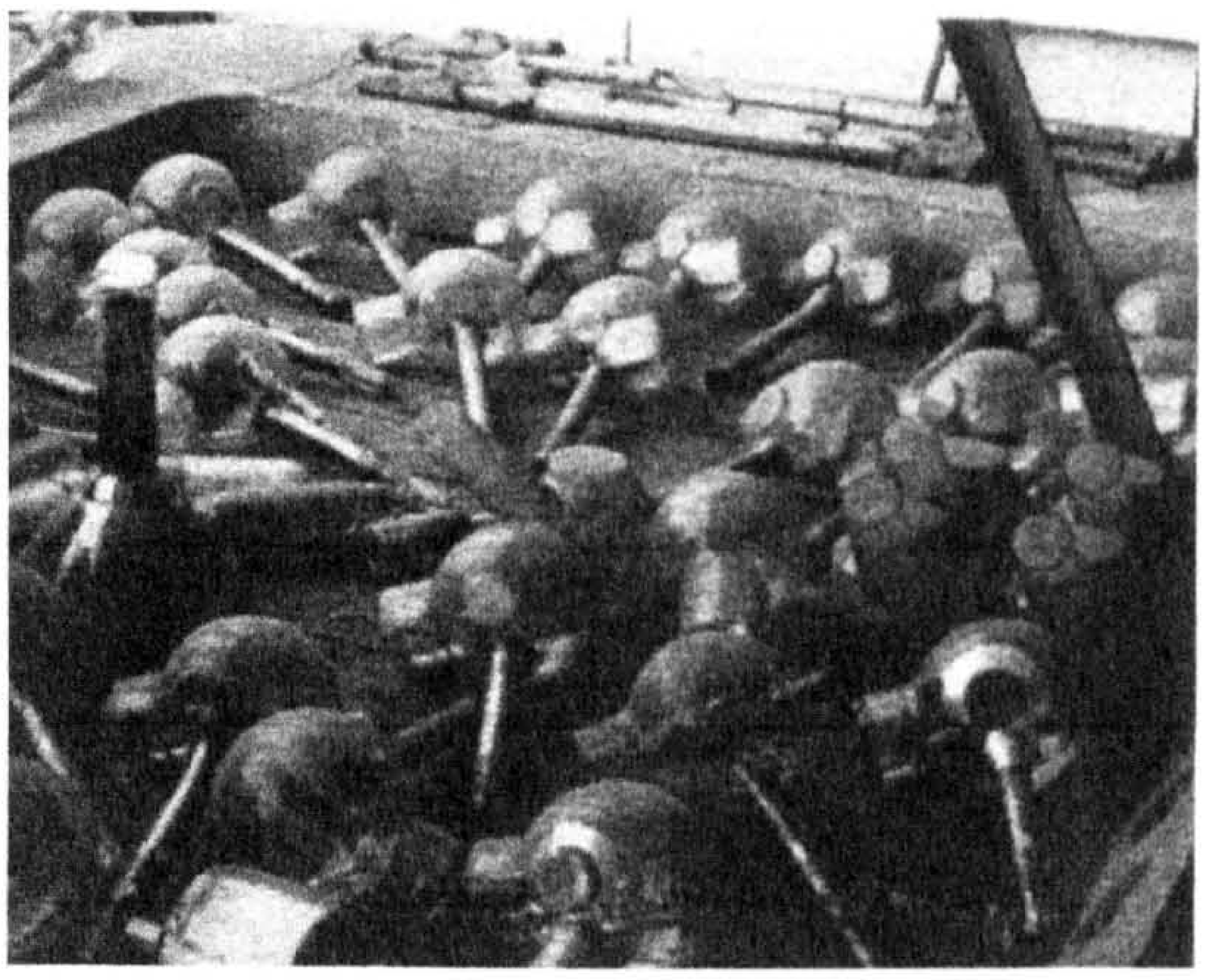


Figure 6.9: Baird iconoscope camera tubes

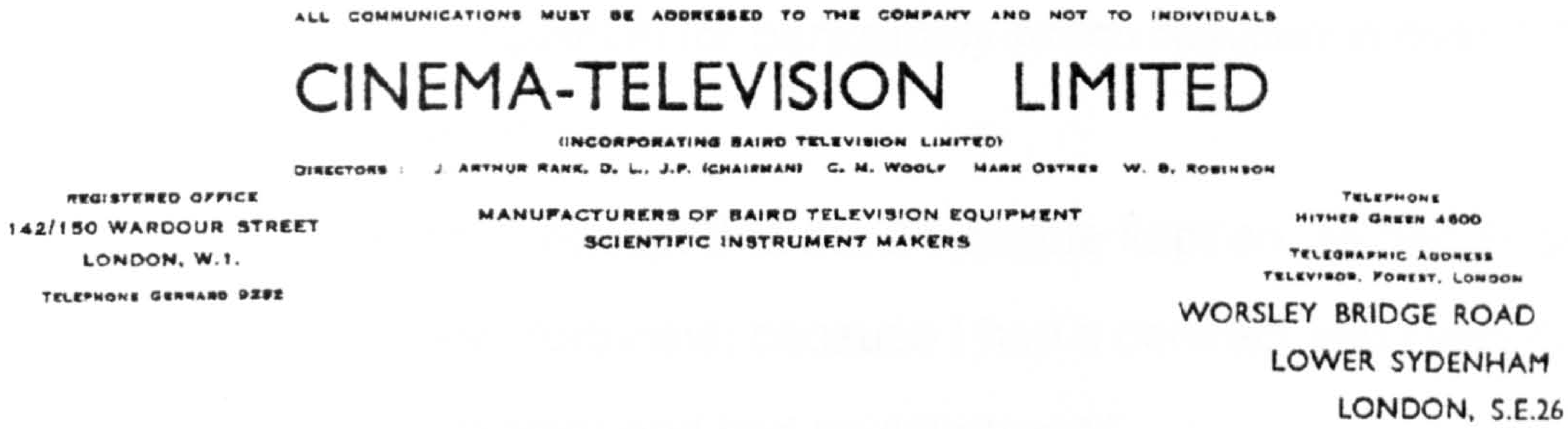
(iconoscope) on a 'dolly' with associated control equipment, while Figure 6.7 reveals the iconoscope tube in yet another Baird camera unit.

R. V. Oakes, Samson's laboratory assistant, (Figure 6.8) can be seen visually inspecting one of the Baird iconoscope tubes in 1939. Figure 6.9 is a photograph taken by Tomes at Baird Television in 1939, which clearly shows a large quantity of completed Baird camera tubes on the factory floor. It must be concluded that Sommer's discovery of the antimony and bismuth surfaces enabled Baird Television to take the lead in producing iconoscopes, image dissectors and multipliers with the highest available sensitivity and spectral advantages gained from the use of panchromatic photosurfaces.

Unfortunately European events precluded any useful profit which the Baird Company could have realised from these unique advantages.

Section 6.2

Cinema Television: Incorporating Baird Television


ALL COMMUNICATIONS MUST BE ADDRESSED TO THE COMPANY AND NOT TO INDIVIDUALS

CINEMA-TELEVISION LIMITED

(INCORPORATING BAIRD TELEVISION LIMITED)

DIRECTORS: J. ARTHUR RANK, D. L., J.P. (CHAIRMAN) C. M. WOOLF MARK OSTRER W. B. ROBINSON

REGISTERED OFFICE
142/150 WARDOUR STREET
LONDON, W.1.
TELEPHONE GERRARD 9282

MANUFACTURERS OF BAIRD TELEVISION EQUIPMENT
SCIENTIFIC INSTRUMENT MAKERS

TELEPHONE
HITHER GREEN 4600
TELEGRAPHIC ADDRESS
TELEVISOR, FOREST, LONDON

WORSLEY BRIDGE ROAD
LOWER SYDENHAM
LONDON, S.E.26

Figure 6.10: The name of Baird Television remained on Cinema Television letterheads throughout the war years

When Germany marched into Poland on 1 September 1939 and war was imminent the television service from the BBC at Alexandra Palace became one of the first British casualties.

Tomes recorded in his diary: [21]

> "1 September 1939: Hitler invades Poland - War is inevitable - Gas masks distributed to everyone - Blackout tests - Television closed down for good - Wireless stations all changed their wavelengths...."

On Sunday 3 September Neville Chamberlain declared war on Germany.

Tomes recalled: [22]

> "The one thing that was furthest from my mind was whether Bairds would continue in business. I was confident that a firm with such a concentration of high technology was bound to be valuable in a war."

The plans which West and Ostrer had made for theatre television dissolved with the cessation of television.

West wrote: [23]

> "The incidence of war prevented the equipping of other theatres and thus the plan to have selected television programs presented at twelve

London theatres to a total audience capacity of approximately 22,000 was never realised."

The declaration of war and the closing down of television had a devastating effect on the company. Tomes recalled that on 13 November 1939 Baird Television Ltd filed for a petition for bankruptcy which resulted in over 120 employees being fired: [24]

"Nothing changed at all except that the 34 people kept on, all had 10 per cent salary cuts. I was fortunate; because I had a contract and I was due to get a rise. I was exempt and had no salary cut."

In his autobiographical notes J. L. Baird reflected on the difficult financial position: [25]

"Gaumont British held some £300,000 in bonds in the company, the total capital being £1,080,000. Shortly after war was declared, these bond holders, under the terms of their bond, installed receivers and ultimately put the company into liquidation, acquiring the company's assets in payment for their bonds. These assets were taken over by Cinema Television a company controlled and owned by Gaumont British. In the meantime, with my contract terminating with the appointment of a receiver, I became a free agent."

Baird Television became 'Cinema Television' and continued with West as technical director, the main difference being that they had become totally owned by the cinema industry. John Logie Baird had originally argued for the formation of Cinema Television while, ironically, Gaumont British manipulated to release the other company stockholders, including Baird. It is interesting to note that the name 'Baird' was used on Cinema Television letterheads (Figure 6.10) dated 1943.

The reason for Gaumont's interest was deeper than just taking possession of Baird's electronic imaging industry and waiting for more peaceful times. The reason was that the United States of America, which had the world's largest film industry, was not at war and Ostrer's entertained plans to promote theatre television in Hollywood. However, to do this efficiently Gaumont British had to set up a facility within the existing Baird Television's headquarters in New York.

Section 6.3

Baird Television Incorporated USA

Szegho [26] recalled that Isidore Ostrer had plans to interest the American motion picture industry in the Baird large-screen equipment. In 1938, [27] demonstration equipment and a crew led by Baird director (and high ranking Gaumont British officer), Cremieux-Javal, were sent to New York. Among the crew were two Baird engineers, Edward Truefitt who was responsible for the large screen equipment receiver and Richard Tingley a specialist on pipeshaped tube deflection circuits. It remained Szegho's task in London to make good projection tubes and ship them to the United States.

Szegho wrote: [28]

> "With commercial television finished for the duration, one had to urgently think about utilisation of our talents for the war effort. I started a project on a microwave amplifier tube which we called the 'tank tube', in which a high current electron beam passes though a gap on which the microwave frequency is impressed."

Szegho who worked on the project with a colleague, Maxwell Scott, selected this approach as it resembled a cathode-ray tube enabling his electron optical knowledge to be put to good use. The amplifier, however, could only supply a modest output of about 50 Watts at 500 megahertz.

Szegho [29] indicated that he demonstrated a very long afterglow tube to Watson-Watt.

"I pulsed-on a raster on a long afterglow green ZnS *(Zinc-Sulphide)*

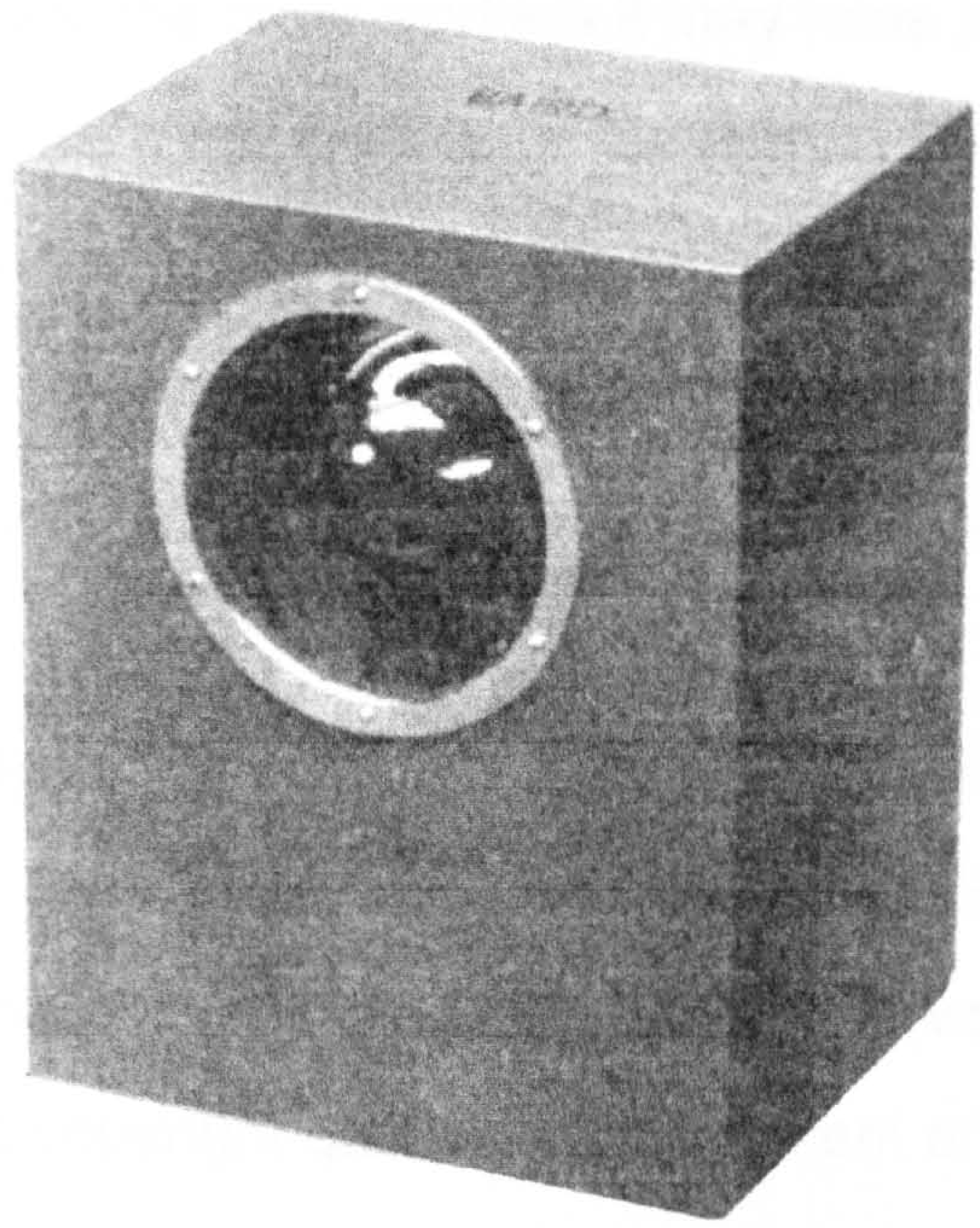


Figure 6.11: The Baird Photoelectric Incendiary Detecto.

(Authors italics) screen once every second observing the afterglow only by obscuring the initial flash by mechanical means. He spent a long time in my laboratory."

Various ideas were suggested to support the war effort including the Baird Photoelectric Incendiary Detector (Figure 6.11) of which Szegho wrote: [30]

"A device I developed was a photoelectric incendiary bomb detector. The idea was to detect the light of the bomb before it was too late and give an early alarm when an incendiary bomb became lodged in the loft of a warehouse, for example, which caused the terrible conflagrations in the city and the docksides of London."

Dr Samson and Dr Sommer who were both German nationals were segregated from the rest of the factory by Capt West who was concerned that if they remained with the other workers it may have jeopardised future possibilities of Government war contracts. Szegho, a Hungarian national and although not an 'enemy' alien was separated from Sommer and Samson and from the other main workers in the factory. [31] This unfortunate situation only served to inspire Szegho's initiative.

Szegho wrote: [32]

> "America was still deep in peace. The technical news from our unit in New York was very good. They had given innumerable very successful large-screen demonstrations at 1600 Broadway, However Javal returned without a deal. The copyright question, the problem of unions and exhibitors, the question of the transmission of sporting events with only NBC broadcasting on a limited scale, were even more complicated in America than they were in England."

Szegho saw a means of alleviating his uncomfortable isolation. He wrote to Truefitt in New York and asked him to talk with Ostrer. Szegho explained that shipping good theatre tubes was becoming increasingly more difficult with U-boat infested seas. The British Treasury were looking for cash payments in dollars for the tubes despite more arriving damaged than not. Szegho presented the case that if he were to set up a fabrication plant in New York the endeavour would benefit. [33]

Szegho wrote:

> "Ostrer requested that I be sent to New York together with some basic manufacturing equipment. To obtain an exit permit during the war for an alien who moreover was a physicist, was a difficult, long drawn out affair. Dozens of cables were exchanged between Ostrer and Capt West, who pushed the matter in various ministries diligently."

On 16 October 1940 Szegho finally arrived in New York with a view to establishing a cathode-ray tube facility to produce pipeshaped tubes for the Hollywood demonstrations. Szegho's American 'visitor's visa' which lasted for a limited duration was eventually converted to an immigration visa. Tingley returned to England to take part in the war effort leaving Szegho virtually alone in New York. Theatre Television was attracting its share of bad press and a strong resistance to the concept was growing from within the film industry:

Hollywood Reporter. 21 April 1939.

"Films Fight Television Threat: US Radio and Television in Bid for Industry Tieup; Battle for Supremacy Looms as British Invasion Compels Coordination of Radio." [34]

Motion Picture Herald. 22 April 1939.

"Films on First Fair Telecasts; FCC Urges Definite Standards." [35]

Motion Picture Herald. 6 May 1939.

"GB Invades US Television Field; Has Plans for Theatre Programs." [36]

World Telegram. 20 May 1939.

"Hollywood Keeps a Wary Eye on Television." [37]

Plans to establish a facility in New York floundered and in 1942 Ostrer sold the entire Gaumont British empire to J. Arthur Rank. The American Baird Company was sold to E. N. Rauland and a contract was drawn up to establish a reciprocal exchange of knowledge with Cinema Television (Incorporating Baird Television). Szegho was hired by the Rauland Corporation to establish cathode-ray tube research at their Chicago factory.

One of the best kept secrets of the second world war was the P7 long after-glow radar receiver tube. It was so secret that when the US Government tendered for potential contractors to manufacture the tubes they were not prepared to reveal the specifications. [38] Rauland left the problem with Szegho, who realised that there must be some special concept involved in the P7's fluorescent screen. He was aware that no known fluorescent material could produce the long after-glow effect exhibited on the screen of this cathode-ray tube.

Szegho wrote: [39]

> "From the small bits of information which the Services could relate regarding the performance requirements of these tubes, I succeeded in the same year in making a number of these secret tubes at Rauland, which were submitted for tests to the Signal Laboratory at Camp Evans."

Rauland and Szegho astonished the military by unveiling a tube that was a duplicate of their top secret P7 radar tube. Rauland received substantial orders for the P7 which, when the war was over became the basis for his entry into the television business. [40]

Keller described the P7 process: [41]

> P7 is a particularly interesting phosphor that was developed by the British early in World War II for radar indicators. It consists of two layers of phosphors in what is known as a cascade screen. The phosphor that is deposited directly on the glass tube face is a long persistence, yellow-green phosphor. Since this phosphor has longer persistence when excited by ultraviolet light than under electron beam bombardment, a second layer of near ultraviolet emitting phosphor is deposited on the first phosphor so that it is the phosphor struck by the electron beam. The near ultra violet light emitted then excites the longer decaying phosphor

closest to the viewer. Some blue light is emitted by the near ultraviolet phosphor."

The next section returns attention to Cinema Television in England and describes important developments in Baird telecine equipment.

Section 6.4

The Baird Telecine

The Baird telecine was used for televising films during the 1936/1937 trials between Marconi-EMI and Baird Television. As previously stated in Chapter 4, (Section 4.1. p.168) it provided a better quality of television image from film than the emitron. Initially a precision Nipkow disc had been used as the scanner but this was phased out by developments of the cathode-ray tube flying-spot scanner at Baird Television. This project, which was carried into Cinema Television Ltd, continued after the war and made an important contribution to British television.

Nuttall, the principal designer of the electronically scanned Baird telecine, indicated [42] that in the early days of mechanical scanning, (up to 1936), film was perhaps the only reliable medium for producing a television picture. This situation changed with the development of electronic cameras and attention was moved to the novelty of instantaneous television.
A problem arose, however, when films were to be shown.
Nuttall wrote: [43]

> "When film transmission was required it was effected by combining a conventional film projector and a television camera of the studio type, with little modification to either. The results were naturally of poor quality, and it soon became obvious that if films were to be used in television they would require better treatment than was possible with such improvised equipment."

Baird Television researched various possibilities and in 1938 produced an experimental film scanner for continuously moving film using a Farnsworth image dissector. Nuttall [44] indicated that although the machine was experimental and never put into service it was a valuable development showing that good quality images could be obtained from film. Work on this system continued until early September 1939 and was stopped for the duration of the second world war.

Before the outbreak of war the BBC first adopted the intermittent film projector with a synchronising shutter which focused complete film frames on to the mosaic of an iconoscope camera tube. [45] This was superseded at the BBC by the Mechau continuous film projector which employed a mirror drum using cam operated mirrors to neutralise the movement of the film during the frame exposure period. The Mechau transmitter was in operation at Alexandra Palace up to the cessation of the BBC Television service on 1 September 1939.

Holman and Lucas wrote: [46]

> "It was realised that a new approach to the problem was necessary, and this was found in the continuous-motion flying-spot system."

Nuttall [47] indicated that work was resumed again on Baird film transmitters in 1946 and a new machine founded on the flying-spot principle, was completed in 1947.

Nuttall wrote: [48]

> "A duplicate of this machine was shown publicly for the first time at the British industries Fair in 1948. In May 1949 the machine was installed at the BBC television station at Alexandra Palace, where it operated for eighteen months on regular service."

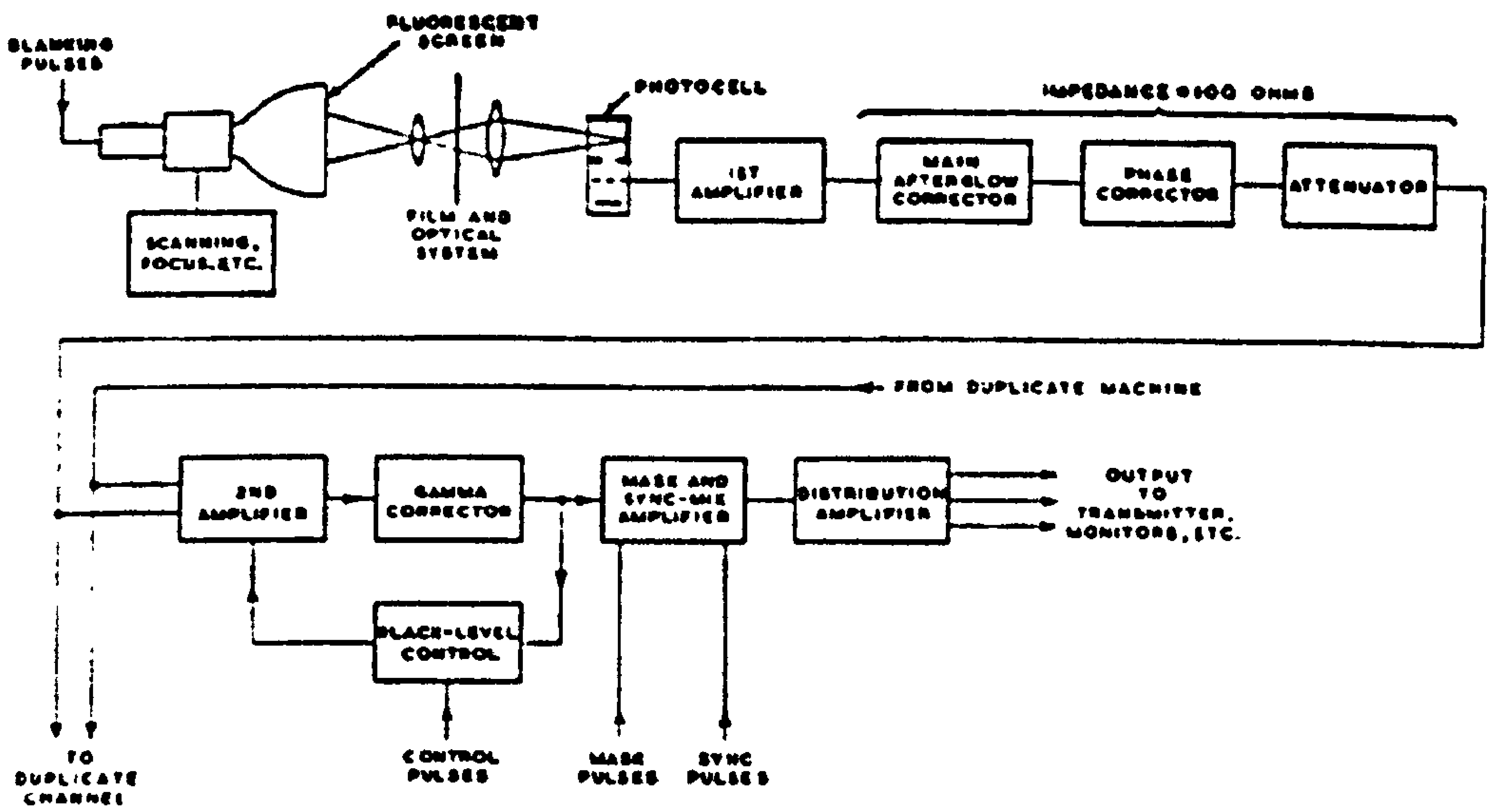


Figure 6.12: Baird Television's Flying-Spot Telecine vision chain

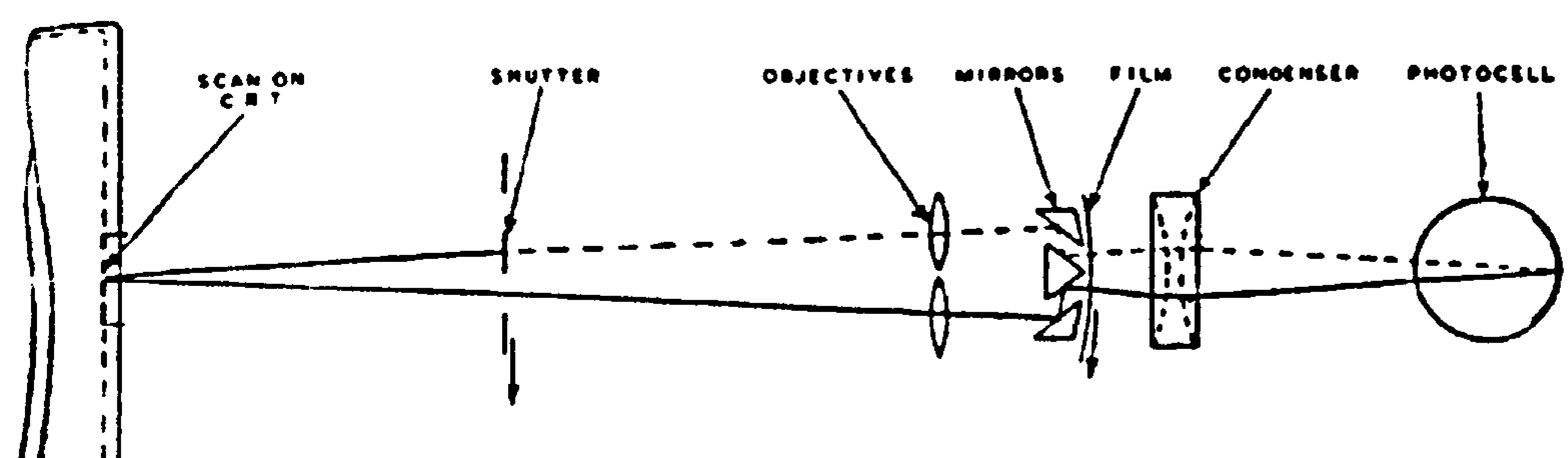


Figure 6.13: Diagram showing the Baird moving shutter
in the continuous-motion flying-spot scanner

On the basis of this success, two new machines were commissioned to be designed and built expressly for BBC requirements, but which were electrically the same as the 1947 flying-spot prototype. (Figure 6.12). Nuttall described the main differences between the intermittent and continuous film traction systems. [49] He explained that instead of rapidly pulling down each frame to be scanned as in the intermittent film traction system, which results in rapid mechanism and film wear, the continuous film method moves the film at a constant velocity while making allowances for the steady movement of the film during the scanning process. In the Baird system (Figure 6.13) the film is chased as it moves down by a moving shutter.

By 1952, about half of the BBC's output originated in film [50] and this figure continued to increase until the present day.

While most people may believe that Baird Television Ltd were the losers and that Marconi-EMI were the champions of modern television, the company, inspired by J. L. Baird, continued as the main recording and playback media system for the industry until the advent of magnetic video recording in the 1970's. Despite this, Cintel remains to this day as the world's leading manufacturer of flying-spot telecine and telerecording equipment for the industry.

Cintel described their position in 1996: [51]

> "In the 1970's and 1980's a major change overtook the telecine business, threatened with replacement by the video recorder. The solution was to move the telecine away from its workhorse origins and make it part of the creative business. Today, there is a common feeling that, while video is convenient, it does not have the intrinsic qualities of film. Film, in short, looks better, it gives a more satisfying image. The telecine lives on, perhaps not in such great numbers, but by making an important contribution where quality is paramount."

The next section returns to Baird Television in 1936 and describes a long running secret project for the French Air Ministry utilising high definition television facsimile and aerial reconnaissance.

Section 6.5

Air Ministry File on Baird Television Ltd

Captain West informed the British Air Ministry on 23 May 1936 that the Baird Company had been offered a contract by the French Government to produce a light weight television transmitter suitable for installation in an aeroplane, and inquired if there would be any objection. An Air Ministry file number S.38110 was opened on Baird Television by the British Air Council on 9 June 1936 and A. H. Self [52] replied in a confidential letter to West indicating that they had no objection for discussions to go ahead on that basis with the French Government. In the same letter it was indicated that the British Air Council were also interested in the production of a light television transmitter suitable for carriage in an aircraft, and the Director of Scientific Research and his staff would keep in close touch.

Herbert [53] who worked on this project at Baird Television, indicated that as far back as 1924 the Admiralty Research Laboratories at Teddington had carried out television experiments, but could not equal the results obtained by J. L. Baird. This led to meetings between Baird Television and the Service establishments.

An internal Air Ministry report [54] reveals that both EMI and Baird Television had been asked to supply television equipment for installation in the French aircraft. A visit was made by Hecht [55] of the Research and Development Instrument Laboratory of the British Air Ministry, to the EMI works on 28 April 1936 and to Baird Television on 29 April 1936. This was in order to obtain knowledge about the state of development of these rival companies and to form an opinion on the likelihood of obtaining demonstrations of special interest to the Air Ministry. EMI gave a closed circuit demonstration of an iconoscope camera tube operating at 480 lines situated on a canal bank. It was reported that with sun shining through light mist and clouds it was possible to distinguish, though somewhat dimly, the telegraph wires on the opposite bank at a distance of about 100 feet. EMI stated that they intended to resolve 1000 lines for aircraft purposes. It was indicated that the EMI iconoscopes (emiscopes) were difficult to produce and that 70 per cent of the total output were scrapped as rejects. Emiscopes could be expected to operate from between a few hours to about four hundred hours.

The report [56] stated that although Baird Television had been limited to 240 lines per picture using mechanical scanning gear, they now had an electronic camera capable of higher scanning rates. (image dissector). A demonstration was given of an open air view but due to dull and misty conditions a poor quality picture emerged. In describing the technical capabilities of Baird Television Hecht [57] noted, that the company manufactured all equipment including electronic tubes, and were currently in the process of building a new transmitter with a power of 500 kW using Metrovick demountable valves. [58]

On 17 July 1936, another routine visit was made to the Baird Company by Hecht [59] who was accompanied by Wing Commander Archer, MI5, War Office, who wished to effect a liaison with West, in respect of his duties on industrial security. It was recorded in a British Air Ministry minute sheet, [60] that progress had been made by the Baird Company in respect of the development of an iconoscope of their own design and that the situation would be carefully monitored. It was noted that Baird had designed and constructed electron multipliers which were 15,000 times more sensitive than ordinary photoelectric cells. The minute sheet [61] described the installation which Baird Television had in mind for the French Air Ministry aircraft:

Installation Cost	£10,000
Weight	400 lbs.
Scanner	Mechanical film or iconoscope.
Resolution	800 lines per picture
Frame Repetition	5 pictures per second.
Record	Selected frames telerecorded on film.

It was reported [62] that the British Air Ministry felt that the approach of concentrating on detail rather than on pleasing reproduction was the proper course for aerial observation. Captain West [63] indicated that although no arrangement had been so far made for a demonstration to the British Air Ministry, they would welcome any proposal in that direction. West [64] suggested that if the British Air Ministry were interested it was likely that subsequent equipment would cost perhaps £2,000 and that given the necessary incentive the weight could be reduced towards a lower limit of about 100lbs.

Herbert [65] indicated that although Marconi-EMI had obtained a similar contract with the French Air Ministry based on the emitron, no liaison was allowed between the two participating organisations.

The British Air Ministry received Information from Captain West regarding the German position. [66] It was explained that there was a business agreement between Baird Television and the German firm Fernseh whereby each shall supply the other with all knowledge recently acquired. Recently, however, the Germans had taken all they could but had given away nothing. The German Government had complete control over all television developments and these were kept secret. West indicated that they were on the point of discontinuing their business agreement unless reciprocal facilities were given. It was also noted [67] that Baird Television received frequent visits and applications for information from the whole of Europe and elsewhere. The only important country not catered for was Japan, there being a strict rule that the Japanese are told and shown nothing at all, and are not to be admitted on to Company's premises. [68]

Captain West wrote to Hecht on the 19 August, 1936, confirming points of discussion covered during a meeting on 17 July, 1936: [69]

(1) The visit of Radio Engineers from the French Government and French Air Ministry, to the Baird Laboratories.

(2) Multiplier tubes for amplifiers.

(3) The use of the Electron camera in the air.

(4) The use of infrared rays for fog penetration.

(5) Sound location, using modern amplifiers and cathode-ray tubes.

On 11 September 1936, Jarrard of Baird Television wrote to the Secretary of the British Air Ministry. In the letter marked 'SECRET', [70] Jarrard indicated that preparation for the opening of the Alexandra Palace station had caused them delay in replying. He thanked the British Air Council for an offer to place an aircraft at their disposal to test the apparatus being constructed for the French Government. Jarrard also clarified that any work carried out for the French Government would be with the full knowledge and consent of the British Air Ministry.

Reporting on another visit to Baird Television on 11 February 1937 Hecht noted: [71]

> "Owing to a number of circumstances it had not been found possible to meet Captain West on routine visits for several months. Air Ministry work, Television (BBC) demonstrations and the Crystal Palace fire interfered successively and even at present the laboratories are in a chaotic state."

Hecht [72] indicated that Baird Television expected a firm order worth £10,000 from the French Government for an air and ground installation including radio telephony. Power was to be 250 watts on 10 metre wave band. The intermediate film system was to be used both in the air and on the ground. Five or ten pictures per second would be provided. The ground staff would be able to concentrate on any one picture at will, a storing gear being incorporated. Hecht reported that Baird Television also expected to receive a contract from the Russian [73] Government worth £40,000, for apparatus identical to the French gear, and that the Russians had stated that they were prepared to pay 'almost any price' for apparatus to enable them to 'see in the dark.' (i.e. infrared electron cameras).

Hecht [74] also reported on demonstrations of 5 pictures per second using:

(a) Normal transit time between pictures of $1/_{10}$ second

(b) Fast transit without shutter of $1/_{80}$ second.

Hecht concluded that (a) showed unpleasant flicker while, (b) showed practically no flicker but the picture moved in jerks. It was proposed to add a shutter to shut off the picture while it is being moved up one which should give improved results. The electron multiplier was discussed again but this had been set-back due to the loss of equipment destroyed in the fire at the Crystal Palace, and infrared photography for mist penetration was briefly mentioned.

In closing this report Hecht wrote: [75]

> "Future work at Baird's was said to be under consideration and they fully intended to continue research on all aspects of television, including electron cameras, infrared and other incidentals."

On 26 February 1937 a letter marked 'SECRET' [76] was sent to West from the Directorate of Research, confirming that the following were of interest to the British Air Ministry:

Infrared: Improvements in photo-cells; photographic films; photoelectric surfaces and other infrared detectors.

Electron Cameras: Devices based on optical converters and electron focusing leading to direct vision of infrared radiations both artificial and natural.

West replied on 3 March 1937 to Wimperis at the Air Ministry: [77]

> "We have a large programme of work which includes the subjects mentioned by you, and we shall be very pleased to keep you informed of our progress in these directions."

Figure 6.14: The Marcel Bloch Bomber at Hendon, May 1939

A letter from the Baird Company marked 'Private and Confidential' to Hecht on 15 April 1937, [78] gave a description of the Baird apparatus for the French and Russian Governments. The reply marked 'SECRET' dispatched on 12 June 1937, [79] from Self, indicated that the Air Ministry offered no objection to the Russian order, provided that no details of important advances in research or development were communicated to the Russian Government without previous reference to the Directorate. This was confirmed by Baird Television on the 6 July 1937. [80] Other letters in this British Air Ministry file [81] dated from 5 August to 28 October deal with the practicalities and storage of the French Bloch Bomber, which was located at Royal Air Force Station, Hendon, Middlesex. (Figure 6. 14).

Herbert wrote: [82]

> "The Baird contract, known for security reasons only as job number 4141, amounted to about £10,000. A team of 11 engineers under the leadership of B. B. Austin worked in the Crystal Palace School of Arts, which had survived the fire, and in the incongruous surroundings of busts and statues this piece of television history took shape."

Herbert [83] described the aircraft as a Marcel Bloch 200, twin engine night bomber number ED83, with a flying speed of 150mph (241kmh). The crew of five consisted of a French pilot, a mechanic and three Baird engineers. In July 1939 from flights out of Hendon aerodrome, test pictures of around west London were radiated regularly.

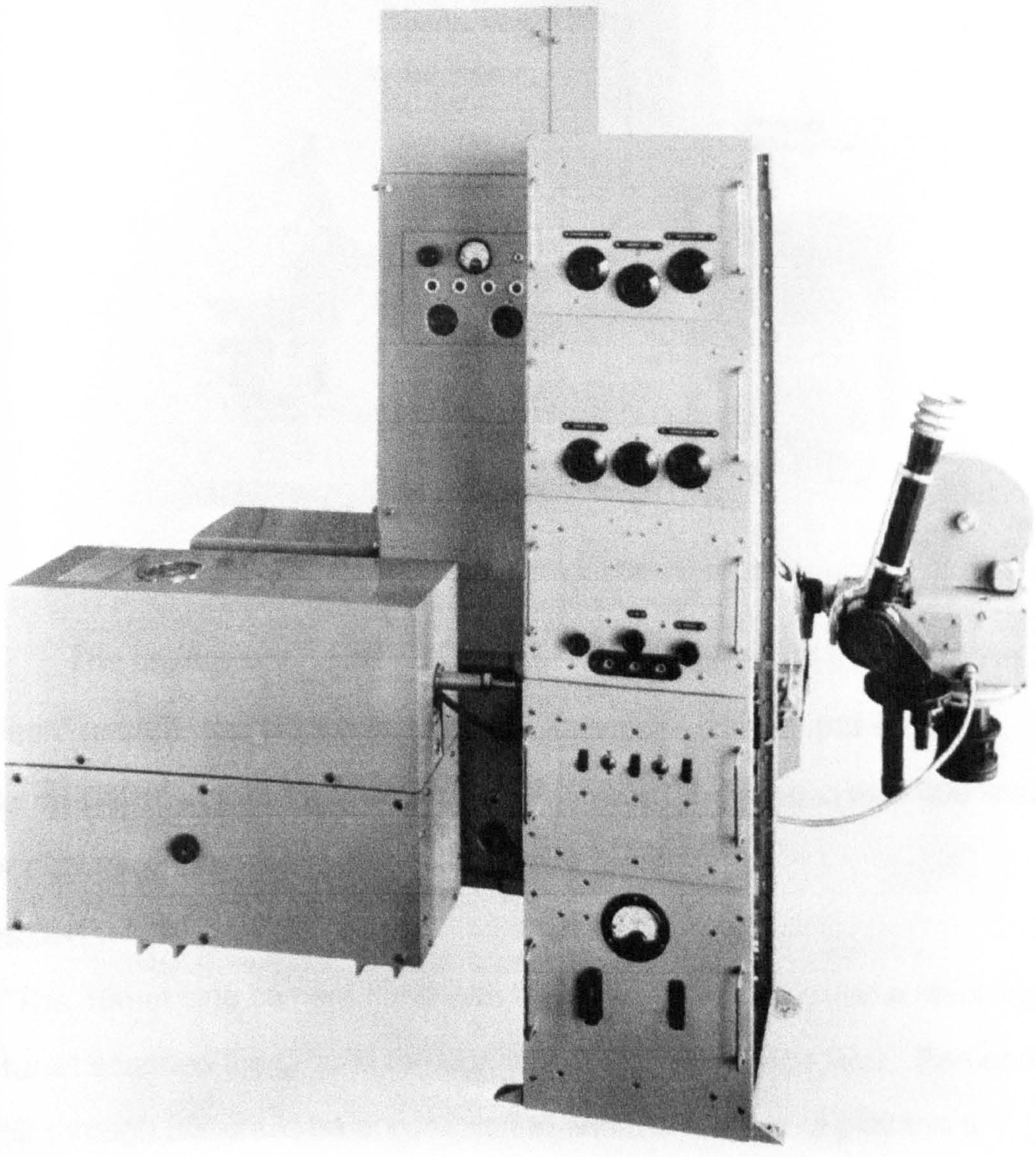


Figure 6.15: The processing unit and the 35mm camera which scanned the ground through the fuselage floor

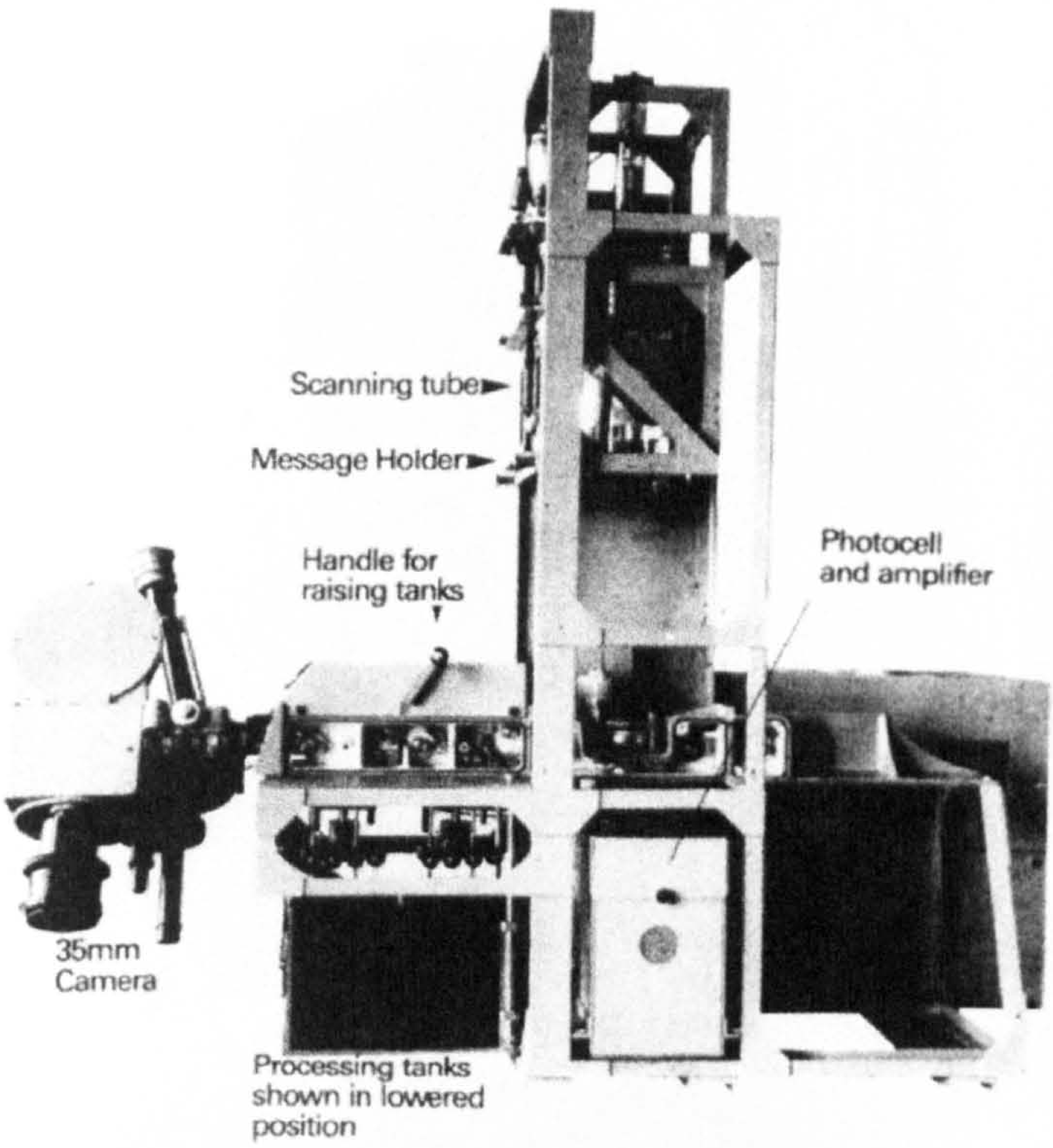


Figure 6.16: Camera Unit showing the message holder and scanning CRT

The preliminary report on Baird television equipment in the French "Bloch" aircraft, dated 19 July,1939, [84] describes the camera as an intermediate film system operating at 25 pictures per second with 400 lines per picture. (Figure 6.15).

Herbert wrote: [85]

"The 16mm cine camera fitted with two fixed focus lenses on a revolving turret scanned the ground through a hole in the fuselage floor. Pan and tilt through 30° could be accomplished and the number of pictures a second was variable between 20 and 30. Synchronisation pulses were generated by a slotted disc attached to the variable speed DC motor driving the camera."

With reference to Figure 6.16, Herbert described the process: [86]

"The exposed film was processed immediately in sealed developing and

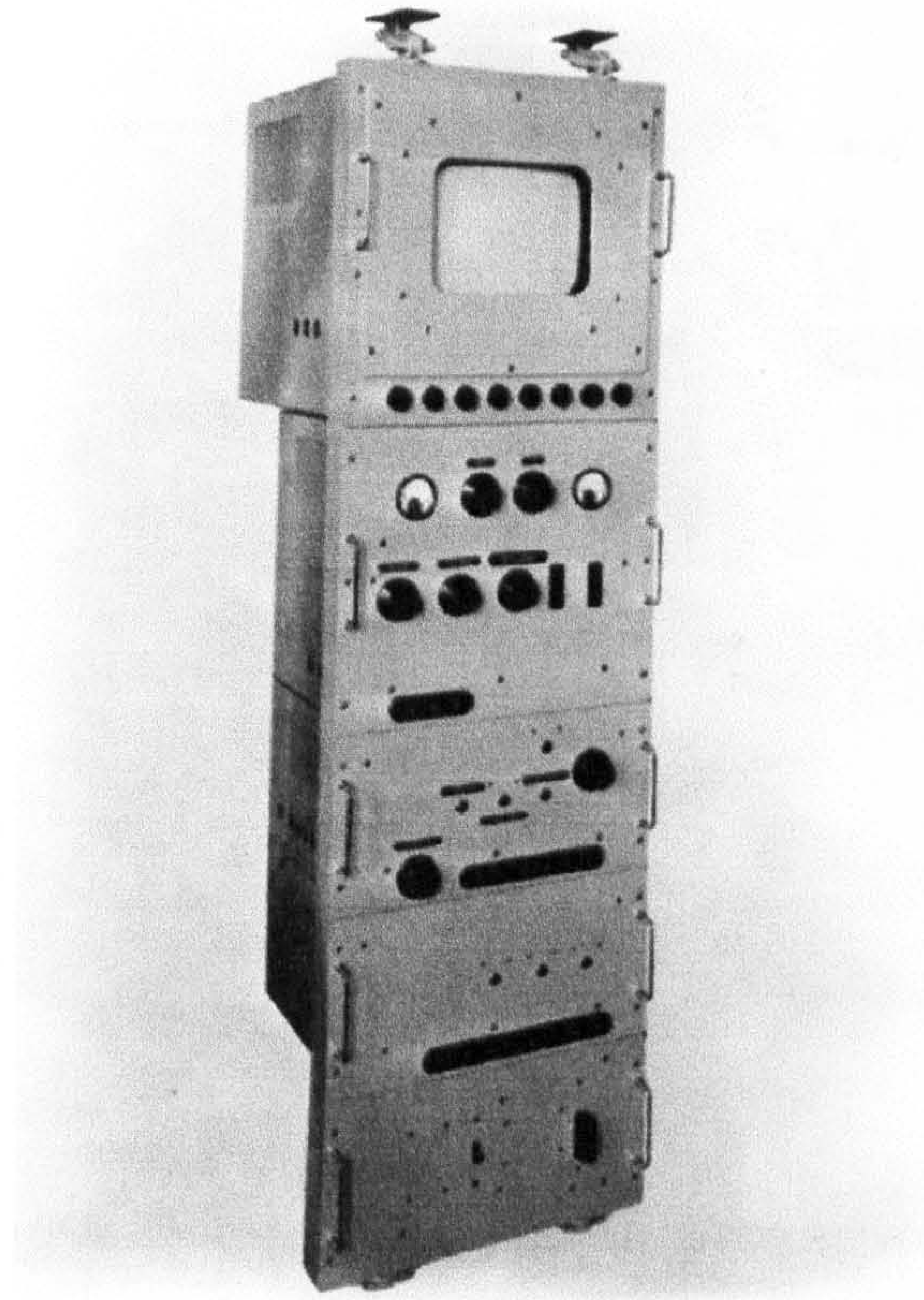


Figure 6.17: Monitor situated in a rack which also housed the modulation amplifier and pulse generator.

fixing tanks maintained at 28°C, emerging 16-20 seconds later and then passing still wet to the scanning unit. This consisted of a vertically mounted, high intensity 7" (178mm) tube in association with an optical system and photoelectric multiplier. Messages and sketches written on transparent material could be placed in a holder immediately beneath the scanning tube and transmitted in the same way as the film."

Herbert [87] indicated that an auxiliary rack adjacent to the camera position contained temperature control equipment for the processing tanks, and high and low frequency timebases. The camera operator viewed the transmitted pictures on a monitor screen (Figure 6.17) situated in a rack which also housed the modulation amplifier and pulse generator.

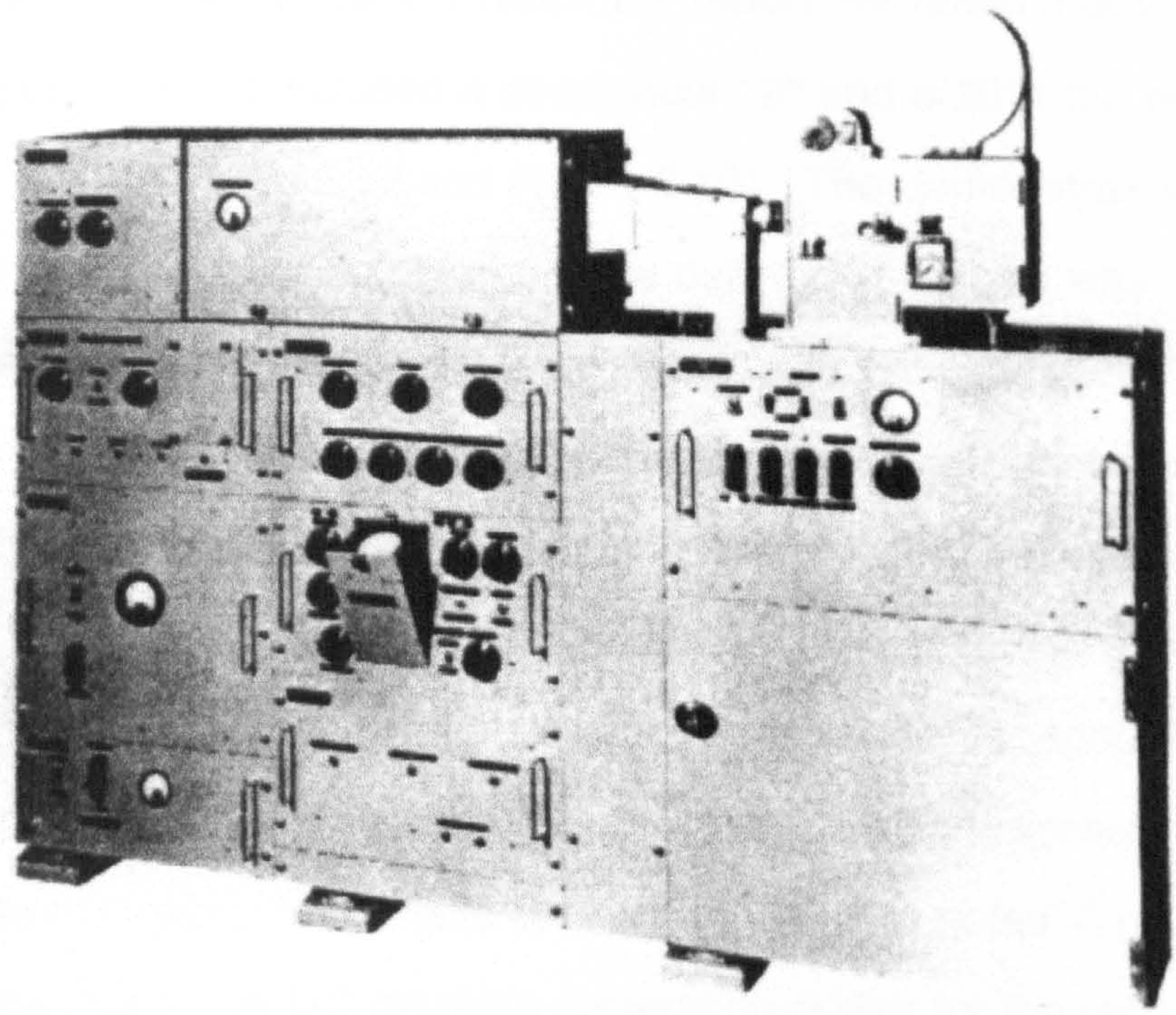


Figure 6.18: Air reconnaissance ground receiving Apparatus.

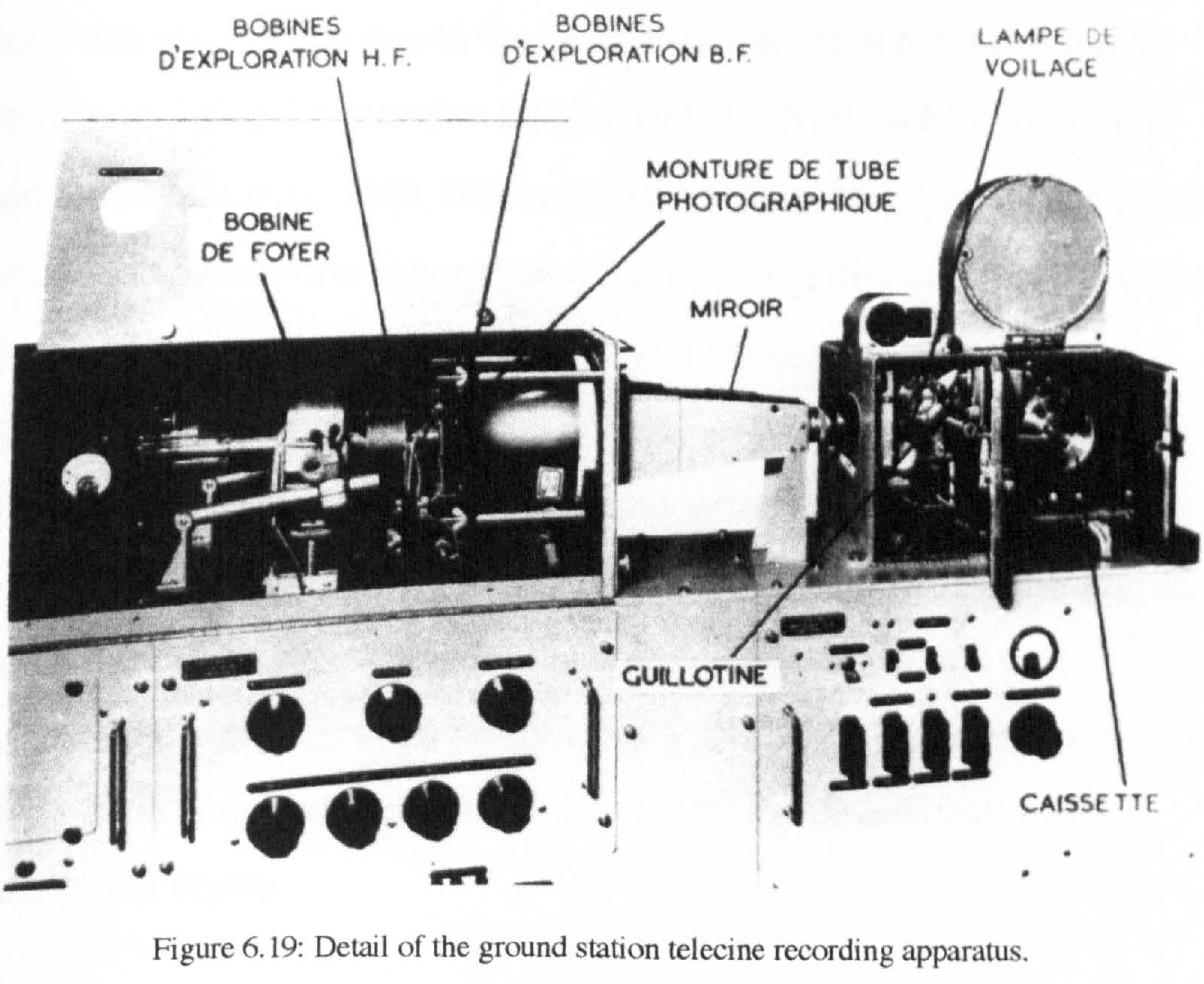


Figure 6.19: Detail of the ground station telecine recording apparatus.

The British Air Ministry 'Preliminary report' [88] noted that the ground receiving equipments included a direct view 12" and a 20" tube with reflected vision. (Figure 6.18 and Figure 6.19). The demonstration indicated that good pictures could be obtained, the definition of which was exceedingly sharp. It was possible to differentiate between certain types of vehicles and to note a white line down the centre of an arterial road, the aircraft being at a height of 2,000ft. Owing however to the small field of view, the speed of the aircraft, and to the rather jerky handling of the camera, the objects moved out of the picture too rapidly for accurate observation. The frame rate of 25 per second was also distressing and fatiguing to the eyes. Two effects of interference were noted. One was stated to be due to the DC machine generating power for the receiving equipment, which produced a series of white spots on the screen. The other interference, which produced broad dark horizontal bands across the picture was stated to be due to the rotation of the metal blades of the air screws modulating the radiation by absorption. In an addendum to this report dated 1 August, 1939, [89] it was stated that a facsimile record could be inserted between the light cell and the scanning device which may be a map or a message. It was also noted that a future provision was being made for a permanent record at the ground station and that by pressing a button every third picture could be photographed. Herbert [90] indicated that the system used for recording was the reversal of that used on the aircraft, with the same high intensity tube producing a negative image on the film emulsion. After exposure the film passed to a storage cassette which could then be transferred to the processing unit for rapid developing, fixing, washing and drying.

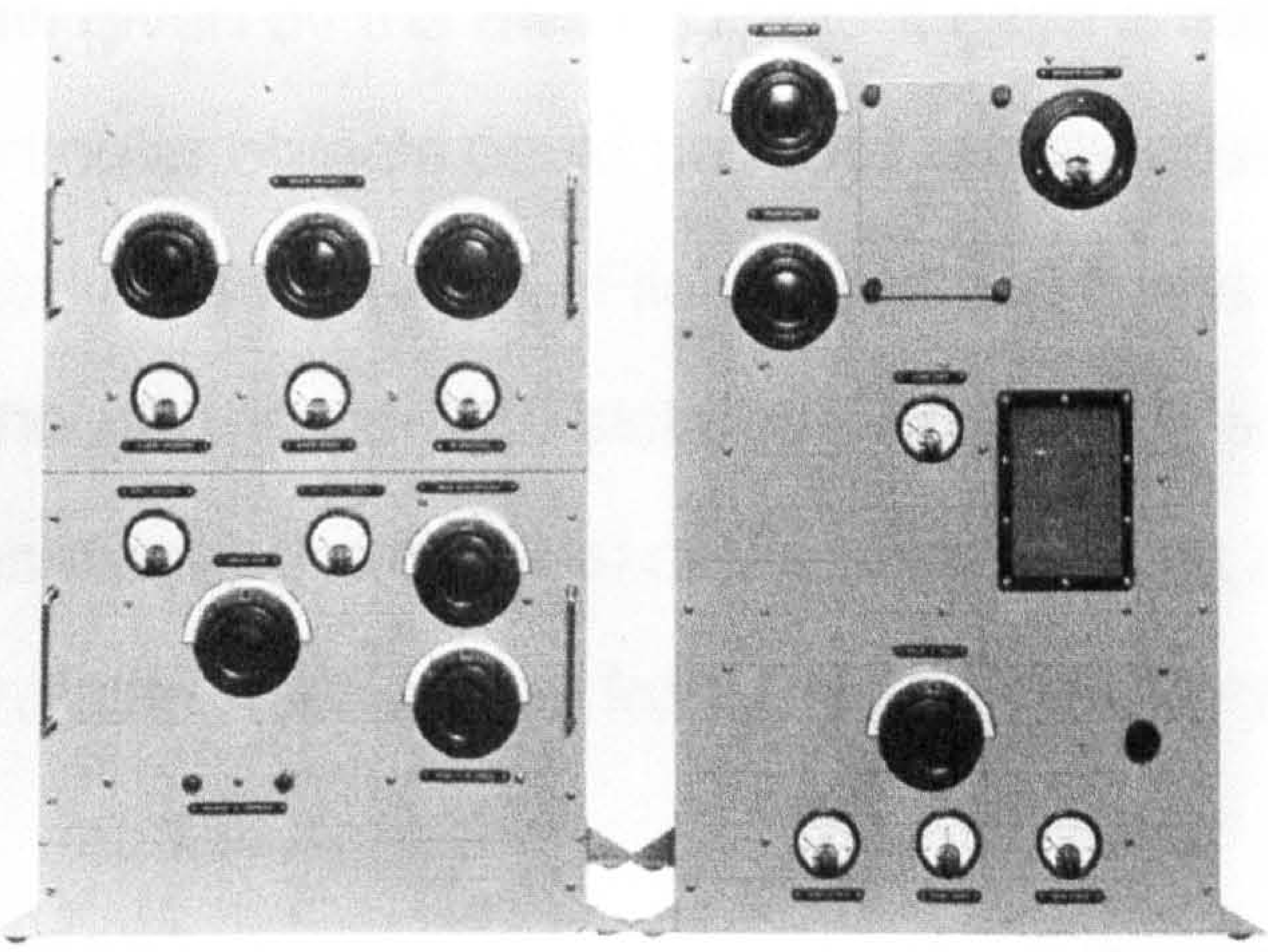


Figure 6.20: The Baird vision transmitter units before fitting in the French Bloch bomber.

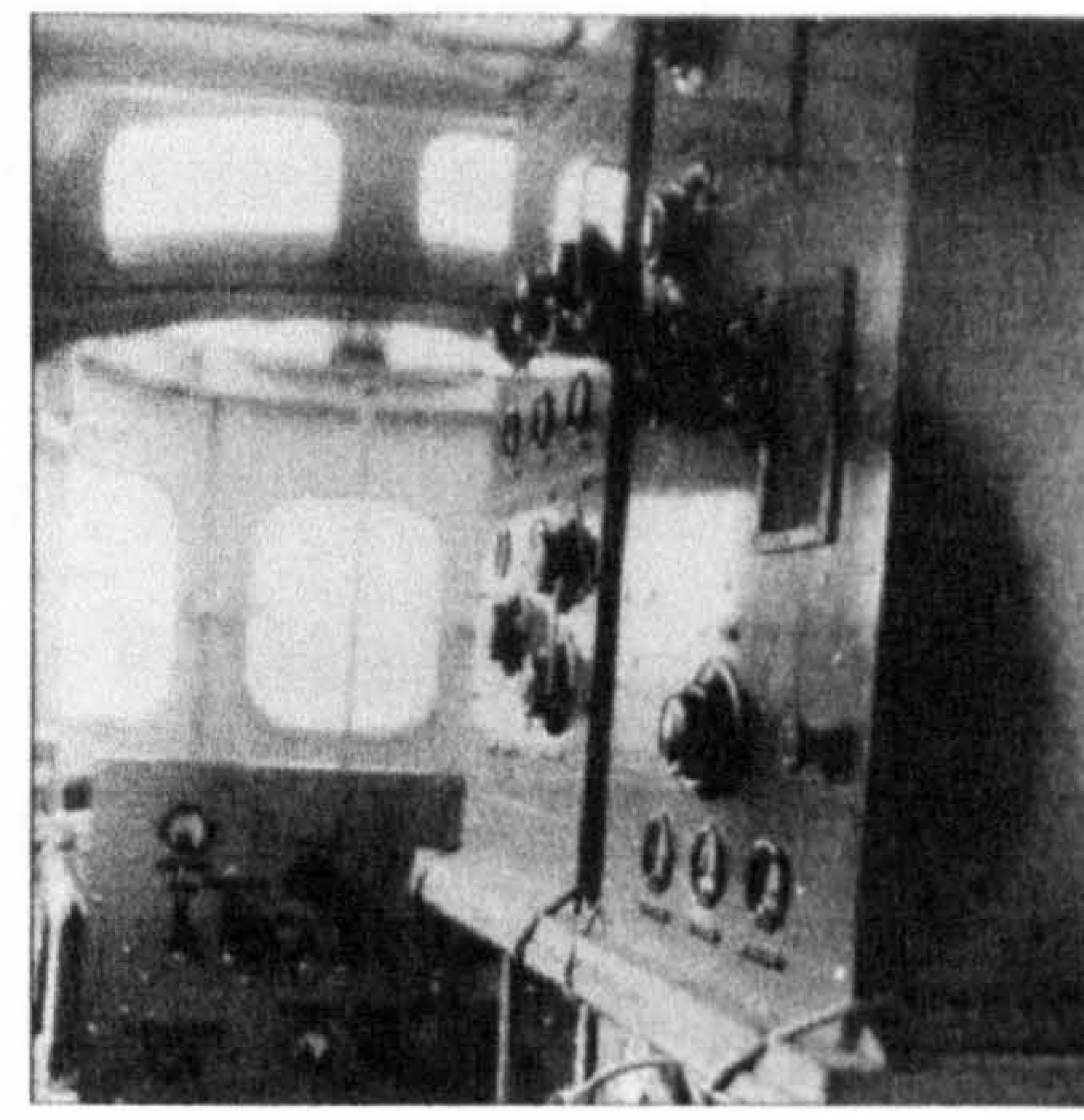


Figure 6.21 Baird Vision transmitter in the forward gun turret.

Herbert wrote: [91]

> "The vision transmitter which was located in the forward gunner's position, consisted of a master oscillator, frequency doubler, drive amplifier and push-pull final stage incorporating Raytheon RK47 tetrodes, grid modulated. This produced a power of 200 watts at 51MHz fed to a quarter wave retractable antenna."

The transmitter units shown in Figure 6.20, on the bench at Baird Television, are shown fitted in the forward gun turret of the bomber in Figure 6.21.

EMI were also offering the provision of television apparatus for use in aircraft to the British Air Council. [92] A brief comparison of Baird and EMI television from aircraft was made on 1 August, 1939. [93] The definition of the EMI picture did not appear to be so sharp as that produced by the Baird equipment, although a definite comparison could not be obtained owing to the differences of field of view in the two pictures. The size of the image produced by the Baird equipment was much greater than that of the EMI indicating either that a lens of longer focal length is used by the former or that the estimate of height was incorrect. The effect of the increased field of view given by the EMI equipment gave a very much steadier picture and particular objects could be more readily observed than was possible at the Baird demonstration. Flicker was much less marked in the EMI pictures although the rate (25 pictures per second) was the same in both cases. This was due to the material of the screen, but it had the disadvantage of lower contrast. Interference from the air screw was also present.

It is known from a minute sheet [94]in the British Air Ministry file that an EMI system was installed in a British Aircraft for appraisal purposes:

> "It should be noted that we only possess an EMI set and this will be the one shown. The French have a Baird set. The EMI transmits a picture instantly but does not record. The Baird system has a lag of 20-30 seconds but keeps a photographic record."

By mid October 1939 the importance of keeping a permanent ground record was recognised. In a communication from Aspley Guise, Station Bletchley, to Squadron Leader Eeles [95] it was indicated that they had resolved this problem:

> "The equipment as it stands, leaves one point uncovered. The observer makes a permanent record of his observations which he televises to the ground Receiving Station. If he fails to return, that permanent record is lost. We have overcome this disability, and the Baird technicians are leaving for France today to add a film reproducing unit to the ground-equipment so that a permanent record of the televised picture will be available."

The implications of this communication indicate that Baird Television were working with military personnel at Station Bletchley.

Herbert wrote: [96]

"Intensive testing commenced during the summer of 1939 from Hendon Aerodrome and during July a total of 15 transmissions had been made from the aircraft. At the end of that month the bomber returned to its base at the Centre d'Essais, Villa Coublay, near Paris, and the acceptance trials continued from that location. Due to the imminence of World War 11 the full potential of the project, particularly the possibility of using infrared devices, could not be exploited. After the outbreak of hostilities the aircraft moved to Orleans and later Toulouse. Its ultimate fate is unknown but almost certainly it fell into the hands of the Germans."

On 7 November 1942, Hecht, wrote to West at Cinema Television: [97]

"I have to refer to work which was done by Baird Television in 1938 on the subject of transmission from aircraft of films taken in the aircraft. The American Government have asked us to obtain any technical information which may be available. I shall be glad, therefore, if you would let me have as much information as possible including results of trials."

Television was replaced with radar installations both on the ground and in the air. The obvious choice of manufacturers for radar equipment was the television industry and especially Cinema Television and EMI who were ideally suited for the mass production of radar display tubes.

Section 6.6

The Skiatron Radar Display Tube

In 1941, there was requirement to devise a radar display to enable the pulses reflected from distant objects to persist on a screen for several seconds. An important application of such a device was a back-projected radar image on a display table known as a 'Plan Position Indicator' or PPI. The concept of a PPI had a number of advantages: it could be used for strategic operations; viewed and interpreted by a number of people; be engraved with a map and grid enabling the traces from various echoes to be recorded directly with a pencil on the grid.

King indicated that: [98]

> "Normally these indicators use a large diameter cathode-ray tube with a long after-glow fluorescent screen, and the echo from any particular target is visible on this screen until another echo is received, ie, for several seconds. The after-glow has, however, very low intensity and can be viewed only directly and under conditions of low external illumination."

One particular device, developed for commercial exploitation just before the war was the Skiatron, an unusual cathode-ray tube, which combined the principles of light control with optical storage.

The Skiatron was invented and patented [99] by Dr Alfred Heinrich Rosenthal of the Scophony Company who later became the director of research of the Scophony Company of America. [100]

Wikkenhauser wrote: [101]

> "Before the war, Dr Rosenthal succeeded in showing a television image received on a 'Skiatron' tube, of the standard 405-line interlaced television transmission of the BBC, although the picture was not quite satisfactory. It was recognised at that time that much work would be required to achieve the necessary perfection."

It was described [102] that the images received were poor because of insufficient contrast due to the fact that the trace stayed on the screen too long and disappeared only gradually. Rosenthal made reference to crystals of the alkali and alkaline earth halides, such as the chlorides, bromides and iodides of sodium and potassium, lithium bromide, calcium fluoride, and strontium fluoride and chloride. These he explained belonged to the class of 'ionic crystals': [103]

> "materials which, normally transparent to visible light, are coloured, ie, rendered more or less opaque, when they are struck by cathode rays."

King and Gittins [104] indicated that the Skiatron screen comprised of a thin microcrystalline structure of translucent alkali-halides, prepared by the evaporation in vacua of pure potassium chloride, which has the property of electron-opacity in that it becomes coloured by electron bombardment. A magnified image on the screen of the tube can be produced by episcopic projection, when brightly illuminated, and can be viewed directly. The properties of the screen are such that the colouration or opacity does not disappear immediately the excitation is removed, but decays at a very slow rate depending on excitation, temperature and illumination. [105] Both light and heat are required for any decay to take place at all. Traces kept in the dark are therefore quite permanent. King [106] indicated that there is a conflicting requirement regarding screen temperature. In order to obtain the

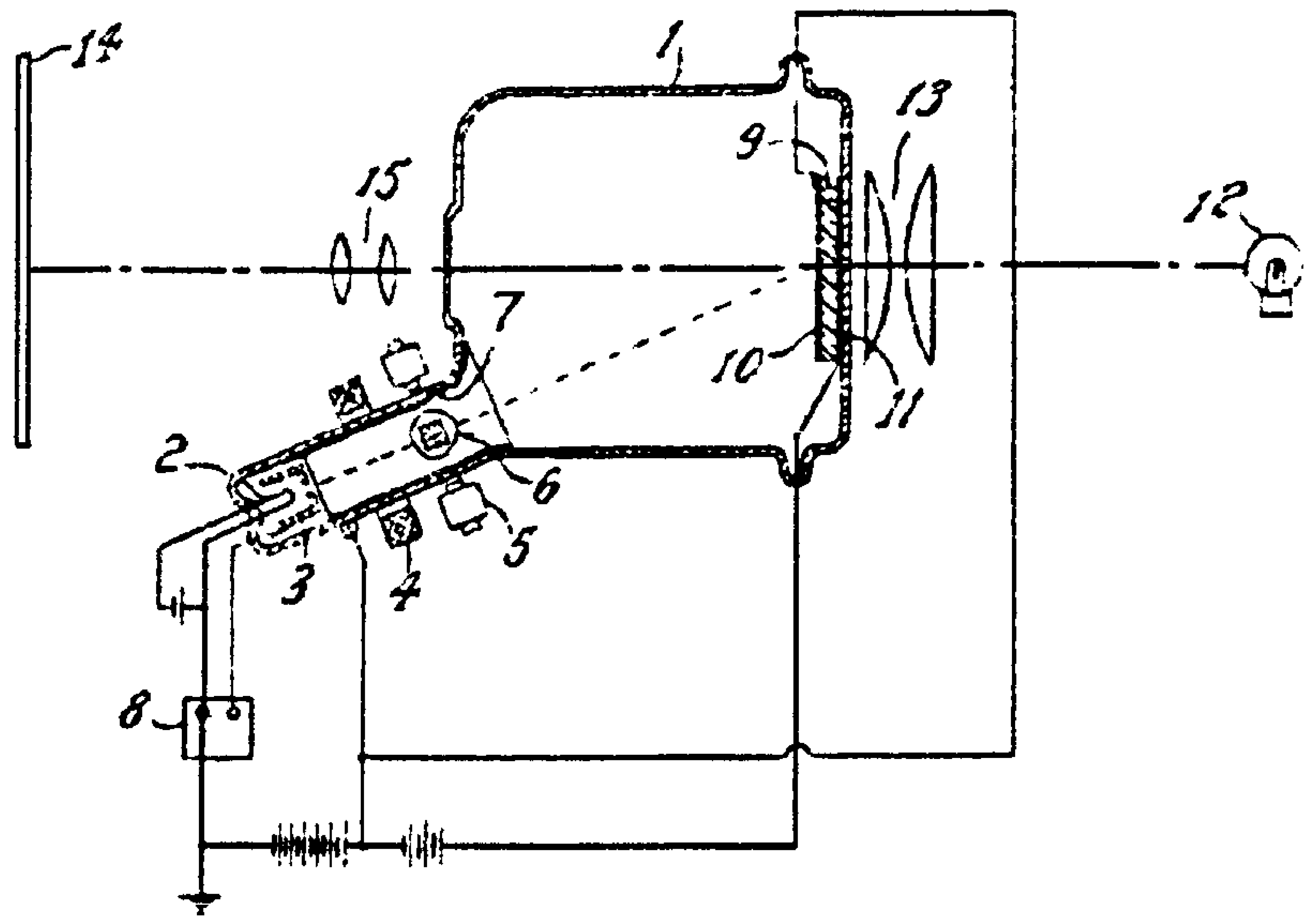


Figure 6.22: Diagram showing the principle of the Skiatron.

maximum contrast it was important to keep the screen temperature low, but to keep the decay time correct it was necessary to keep the screen temperature high.

With reference to Figure 6.22 the operation of the tube was described by Rosenthal [107]

> "A cathode-ray tube '1' is provided with cathode '2', a control grid '3', a beam focusing coil '4', deflecting coils '5','6', and an accelerating anode '7'. Picture signals from the receiver are applied between the cathode and control grid in such a way that the positive potential of the grid decreases with increase in signal strength, so that a modulated beam is produced and is swept over the image screen in the usual manner."

Rosenthal [108] continued to explain that the image screen consisting of potassium chloride '9', is flooded by light from an incandescent lamp '12', producing an illuminated image of the crystal on the projection screen '14' via the projection lens '15'.

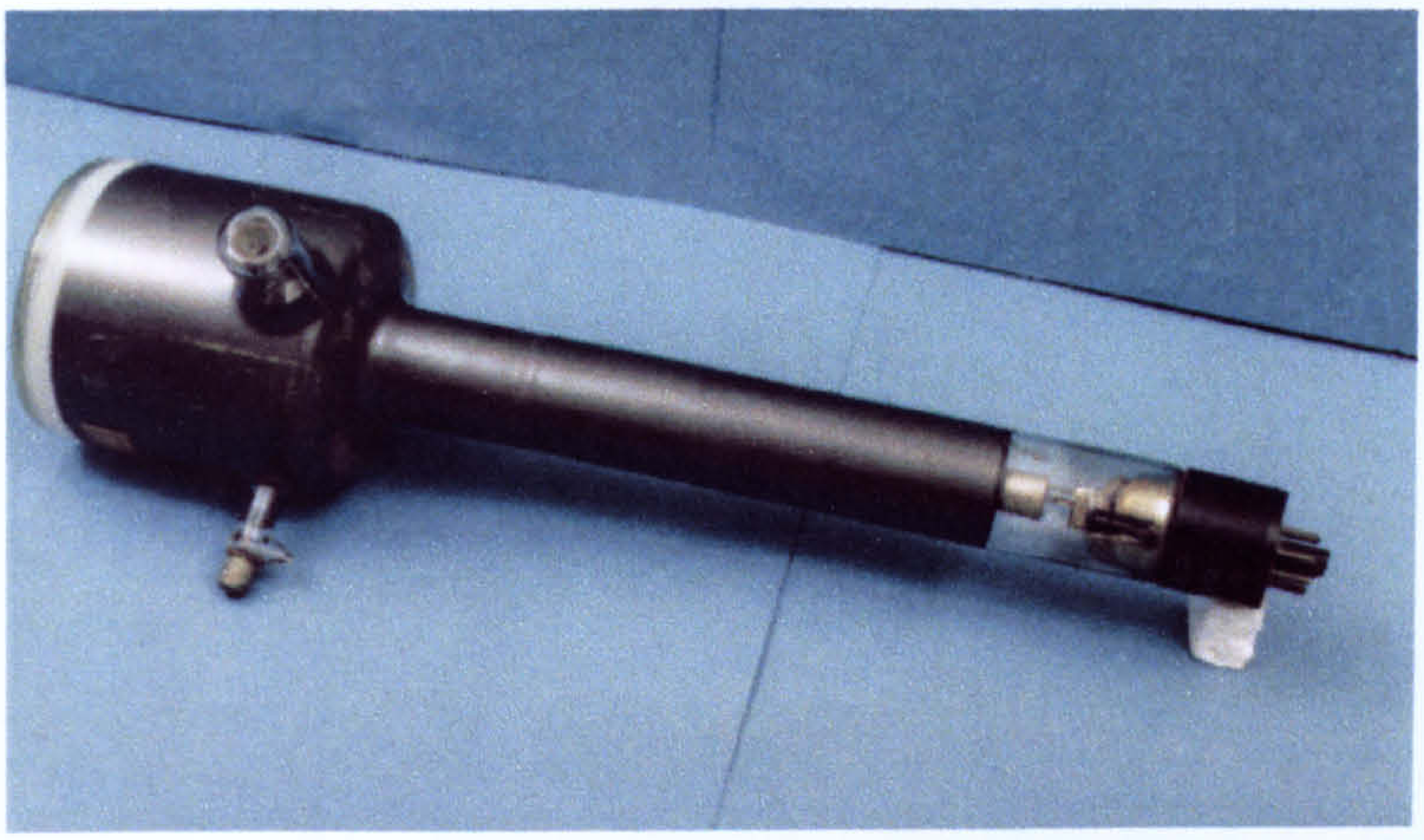


Figure 6.23: The Skiatron Radar Display Tube manufactured by Cinema Television (Incorporating Baird Television Ltd)

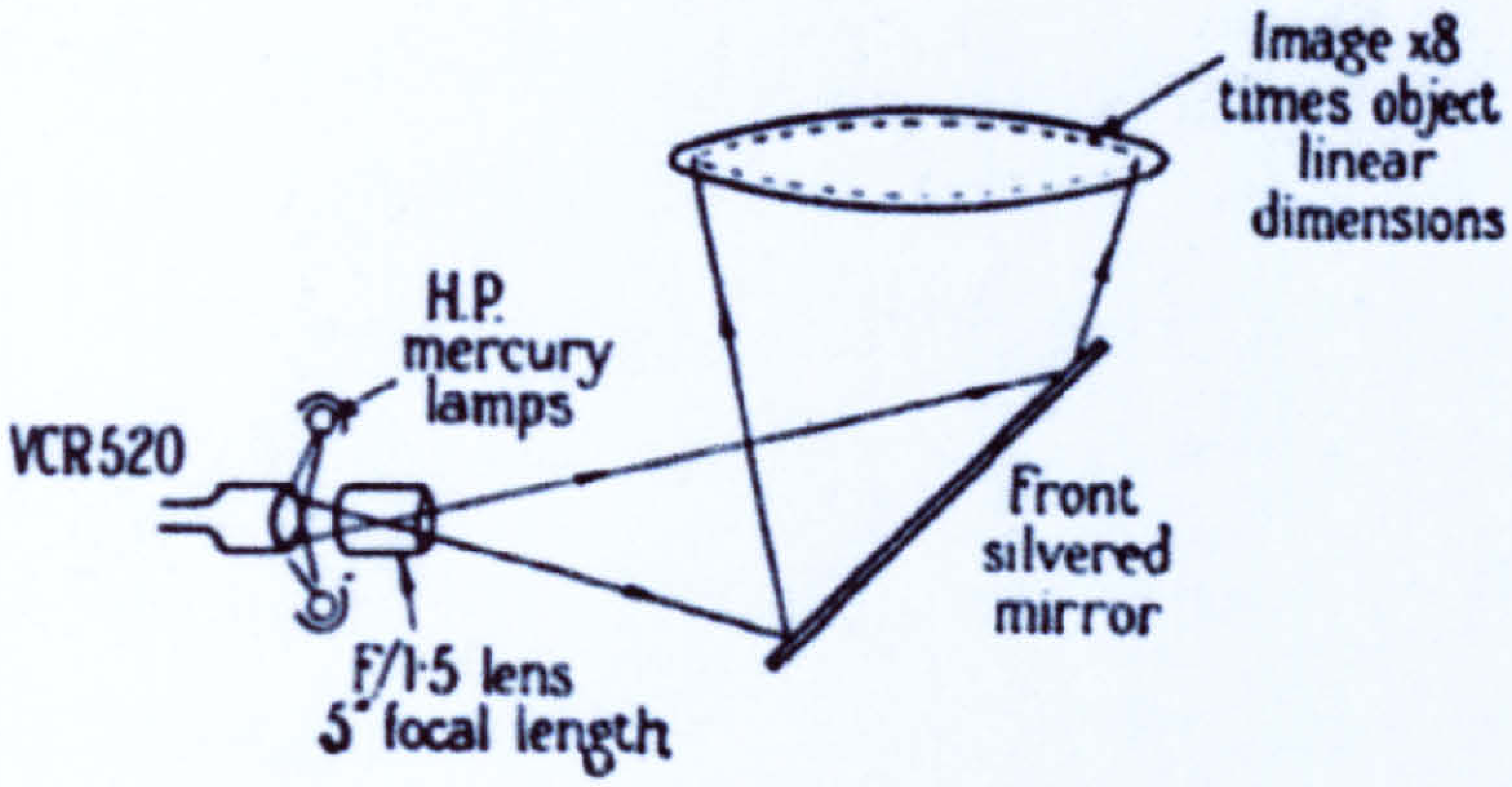


Figure 6.24: The Skiatron PPI optical path

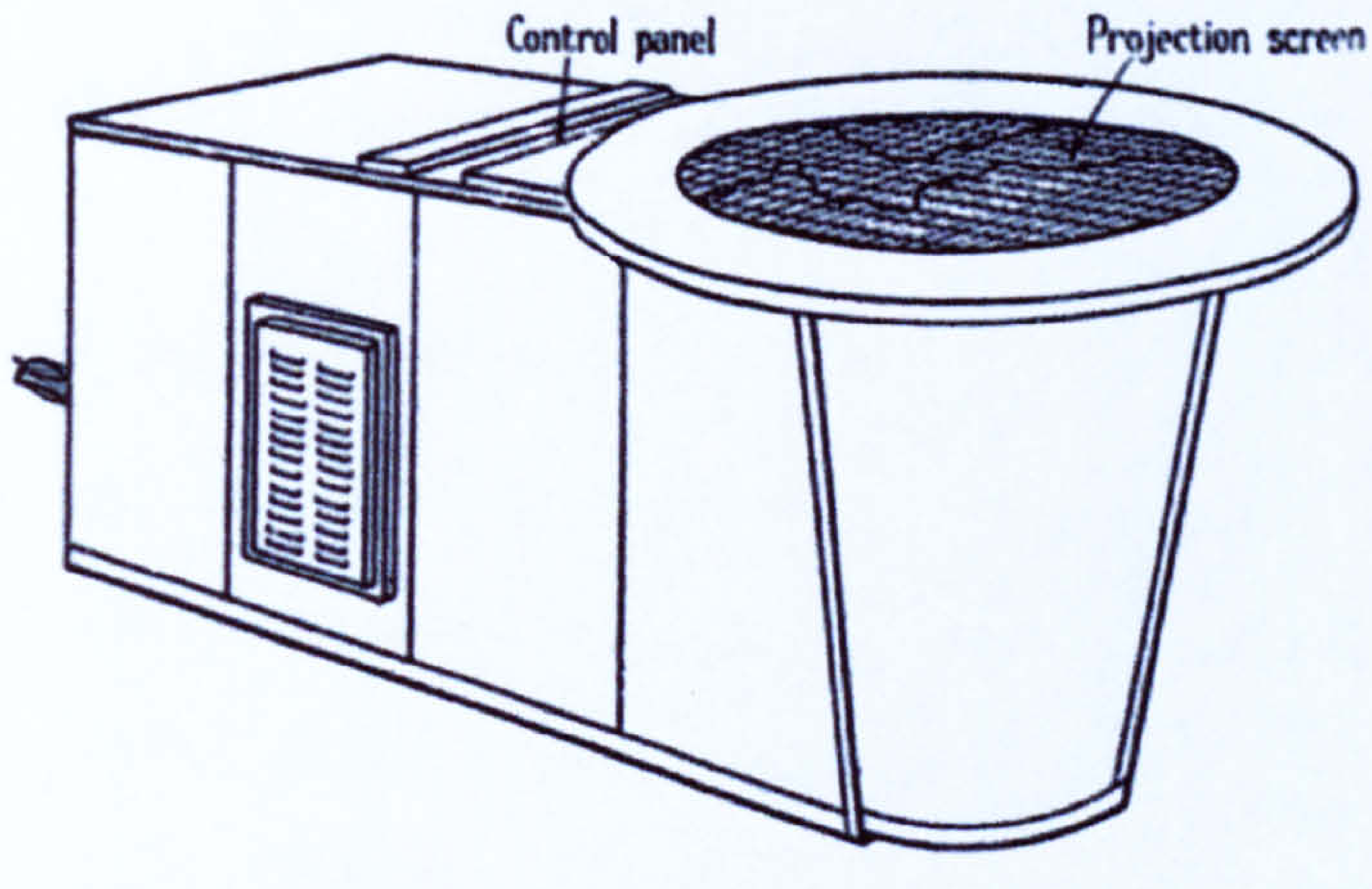


Figure 6.25: The Skiatron PPI Unit

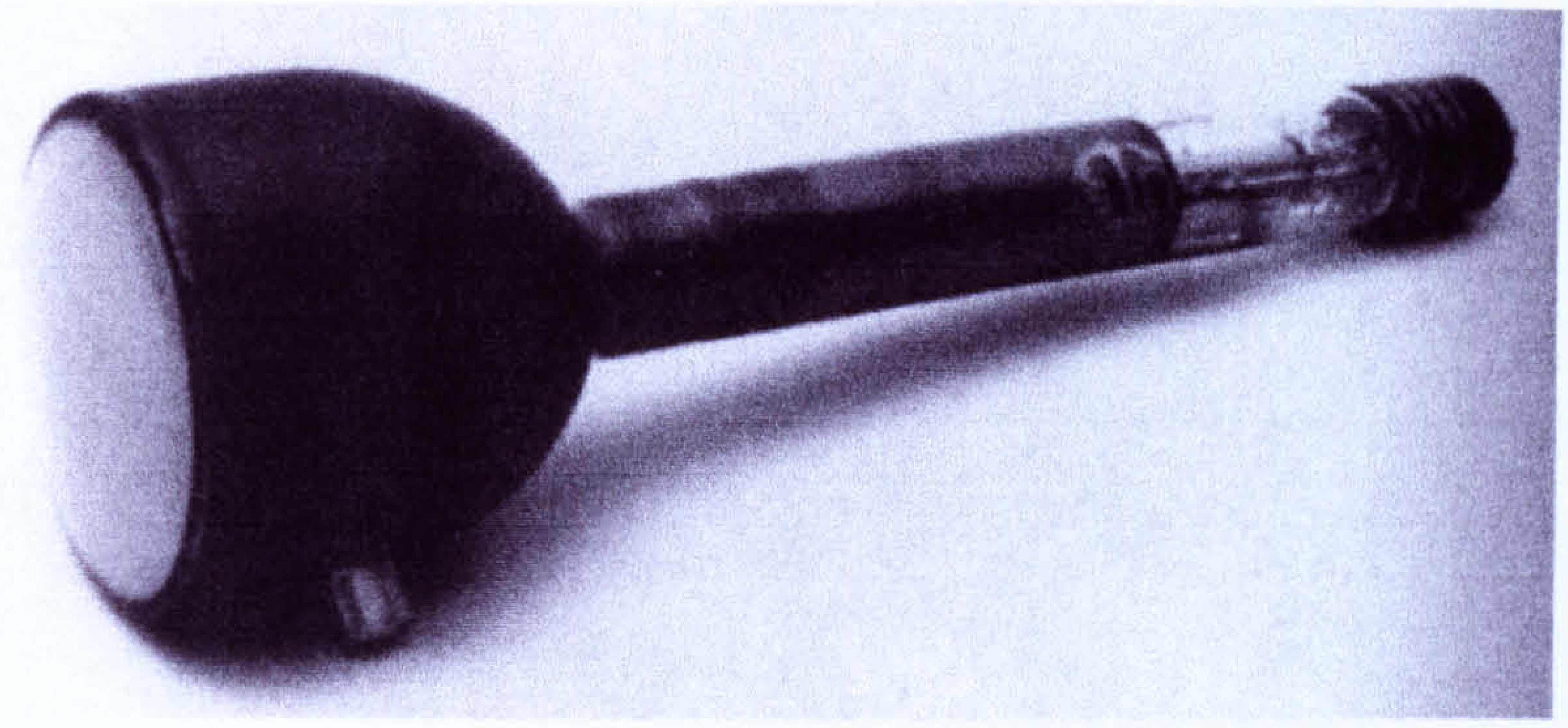


Figure 6.26: The RCA Skiatron 1944

The Skiatron tube produced displays of a negative nature in comparison to the conventional cathode-ray tube and because of this they were known as 'dark-trace tubes.' Singleton [109] indicated that work on the Skiatron was conducted on behalf of the Admiralty by the Physics Department (Fort Royal) of Bristol University, and the main contractor for mass production of the tubes was Cinema Television under the direction of Dr Samson. According to Bartle, [110] the senior glass technologist, who supervised the production lines of these tubes at the Cinema Television factory at Worsley Bridge Road, a total of approximately 15,000 Skiatron tubes were produced for the war effort. The 'Ministry of Supply' reference was CV1520 and the tubes were known as type VCR520. (Figure 6.23). Figure 6.24 shows the optical path for the Skiatron PPI unit which is illustrated in Figure 6.25.

Keller explained [111] that in the US similar tubes appeared including the RCA 4AP10 Skiatron dark-trace tube which was registered in 1944 (Figure 6.25). The screen was describes as comprising of a 'scotophor' or 'cathodochromic' material, however, it comprised of the same crystalline material as the British Skiatron, potassium chloride. Keller [112] indicated that after the war, Du Mont, National Union, Dollman and Freed (Rosenthal), Lorenz and Thomas Electronics all produced Skiatron devices.

While the VCR520 tubes were manufactured in Britain by Cinema Television at Worsley Bridge Road, a distinctly different section of the company, was formed to carry out another highly secret project based in the Rotunda, a location previously used by Baird Television for the manufacture of television cathode-ray tubes. Later this isolated unit of Cinema Television would produced large numbers of cathode-ray tubes for use in ground tracking stations and airborne radar.

Perhaps one of the best kept secrets during the war was the development and production of photocells by Tomes at Cinema Television for a device known as the optical proximity fuse. This was the forerunner of the very successful radar fuse.

Section 6.7

Photocells in the Rotunda

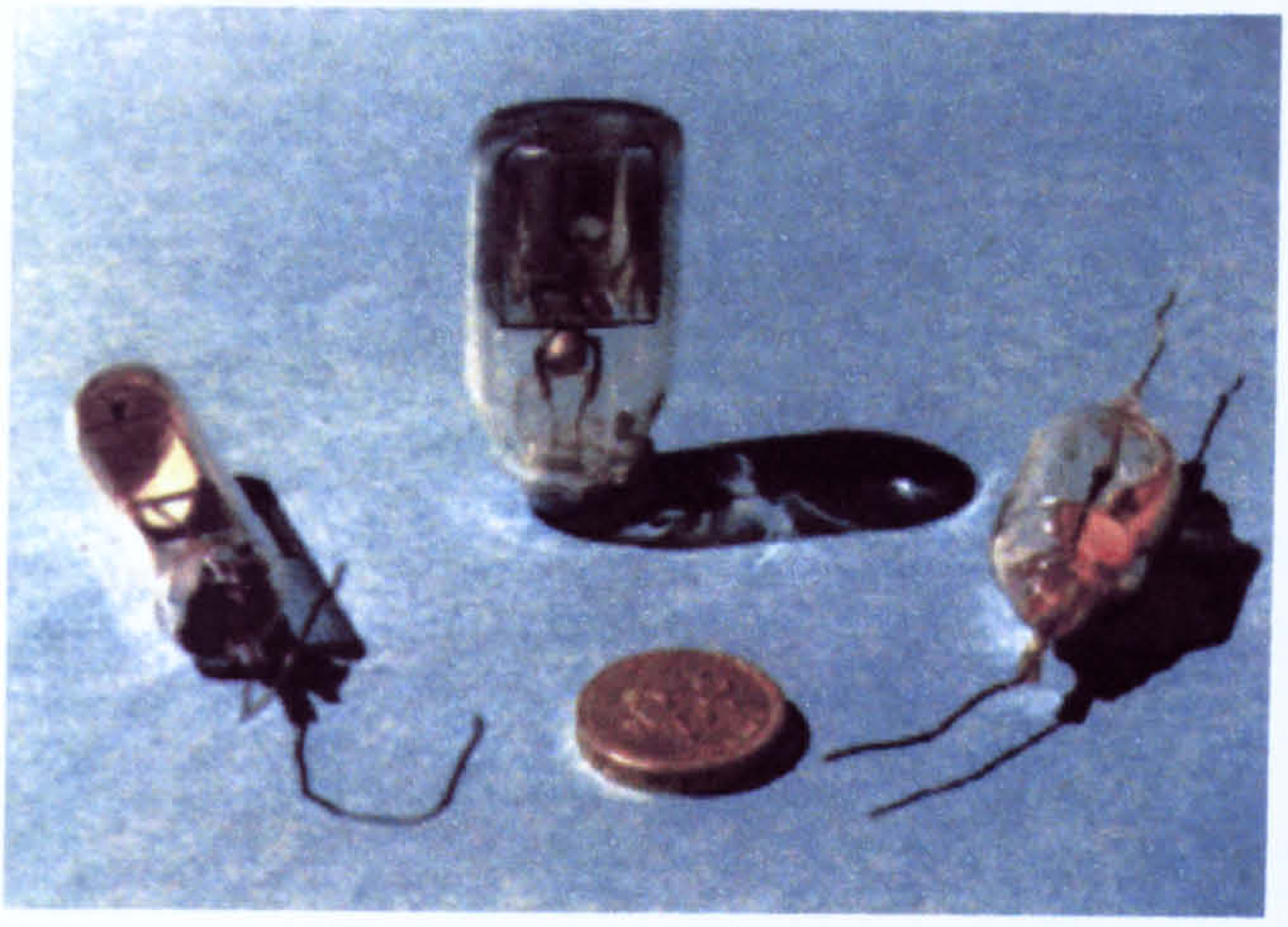


Figure 6.27: Photocells for sound film projectors

Early in January 1940, the remaining 34 former Baird employees at Lower Sydenham, were told by West that 'Cintel' (Cinema Television) would continue research on television. Tomes [113] recalled that initially the only war work being undertaken was by his department in the manufacture of photocells (Figure 6.27) for use in film projectors by the armed forces. He had registered his name with the Navy for military service but as he was also on the scientific register and working in a reserved occupation he was not called upon for active duty.

Winston Churchill's scientific adviser was Professor Lindemann and in turn, Lindemann's close associate at Oxford, was Mr Bolton-King who had for some years been retained as a consultant on photocells by West. Tomes wrote: [114]

"Then on 26 April my peace was shattered. I received a visit from Bolton-King; his visit was to set in train a series of events which would eventually give me the opportunity in my life. It would also bring Cintel highly profitable war work."

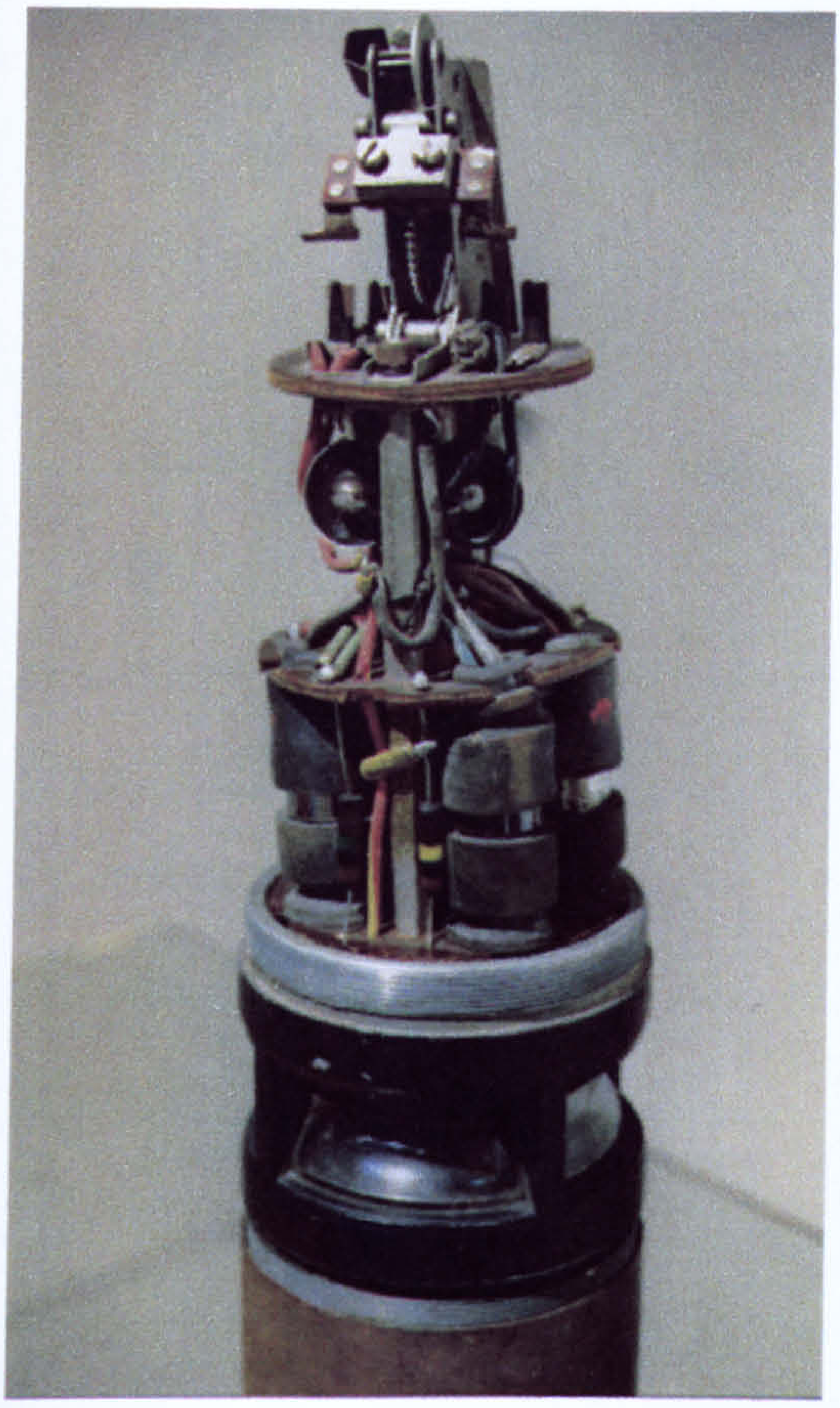


Figure 6.28: The secret proximity fuse.

Bolton-King asked Tomes to make some special purpose cells using Sommer's discovery of caesium antimony surfaces and suggested that if they were successful an order of 1,000 per day may result. Tomes and his glassblower worked all night to produce the tubes.

Tomes noted in his diary: [115]

"27 April 1940: Worked all day at factory 9 - 1, 2 - 7 and 7 - 11pm ... ...Special job conical shape cells."

Tomes [116] indicated that he was summoned by West to meet Bolton-King in the tea rooms at Paddington Station where they were told that the tubes worked perfectly and that another 50,000 were required as soon as possible. During the meeting Bolton-King produced a violin case which he opened to reveal an anti-aircraft shell. (Figure 6.28).

Tomes wrote: [117]

"When he unscrewed the conical casing, it revealed sophisticated electronics built around our photocell, which was located in the centre of a circular lens. The device could be fitted to a rocket projectile and was known as a proximity fuse."

The background to the development of the proximity fuse is described by Pawle, who wrote: [118]

"With the shortage of guns, the rockets seemed the only substitute. It was simple to make, and it needed no elaborate barrel or mounting. Professor Lindemann, the Prime Minister's scientific adviser, foresaw the rocket supplanting the gun altogether, and intensive research into the development of 2-inch and 3-inch rockets was launched by a team headed by Sir Alwyn Crow, first at Halstead and later at Aberporth, on the Welsh coast."

The device from which the rockets were fired was known as a Pillar Box, [119] which was operated by a gunner who shut himself inside a circular, swivelling cabin with a bank of rockets situated outside on either side of the casing. Fourteen rockets could be elevated by moving levers on steering arms which resembled the handlebars on a bicycle. [120] The rockets known as Harvey Projectiles were produced in large quantities with Professor Lindemann's backing. The first Harvey's to go to sea were fitted to large banana ships converted to carry out patrols in the North and South Atlantic. Pawle [121] indicated that the spectacular career of the Harvey did not begin until a group of scientists at the University of Exeter, with encouragement from Lindemann and the Prime Minister, produced a remarkable new fuse. The main difficulty in destroying dive bombing targets had been the great speed of aircraft and the requirement of a direct hit. The proximity fuse, which was the forerunner of the radar fuse, detonated the explosive in the projectile automatically when the silhouette of an aircraft was detected within 120 degrees of its 'vision', so destroying the plane.

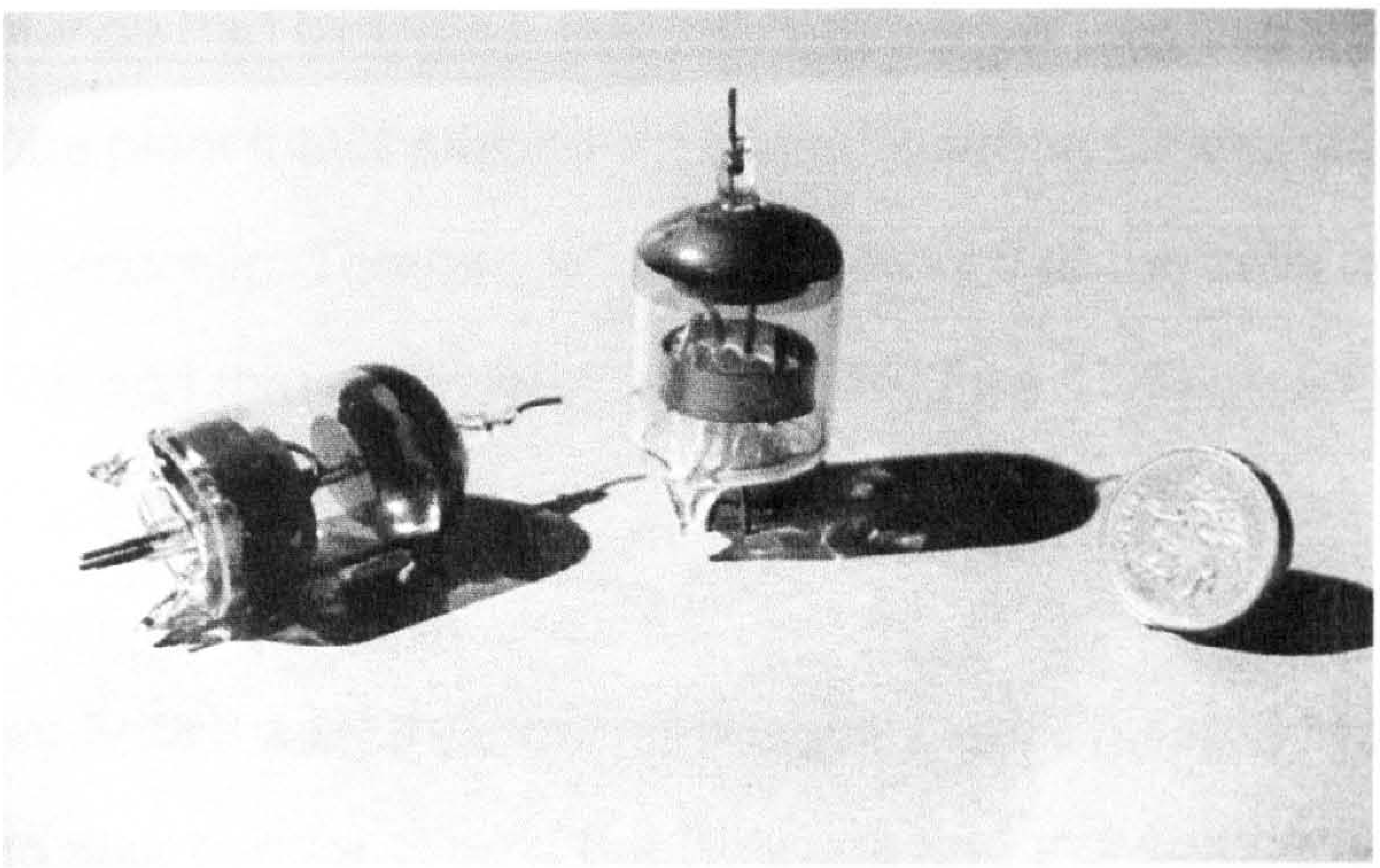


Figure 6.29: Photocells designed for the proximity fuse

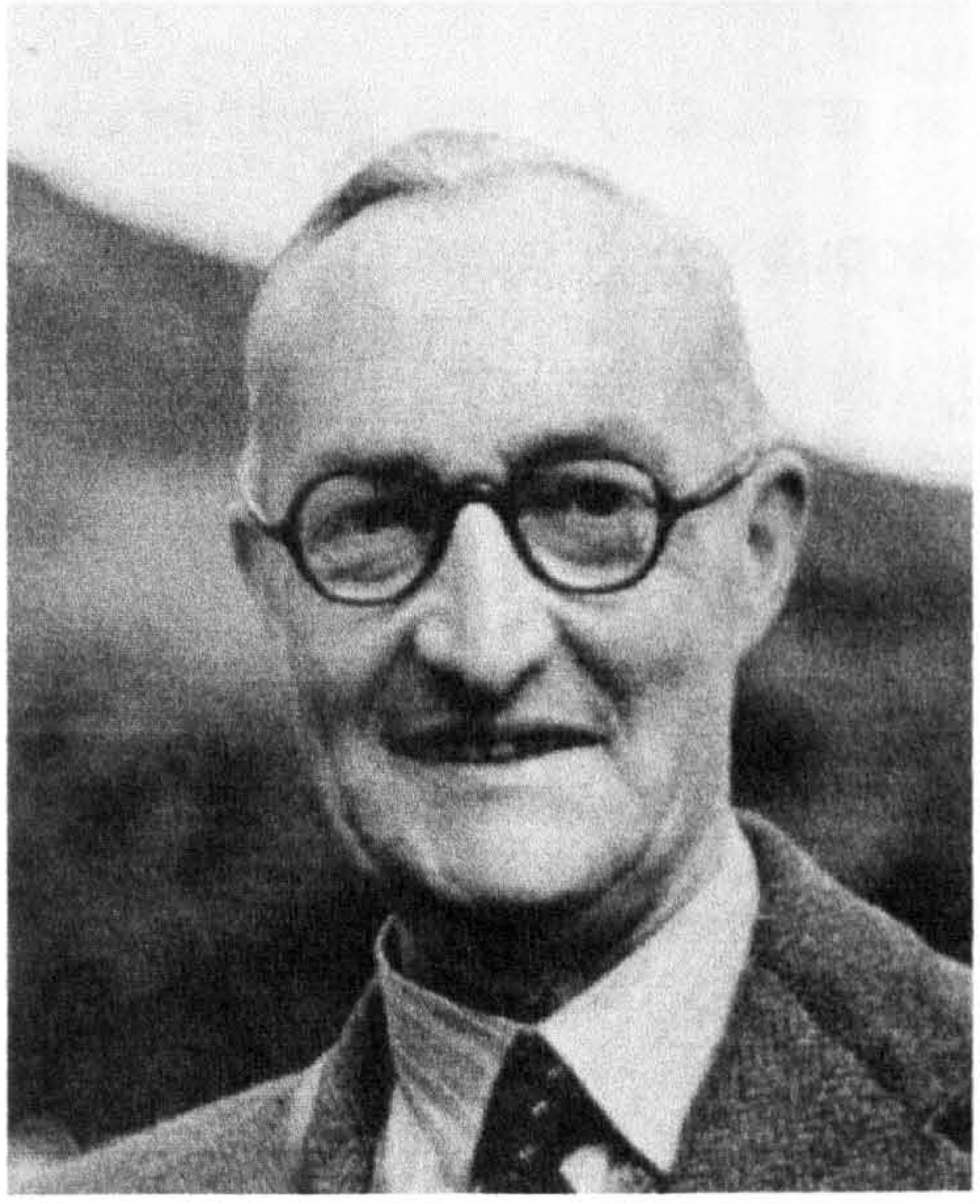


Figure 6.30: Captain Thurston Moon

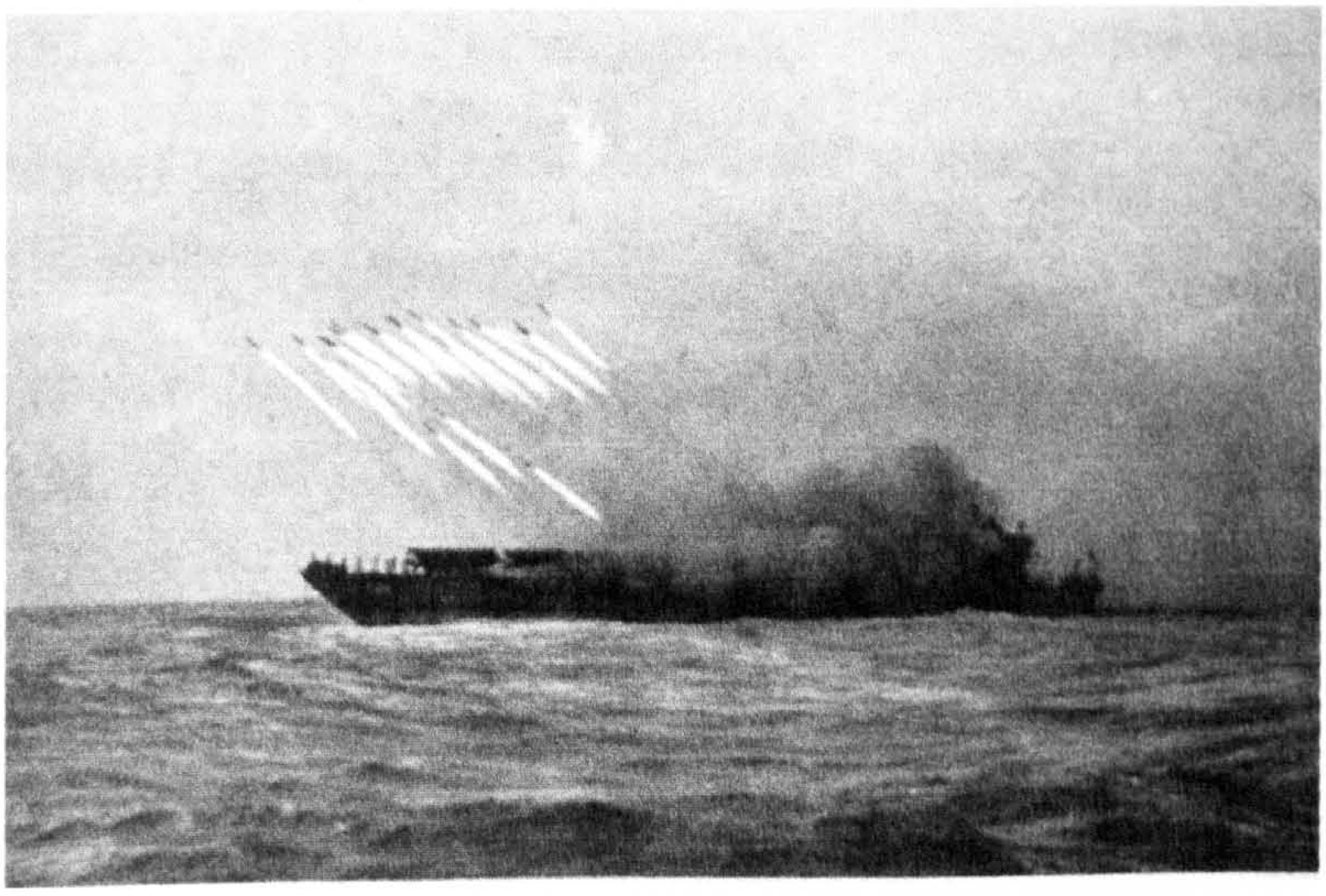


Figure 6.31: Testing proximity fuses at Aberporth firing range

The Rotunda had lain idle since the outbreak of war and still had the cathode-ray tube plant intact making it an ideal location for the mass production of photocells. Tomes [122] assured West that the cells could be made in quantity and that a simplified version (Figure 6.29) could be developed.

Gaumont British sent their own manager, Capt Thurston Moon (Figure 6.30) to take control of both the Rotunda and the Admiralty contract to supply 50,000 photocells. Tomes noted in his diary [123] that he first met Captain Moon on the 11 June 1940, and on 13 June he wrote: [124]

"Went to EMI with Capt West and Lance - very successful visit."

EMI was the firm assembling and testing the proximity fuses. Spencer and Gauss of EMI showed them the whole missile. Tomes [125] recalled that the tests of his latest design were good. Although West wanted to hold onto a level of control of the contract, Moon took complete control. For the next five years the Cinema Television Rotunda factory in the Crystal Palace grounds worked continuously for the war effort [126] independently from West.

On the 30 August 1941 Tomes learned [127] that at the end of the 50,000 proximity cell contract it was likely that there would be no further requirement due to the successful development of the radar fuse. In 1942 with the completion of the photocell contract in sight they were asked by the Ministry of Supply to manufacture in the Rotunda, 12 inch VCR140 cathode-ray tubes for radar applications.

Tomes recalled: [128]

"We started making 12 inch VCR140 tubes. They were used in ground radar tracking stations and were copies of tubes designed and made by

Dr Samson. Captain Moon persuaded Cintel director to have Williams, the experienced chemist, to be seconded to us from Lower Sydenham." Tomes recalled [129] that on 30 April 1942, they went over to see EMI regarding making copies of their electrostatic VCR97, a 6 inch radar tube used in airborne radar. On 18 July 1942, Tomes [130] visited the Post Office research laboratories at Dollis Hill where he met Dr Speight who had a requirement for 6,000 photocells for a "speaking clock" type of recording machine. On 3 February 1943, Tomes recorded that they had secured a large contract to produce 12 inch cathode-ray tubes including VCR140's and later a smaller version VCR516.

The contribution to the war effort carried out secretly in the Rotunda by Tomes and others was under the direct control of Captain Moon. This work was not related to the other war effort work carried out at Lower Sydenham under the leadership of Captain West. Although West's main concern was the mass production of Skiatron radar tubes, Appendix 4 serves to illustrate that there was interest in the imaging work of Sommer and Samson.

This concludes the work of this research which also includes lists of Baird patents. The next chapter is the analysis and conclusions.

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Chapter 7

Analysis and Conclusions

Figure 7.1: J.L.Baird's 600-line television picture of Paddy Naismith

Section 7.1

Analysis and Conclusions

The work of this research has shown that the scientists, and engineers, who were brought together by the Baird Company made a significant contribution to the development of modern electronic imaging. New evidence provided by this research has indicated that the Baird Television Company, under the leadership of Captain A. G. D. West, hired physicists, chemists, vacuum tube engineers, and other specialists who were of the highest calibre. It has been shown that the early television technologies of J. L. Baird, Fernseh, Farnsworth and Zworykin, which converged on the Baird Company in 1934, established targets which were realised and expedited with great precision.

The work of this research has also described in detail the Baird Television workshops, laboratories, studios and staff structure at the Crystal Palace and given an accurate account of the facility, expertise and technology practised. Key television development in Britain during the period 1931 to 1934 has been described and it has been shown that in 1933 Baird demonstrated for the first time a cathode-ray tube television system, which was in advance of the Farnsworth contribution. This research has indicated that the development of the iconoscope and its subsequent adoption by Marconi-EMI was an important catalyst for the radical work of the Baird scientists and engineers. Evidence has been cited to show that from 1939 Baird Television produced their own storage camera tube.

It has been shown that Baird Television's application of the Metropolitan Vickers demountable tetrodes in their vision transmitter either anticipated, or was part of, the program of development for the British Chain Home Radar stations, which also used these valves.

The work of this research has shown that Baird's early film scanning techniques, namely the intermediate film and the telecine, reached a sophisticated level of refinement by Cinema Television, (Now Cintel International) to become the universal standard for televising and archiving recorded video material. It has also been shown that despite the advent of the video recorder the modern Cintel telecine is still regarded as the most professional method for quality post-production television work.

This research has shown that Dr Samson was responsible for the development of the Farnsworth image dissector camera at Baird Television and that Dr Sommer improved the sensitivity by replacing the inefficient Farnsworth multiplier with the Weiss multiplier stage. It has also been shown that the image dissector camera and control gear was safely at the Alexandra Palace and remained undamaged by the fire which destroyed the Crystal Palace on 30 November 1936. It has been described that while Dr Szegho developed and produced prototypes in the cathode-ray tube research and development laboratory for Merdler (television receiver development), it was Dr Hodgson who had the production knowledge required to manufacture Baird Cathovisor tubes in quantity. It has also been shown that Baird television receivers with 15 inch tubes produced the largest television images available in Britain between 1936 and 1937.

This research has also revealed that in 1936, Dr Szegho produced an image convertor tube and a monoscope still picture tube, providing evidence of the level of sophisticated technology practised. Szegho and Tomes also produced the first projection cathode-ray tubes for theatre screens at Baird Television which culminated in the invention of the pipeshaped projection tube.

In comparing the specifications of the Baird 240 sequential line to the Marconi-EMI 405 interlaced line broadcasting standard, it has been described that the number of pixels in the Baird system slightly exceeded the number available by the Marconi-EMI system. The main advantage of the Marconi-EMI system was the reduction in perceived flicker while Baird showed a marked improvement in horizontal line resolution.

This research has also identified and analysed the formerly secret British Air Ministry Files which describe the Baird Television contract to fit and commission television apparatus in a Marcel Bloch bomber for the French Air Ministry.

It has been described that Baird Television was put into receivership in 1940 by Gaumont British, and continued as Cinema Television (Incorporating Baird Television) as an industry primarily funded by the Ministry of Supply. As part of the war effort Cinema Television produced mine detectors, photoelectric incendiary detectors, and was the main contractor for 15,000 PPI Skiatron radar tubes at Sydenham under the direction of Captain West. Simultaneously a secret contract to produce 50,000 optical proximity fuses for missiles was carried out by Tomes under the direction of Captain Moon in the Rotunda. It has also been identified that large quantities of other radar display tubes were produced in the Rotunda including: VCR97's, VCR140's and VCR516's.

New evidence has shown that among the most notable work carried out at Baird television was the research by Dr Sommer on novel photoelectric surfaces. This has revealed that in 1938 Sommer invented an alloy photosurface (now known to be a semiconductor layer) using a combination of caesium and antimony, (Cs_3Sb) which had an almost 40 fold increase in blue response over Ag-O-Cs. This research has also shown that Sommer invented the first panchromatic photosurface using a combination of bismuth and silver-caesium oxide (Bi-Ag-O-Cs). This was a cathode material which was used universally in the image orthicon, the standard camera used in commercial television after the Second World War. The panchromatic response photosurfaces were developed initially for J. L. Baird for his 600 line colour television project. Figure 7.1 at the beginning of this section shows a surprisingly good colour television image produced in December 1940 by J. L. Baird.

In analysing the conclusions of this research it is important to reflect on the work of the pacemaker of television development, John Logie Baird, and to show relevance to a section of his work in 1940. Although the demise of Baird Television at the outbreak of hostilities was a major disappointment, it was also the important factor responsible for focusing Baird's attention on contributions to the development of colour and three dimensional television research.

J. L. Baird wrote: [1]

1 Baird, J. L. Letter to Lord Hankey. 25 March. 1944. p.2.

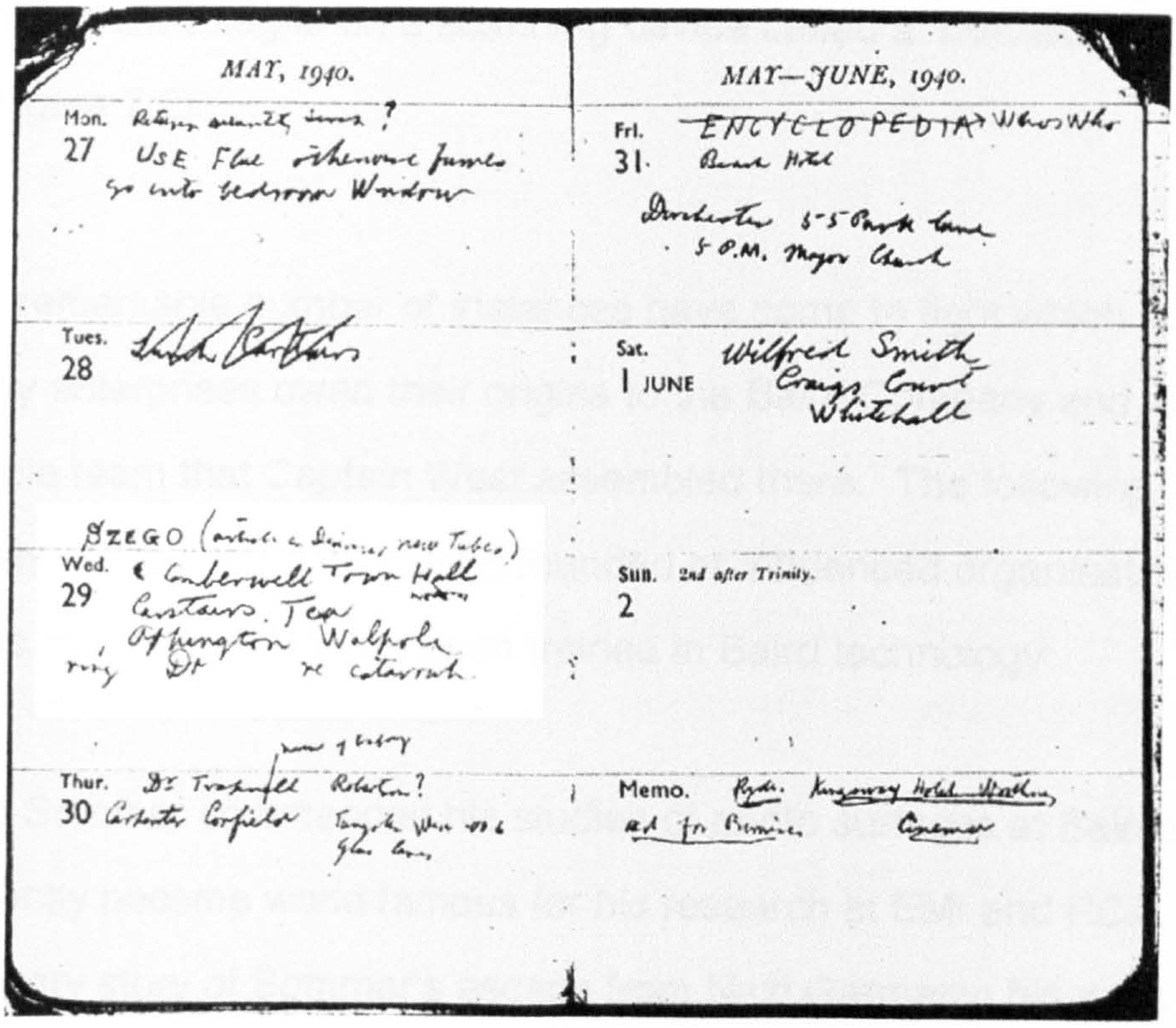


Figure 7.2: Baird's diary 28 May 1940
"Szego (sic) articles on Diavisor, new Tubes."

"My laboratory and my patents since 1939 are entirely my own property. I was approached in 1941 by Cable & Wireless Ltd. (who control the Marconi Co.) and accepted a position with them as Technical Adviser."

Baird's ingenuity was supported by the technology of the Baird Company. The colour photomultipliers he used were unique to Baird Television and consisted of the first panchromatic (Bi-Ag-O-Cs) surfaces made and supplied by Sommer. The scanners which J. L. Baird used to electronically scan living subjects was also state-of-the art, and unique to Baird Television, this was the pipeshaped projection cathode-ray tubes designed, developed and presumably supplied by Szegho. Entries with Szegho's name appear regularly in J. L. Baird's diary until June 1940 and are reminders to contact and obtain projection tubes. Baird also requested information from Szegho on a scanning device called a 'Diavisor' light valve. (Figure 7.2).

A remarkable number of instances have come to light which suggest that many enterprises owed their origins to the Baird Company and to the remarkable team that Captain West assembled there. The following individuals can be listed as having founded or influenced organisations largely as the result of having been trained in Baird technology:

Dr Sommer commenced his studies of photo surfaces at Bairds and subsequently became world famous for his research at EMI and RCA. The extraordinary story of Sommer's escape from Nazi Germany, his work at Baird, EMI and RCA is outlined in "The Sommer Story" currently being researched jointly, by Gilbert Tomes, Robert Allan and Douglas Brown. The Japanese were the first to recognise his achievements, hailing him as the true 'Father of Photoelectricity'. John Logie Baird was one of the few who during the war years recognised the importance of Sommer's work.

Gilbert Tomes left Bairds in 1945 to found 20th Century Electronics, which became the Centronic Group of Companies. He recruited almost all his tube engineers and glass-blowers from Cintel. The Company became world famous as specialist manufacturers of electronic sensing devices, making Radiation Detectors, Photo Multipliers, CRT's Solid State Detectors and Stable Isotopes. The Company was partly financed by selling know-how licenses to firms like ACEC in Belgium, CSF and Thomson-Houston in France, Landis & Gyr in Switzerland and the Eagle Picher Corporation in the USA. The Company, which employed 350 was located at New

Addington, Croydon.

During the second world war, in October 1940, Dr. Szegho left Bairds to go to the USA, where, together with Richard Tingley he represented the Baird Company for a period in New York. They tried to promote projection TV but, as in the UK, it never really took off. Szegho joined the Rauland Corporation for a period, but it was the Zenith Corporation in Chicago that he finally made his mark, where he headed a team developing commercial CRT's for Television. Characteristically, he carried out his duties with immense energy and enthusiasm, striving, above all, to forge strong links with those at the top of what was one of the several giant television set manufacturers in the USA.

Gordon Craig contributed much to the technology of high speed photographic processing for the intermediate film system. Craig left Bairds after the fire to become technical manager of the UK Kodak Company. He held this prestigious post for many years enjoying a distinguished career.

Dr. Hamburger joined the Hartley-Baird Company (founded by J. L. Baird) and after the war and did much work on pay-television systems. He became an acknowledged expert in the field and published many papers.

Bill Bailey worked at Bairds in the Intermediate Film Department leaving after the fire to join North American Philips in the USA. In the early sixties he founded a highly successful company, Bailey Instruments Incorporated located just outside New York, where his principal business was to import and sell Centronic Photomultipliers. Tomes had known

Bailey at Bairds, and gave Bailey an exclusive agency, which enabled Bailey to win the coveted "Beckman Import Award". It is interesting to note that, for many years, the American photomultiplier market was dominated by the two UK firms, Centronic and EMI, both of whom used designs which were developed by Dr Sommer.

Dr. Colls worked at Bairds for a short period in 1938, helping Dr Samson, making electron tubes in the Rotunda. He left Bairds and after the war, founded the firm, Southern Instruments, which pioneered the construction of miniature oscilloscopes and instruments. The Company was located at Camberley in Surrey and exhibited regularly at the Physical Society's Annual show.

Several former Baird Engineers distinguished themselves in Government positions and these included Ian Anderson, who went to the Admiralty, Tempero who became a top scientist at TRE/ Malvern and George Graham who became an adviser in the Intelligence Services. Nuttall joined Bairds prior to the war and worked at the Company for many years. His brilliance as a circuit engineer is legendary and the value of his work both during the war and afterwards cannot be overestimated.

John Logie Baird contributed to the development of television and the industry. He was the catalyst who fired the imagination of the scientists and engineers who followed and improved upon his work. The extent of his work may found in the Baird Television and J. L. Baird British patents, collated and listed numerically in Appendices 5 and 6, which total 503 applications between 1923 and 1945.

Glossary of Terms

AC: Abbreviation for alternating current.

Accelerating electrode: An electrode in a cathode-ray tube, vacuum tube or in a solid state device, to which a positive potential is applied to increase the velocity of electrons or ions.

Actinic: The property of producing a chemical change, such as the photographic action of light.

Active infrared detection: An infrared detection system in which a beam of infrared rays is transmitted toward one or more possible targets, and the rays reflected from the target are detected.

Aerial: Also called antenna. That portion usually wires or rods, of a radio transmitter or receiver station used for radiating electromagnetic waves into, or receiving them from the ether.

Afterglow: The light remaining on the screen of a cathode-ray tube after the trace has been removed. In the case of incandescent lamps the afterglow is caused by the heat remaining to cause the filament to glow after the voltage has been removed.

Alloy: A composition of two or more elements, of which at least one is a metal.

Alternating current: Abbreviated ac or AC, A flow of electricity which reaches maximum in one direction, decreases to zero, and then reaches a maximum in the opposite direction.

Aluminised-screen picture tube: A cathode-ray picture tube which has a thin layer of aluminisation deposited on the back of its fluorescent screen to improve the brilliance of the image.

Amplifier: An electrical device, usually consisting of thermionic tubes (or modern solid state devices), which increase the energy of an electrical signal.

Amplitude: The magnitude of variation in a changing quantity from its zero value.

Amplitude modulation: A process in which the magnitude of a carrier wave is varied in accordance with an input signal.

Anode: The positive electrode in a vacuum tube (or solid state device) which attracts the majority of electrons emitted by the cathode.

Aperture: The size of the scanning electron beam striking the target or mosaic of an electronic tube, or the size of the hole relative to a single picture element in a mechanical scanner.

Aquadag: Trademark of Acheson Industries, Inc. A conductive graphite coating on the inner side walls of some cathode-ray tubes. Also applied to outer wall and grounded it serves with the inner coating as a capacitor to filter the applied high voltage.

Bandwidth: The range of frequencies of a device, within which its performance, with respect to some characteristic, conforms to a specified standard. Previously known as 'cycles per seconds'. bandwidth is specified in Hertz.

Blanking: The method of suppressing the returning trace in a cathode ray tube.

Caesium: Chemical element having a low work function and used in caesium-oxygen-silver photocells.

Camera signal: The video output of an electronic camera.

Camera tube: An electronic tube which converts the light and shade of a scene into electrical signals.

Candela: Formerly candle. the unit of luminous intensity.

Cathode: The negative electrode which emits an electron stream under certain conditions.

Cathode-ray tube: A vacuum tube in which a beam of electrons may be guided toward a fluorescent screen, which glows when struck by the beam.

Chain radar system: A radar system comprising a number of radars or radar stations located at various sites and linked together by data and communications lines for target acquisition.

Charge storage: Electrical charges representing the contrast and brightness of an image stored in a multiplicity of tiny capacitors on the matrix of a television camera.

Cinematograph: Motion picture camera or projector previously known as Kinematograph.

Closed circuit: Television signals not transmitted by cable or radio but directly connected to a local receiver monitor.

Cold cathode tube: A vacuum tube in which no external; source is used for heating the cathode. These tubes rely on electronic emission caused by the attraction of electrons by electromagnetic or electrostatic forces.

Composite picture signal: The complete television signal consisting of the video signal, blanking signal, and the horizontal and vertical synchronising pulses.

Contrast: The amplitude relationship between light and shade in a picture.

Cycle: The change of an alternating wave from zero to a negative peak to zero to a positive peak and back to zero.

DC component: A fixed reference level in the video signal that represents the average illumination of the entire scene.

Definition: The amount of detail in a picture depending on the number of picture elements available.

Diode: An electric device with two electrodes, a cathode and an anode, which passes electrical current in only one direction.

Eddy currents: Those currents induced in the body of a conducting mass by a variation in magnetic flux.

Eddy current heaters: The method of producing heat by subjecting a material to a variable electromagnetic field. Internal losses in the material then cause it to heat up. Also known as induction heating.

Electromagnetic focusing: The focusing of an electron beam by means of an electromagnetic field.

Electron beam: A concentrated stream of electrons consisting of negatively charged particles.

Electron camera: A television camera that used the Image Dissector tube.

Electron gun: The structure in the neck of a cathode ray tube consisting of an electron-emitting cathode.

Electron multiplier: A device for multiplying an electron emission by means of one or more bombardments of targets.

Electronic camera: An device which converts light waves from a scene into corresponding electrical signals.

Electronic multiplication: Electrical phenomenon which uses the principle of release of electrons from a surface when that surface is struck by other electrons.

Emitron: See iconoscope.

Facsimile: The transmission of still photographs by means of telephony or radio.

Field: One set of scanning lines of a television picture. In a 2-1 interlaced system, two fields make up one complete frame.

Filament: A slender thread of material such as tungsten which emits light when raised to a high temperature by an electric current flowing through it, as in an incandescent light bulb.

Fluorescence: The physical property of certain substances giving off visible light.

Flying spot scanning: A form of scanning (either mechanical or electrical) where a spot of light traverses a solid object or an image in a particular pattern to transmit a television image by detecting the reflected light using a photo sensitive device.

Footcandle: The unit of illumination when the foot is taken as the unit of length.

Footlambert: A unit of luminance (photometric brightness) equal to $1/\pi$ candela per square foot, or to the uniform luminance of a perfectly reflecting diffusing surface, emitting or reflecting light at the rate of one lumen per square foot, or to the average luminance of any surface emitting or reflecting light at that rate.

Frame: The total area occupied by the picture which is scanned while the picture signal is not being blanked.

Grid: A free-electron controlling electrode in a vacuum tube or solid state device.

Iconoscope: See also emitron. A camera tube in which a high velocity electron beam scans a photoactive mosaic (or target) which has an electrical storage capacity.

Image convertor: An optoelectric device capable of changing the spectral characteristics of a radiant image, examples are infrared to visible and X-ray to visible. An electron tube that employs electromagnetic radiation to render a visual replica of an image focused on its cathode.

Image dissector: A television camera tube in which an electron replica of an image focused on its cathode is swept past an aperture to be converted into a television signal by an electron multiplier.

Incandescent lamp: An electric lamp in which electric current flowing through a filament of resistance material heats the filament until it glows.

Intensity modulation: The method of modulating the electron beam by varying the intensity of the beam as it sweeps the fluorescent screen.

Interlaced scanning: A form of television scanning in which every other horizontal line of the image is scanned during one downward movement of the scanning beam, with alternate lines scanned during the next downward movement.

Intermediate film process: In the transmitting process, a scene is first filmed by an ordinary motion picture camera, quickly processed, and converted into a video signal by a film scanner. In the receiving process, the video signal is displayed on the face of a tube (or disc) which is photographed by a film camera. The film is quickly processed and then projected onto a screen by means of an ordinary film projector.

Kerr effect: The rotation of a beam of plane-polarized light by means of an iron pole piece under a strong magnetic field.

Kinescope: See also oscillite. A television picture tube.

Lens disc: A television scanning disc having a series of lenses in the apertures.

Light chopper: A device for interrupting a light beam.

Light valve: A device which can control (vary) the amount of intensity of a light source corresponding to an input signal.

Lumen: A unit of light emitted from a point light source of one candle through a unit solid angle.

Lux: A metric unit of illumination equal to the intensity produced by a standard candle on the surface of an object placed one meter from it and at right angles to the light radiation.

Mechanical scanning: Any process of dissecting an image done by means of mechanical parts, including discs, drums, belts, mirror screws, vibrating mirrors, etc.

Mirror drum: A scanning device consisting of a series of mirrors fixed to its periphery. Each mirror is set at a slightly different angle from the one preceding it.

Modulate: To vary, as to vary the amplitude or frequency of an oscillation in some characteristic manner.

Monitor screen: The fluorescent face of a cathode ray tube.

Monochrome: Transmission of television signals in one colour only. Consists of shades of gray and white.

Monoscope: An electron beam tube in which the picture signal is generated by scanning an electrode, parts of which have different secondary emission characteristics.

Mosaic: The light-sensitive plate in an iconoscope or orthicon upon which the optical image is placed and then scanned by an electron beam. It consists of a multitude of individual elements. (See also target.)

Orthicon: A camera tube in which a low velocity electron beam perpendicularly scans a photoactive mosaic that has electric storage capability.

Oscillite: Also see **Kinescope**. A television cathode-ray picture tube.

Polarised light: Light that has been polarised by being passed through certain substances so that the transverse vibrations are in one plane instead of many.

Photocathode: A cathode that emits electrons under the influence of radiant energy such as light.

Photoelectric cell: Any cell whose electrical properties are affected by illumination; a device which converts variations in light into corresponding variations in voltage or current.

Phototube: A vacuum tube in which the electric emission is produced directly by radiation falling on the cathode.

Picture elements: Name given to the minute areas in which a picture is to be dissected by any given means. All are of the same size but may differ in brightness. Also called pixels.

Picture tube: The image-producing electronic tube in a television receiver. (See also Kinescope.) pixels see picture elements.

Projection cathode-ray tube: A cathode-ray tube that produces an intense by relatively small image, which can be projected onto a large viewing screen by an optical system.

Pulse: A periodic or regular beat.

Radar: Acronym for radio detecting and ranging. A system that measures the distance and direction of an object from which a transmitted pulse has been reflected. In primary radar the time measured between the transmitted and reflected pulse is scaled in relative distance.

Raster: A predetermined pattern of lines scanned on the screen of a cathode-ray picture tube.

Radio-relay: The transmission of television signals from point to point.

Regulator: A device which maintains a desired quantity at a predetermined level.

Resolution: The sharpness or degree of reproduction of the detail in a scene after transmission through an electron, optical, or complete television system.

Scanning: The process of analysing successively, according to a predetermined method, the light values of picture elements constituting the total picture area.

Scanning aperture: An opening in a scanning disc through which the scanning beam passes. In an electronic system, the size of the electron beam is determined by the electron gun.

Scanning disc: A perforated disc usually having apertures spaced at equal angular intervals. Some discs have more than one row of holes, may be staggered, may be in a spiral, or may use lenses.

Secondary emission: Liberation of electrons (secondaries) from an electrode when it is hit or bombarded by other electrons (primaries).

Sequential scanning: A simple form of television scanning where the picture is scanned line by line only once during a complete frame cycle.

Shading: The process of compensating for the spurious signals generated in a camera tube during the trace interval.

Shading signals: Spurious signals from a camera tube caused by distribution of secondary electrons on the signal plate.

Signal plate: A term applied to the plate of the Iconoscope tube on which is built a mosaic of minute light-sensitive cells on which the scene to be televised and converted into electrical signals is focused. (See also target.)

Signal to noise ratio: The ratio of the intensity of wanted signals to the intensity of noise signals accompanying it.

Skiatron: A dark trace long persistence oscilloscope or radar cathode-ray tube which is episcopically projected onto a screen. The screen is fabricated from potassium chloride.

Synchronising generator: An electrical device that produces special pulses for keeping the electron beam at the receiver in step with the electron beam at the camera .

Target: The light-sensitive plate in a camera tube on which the picture is formed. It is usually traversed by an electron beam to retrieve the picture information. It may be either continuous or mosaic.

Telecine: The term used for operations involving the sending of motion picture film in television.

Television: The instantaneous electrical transmission and reception of transient visual images perceived by persistence of vision.

Thermionic tube: A vacuum tube in which electronic emission is produced by a heated cathode.

Tetrode: A four electrode electron tube containing an anode, a cathode, a control grid and a screen grid which a stability advantage over a triode.

Triode: A vacuum tube having three electrodes: a cathode, an anode, and a control grid.

Baird and Marconi-EMI System Resolution

Marconi-EMI Interlaced System

The duration of one horizontal line is calculated by dividing the time of one complete frame (two interlaced fields) by the number of horizontal scanning lines. Therefore:

Duration of horizontal line = $40 \times 10^{-3} / 405 = \underline{98.7} \times 10^{-6}$ seconds.

The on-screen duration of the line is less than this due to the line sync pulse which in this case occupied 15% of the line or 14.8×10^{-6} seconds. Therefore:

Visible screen line = $98.7 \times 10^{-6} - 14.8 \times 10^{-6} = \underline{83.9} \times 10^{-6}$ seconds.

The highest frequency transmitted during the trials was set by the Post Office to be 2MHz. To calculate the horizontal definition of the 405 line system it is necessary to divide the duration of the on-screen line by the period of one cycle at 2MHz. As one cycle equals two picture elements it is necessary to double this figure to identify the maximum possible horizontal picture definition of the pre-war 405 line system. Therefore:

Horizontal resolution = $(83.9 \times 10^{-6} / 0.5 \times 10^{-6}) \times 2$ = <u>334 pixels</u>

As vertical resolution is determined by the number of lines on the screen:

Vertical resolution = 405 - (20 lines field blanking) = <u>385 lines</u>

Therefore it can be stated that the maximum number of picture elements possible by the Marconi-EMI 405-line interlaced system = 334 x 385 pixels.

Definition Possible by Marconi-EMI

334 x 385 = <u>128,590 picture elements</u>

Baird Sequential Television System

The duration of one horizontal line is calculated by dividing the time for one complete frame by the number of horizontal scanning lines.

Therefore:

Duration of horizontal line = $40 \times 10^{-3} / 240 = \underline{166.7} \times 10^{-6}$ seconds

The on-screen duration of this line is less due to the off-screen line sync pulse which in this case occupied 10% of the line or 16.7×10^{-6} seconds.

Therefore:

Visible screen line = $166.7 \times 10^{-6} - 16.7 \times 10^{-6} = \underline{150} \times 10^{-6}$ seconds

The highest frequency transmitted during the trials was set by the Post Office to be 2MHz. To calculate the horizontal definition of the 240 line system it is necessary to divide the duration of the on-screen line by the period of one cycle at 2MHz. As one cycle equals two picture elements it is necessary to double this figure to identify the highest horizontal picture definition of the 240 line sequential system.

Therefore:

Horizontal definition = $(150 \times 10^{-6} / 0.5 \times 10^{-6}) \times 2 = \underline{600}$ pixels

As the vertical definition is determined by the number of lines on the screen:

Vertical definition = 240 - (20 lines frame blanking) = <u>220 lines</u>

Therefore the maximum number of picture elements for the Baird 240-line sequential system = 600 x 220 pixels.

Definition Possible by Baird Television

600 x 220 = <u>132,000 picture elements</u>

Appendix 2

Baird Television

Theatre Televison Specifications

1938

SCHEDULE OF PRICES

		£. s. d.
I.	One Twin Projector Unit complete	380. 0. 0.
	One 320 mm f/1.5 Lens for above	150. 0. 0
	Two Cathode Ray Projection Tubes	70. 0. 0
	One complete set of Valves	29.15. 0
II.	Two Tube High Tension Supply Units, complete with limiting resistances and interlocking safety switches	551. 0. 0.
	Four E.H.T.1. Rectifier Valves for above	48. 0. 0.
III.	One Sound Amplifier and Power Supply Unit, and two Loud speakers	37. 0. 0.
	One complete set of Valves	2.10. 0.
IV.	One Television Screen complete	95.15. 0.
V.	Two Television Aerials	5. 0. 0.
VI.	Two Spare Cathode Ray Projection Tubes	70. 0. 0.
	Two Spare E.H.T.1. Rectifier Valves	24. 0. 0.
	One complete set of spare valves	32. 0. 0.
		£1,495. 0. 0.

The Baird Theatre Television
Schedule of Prices

SPARE CATHODE RAY PROJECTION TUBES AND VALVES.

PROJECTOR UNIT.

2 Baird Cathode Ray Projection Tubes.

TIME BASES.

8	Cossor	41 MP	valves.
2	Mazda	AC6/PEN	"
2	Mullard	SP4B	"
2	"	TSP4	"
6	"	354 V	"
4	"	2D4A	"

TIME BASE AND FOCUS POWER SUPPLY UNITS.

4	Mullard	IW4	Rectifier Valves.

VISION AMPLIFIERS.

4	Mullard	TSP4	Valves.
6	Mazda	D 1.	"
2	Mullard	PEN/B4	"

AMPLIFIER POWER SUPPLY UNITS.

4	Mullard	IW4	Rectifier Valves.

VISION RADIO RECEIVERS.

8	Mullard	TSE4	Valves.

SOUND RADIO RECEIVERS.

2	Mullard	EE 50	"
2	R.C.A.	6J5	"
2	"	6N7	"

VISION AND SOUND RECEIVER POWER SUPPLY UNITS.

2	Mullard	IW4/350	Rectifier Valves.

SOUND AMPLIFIER AND POWER SUPPLY UNIT.

2	R.C.A.	6C8G	Valves.
2	"	6L6G	"
1	"	83-V.	Rectifier Valve.

TUBE HIGH TENSION SUPPLY UNITS.

2	Osram	EHT1	Rectifier Valves.

The Baird Theatre Television
Spare Tube and Valve List

REPAIR OF CATHODE RAY PROJECTION TUBES

In the event of failure of the filament or deterioration of the fluorescent screen of a Cathode Ray Projection Tube, the Tube may be returned to us for repair.

Price for re-filamenting a Tube:-	£5. 0. 0.
Price for re-screening and re-filamenting:	10. 0. 0.

Any one Tube may undergo a maximum of three such repairing operations.

In the event of minor damage to the glass work, a Tube may be returned to us for examination, and we will make a special quotation for repair if this is practicable.

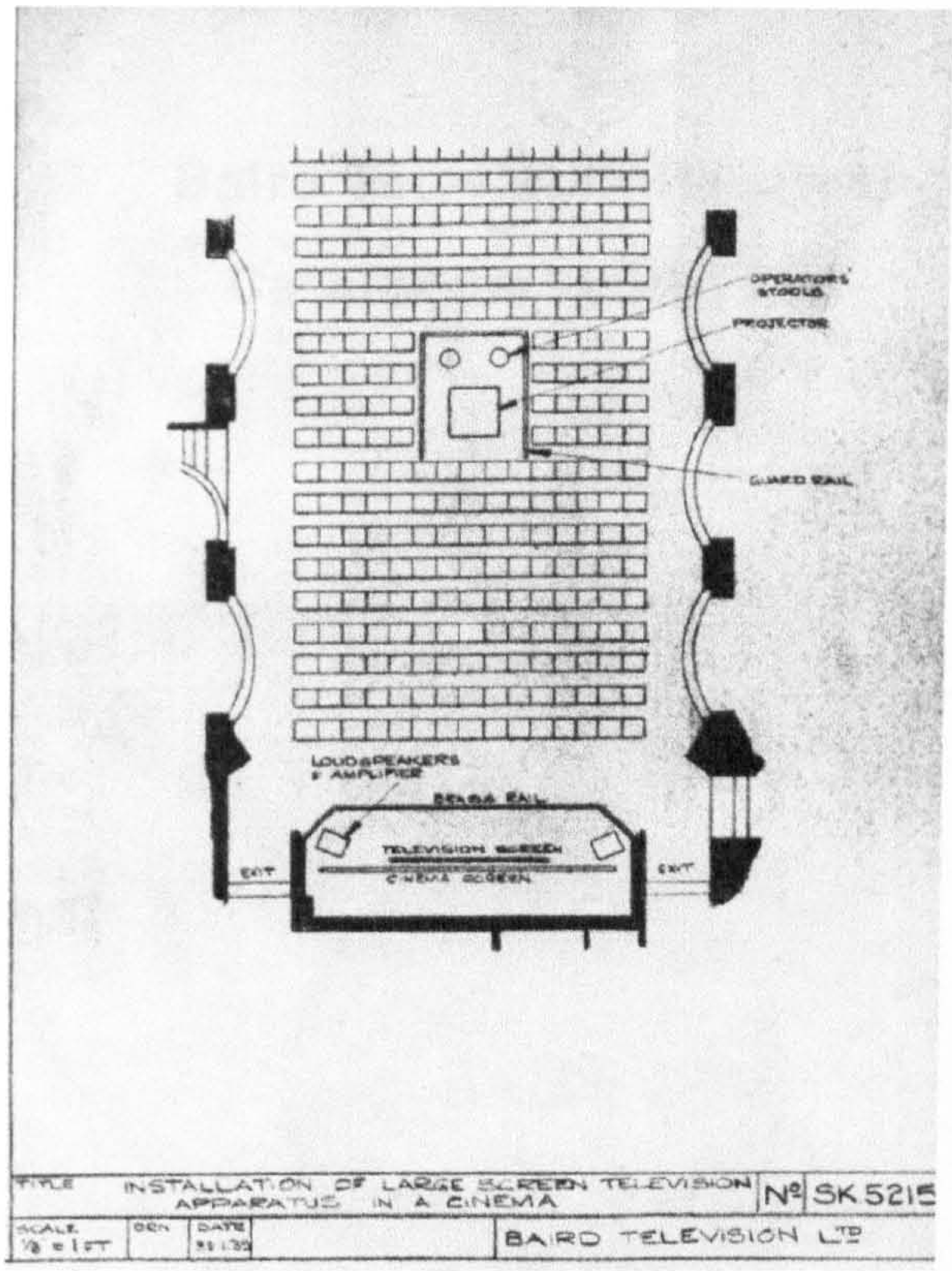
In our Schedule of Prices we do not include for the following, as the cost will depend entirely upon local conditions.

1. Labour and material involved in installation and wiring.
2. Aerial masts.
3. Cubicles for Tube High Tension Supply Units.
4. Special Feeder and High Tension Cable.
5. Mechanism for moving Television Screen.

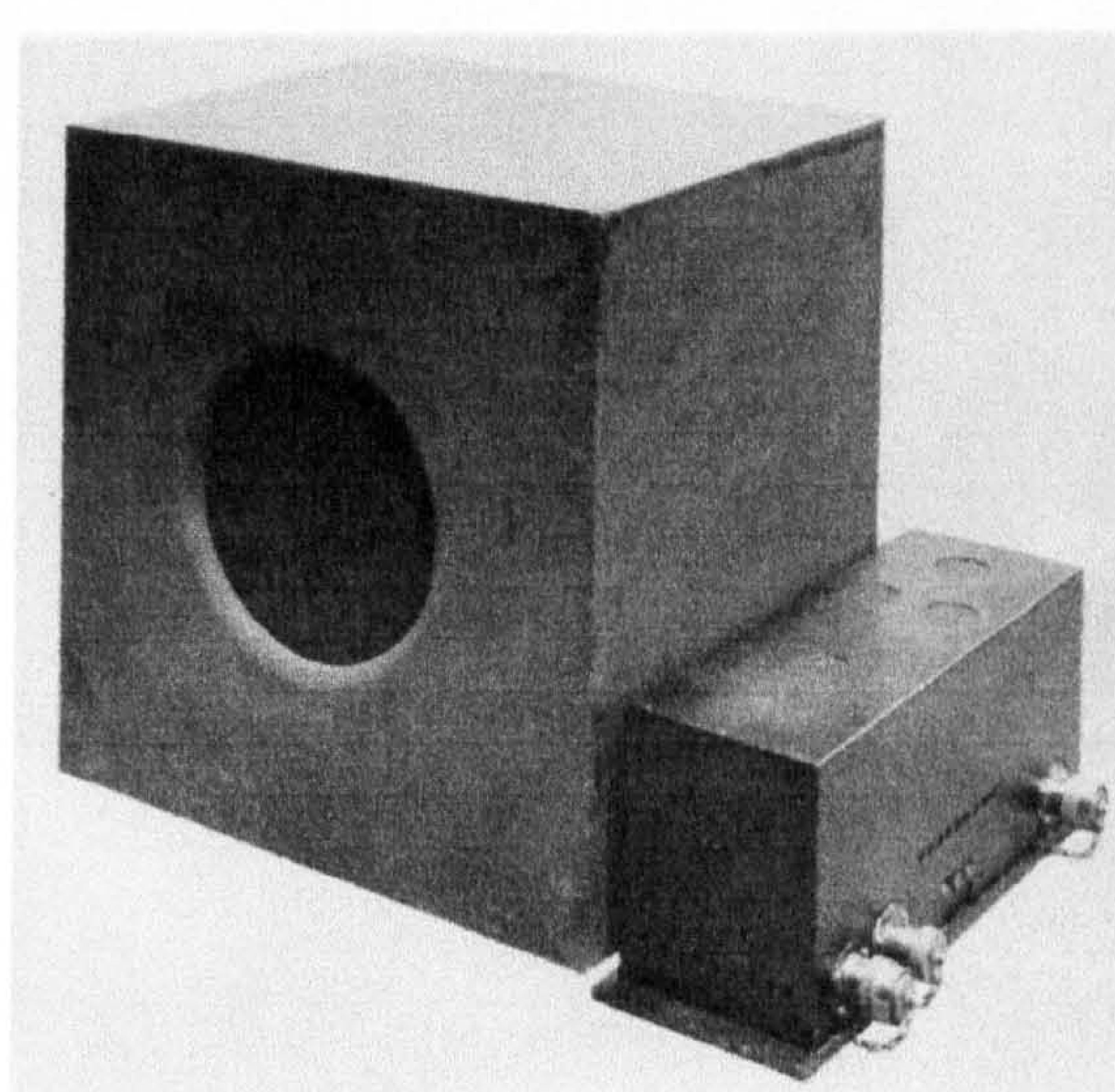
Our prices are f.o.b. London, and do not include any Customs Duties.

Delivery of the complete Equipment could be effected in six months from the date of receipt of your order.

The Baird Theatre Television
Tube Repair Schedule



The Baird Theatre Television Installation
Drawing

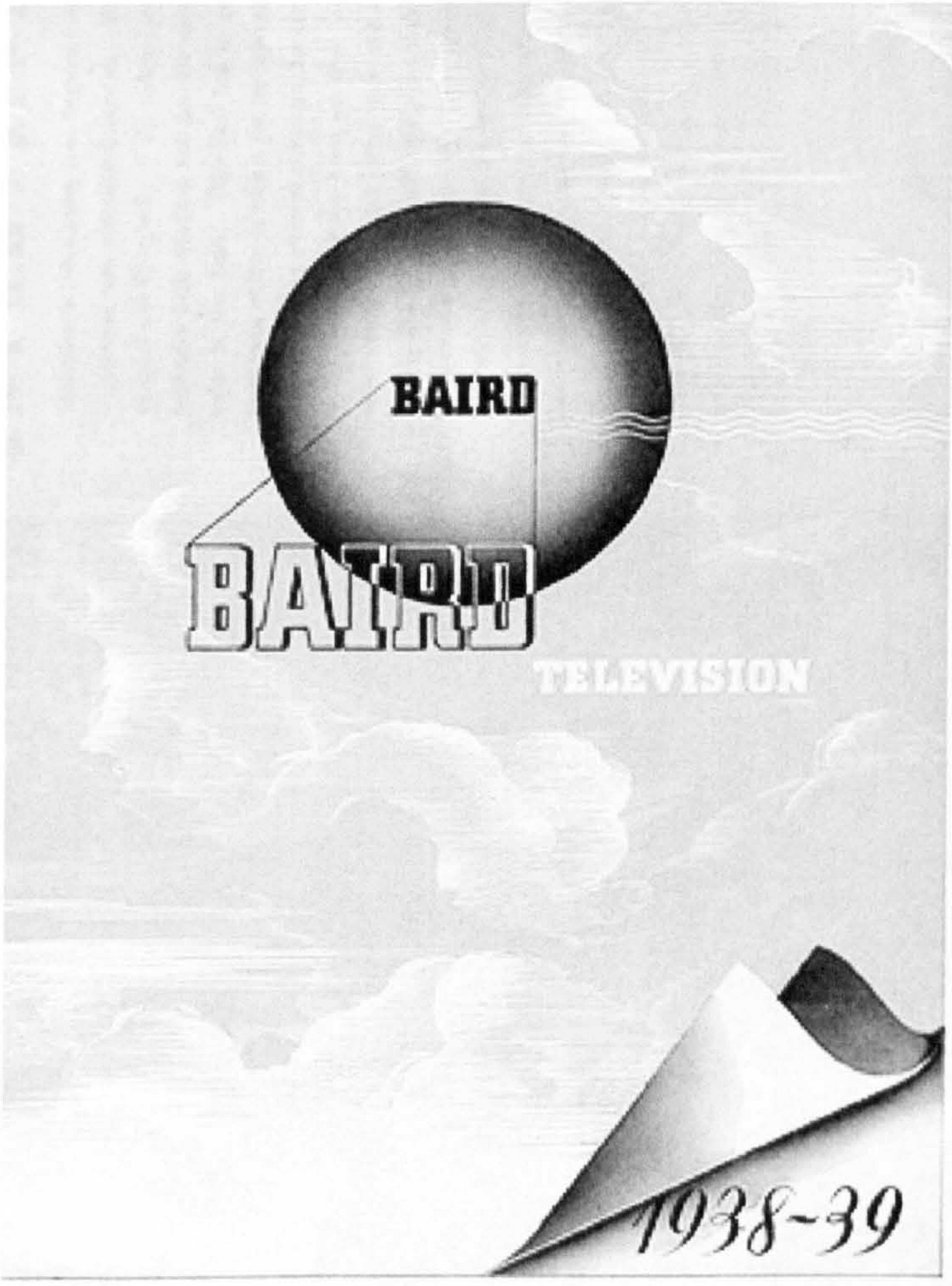


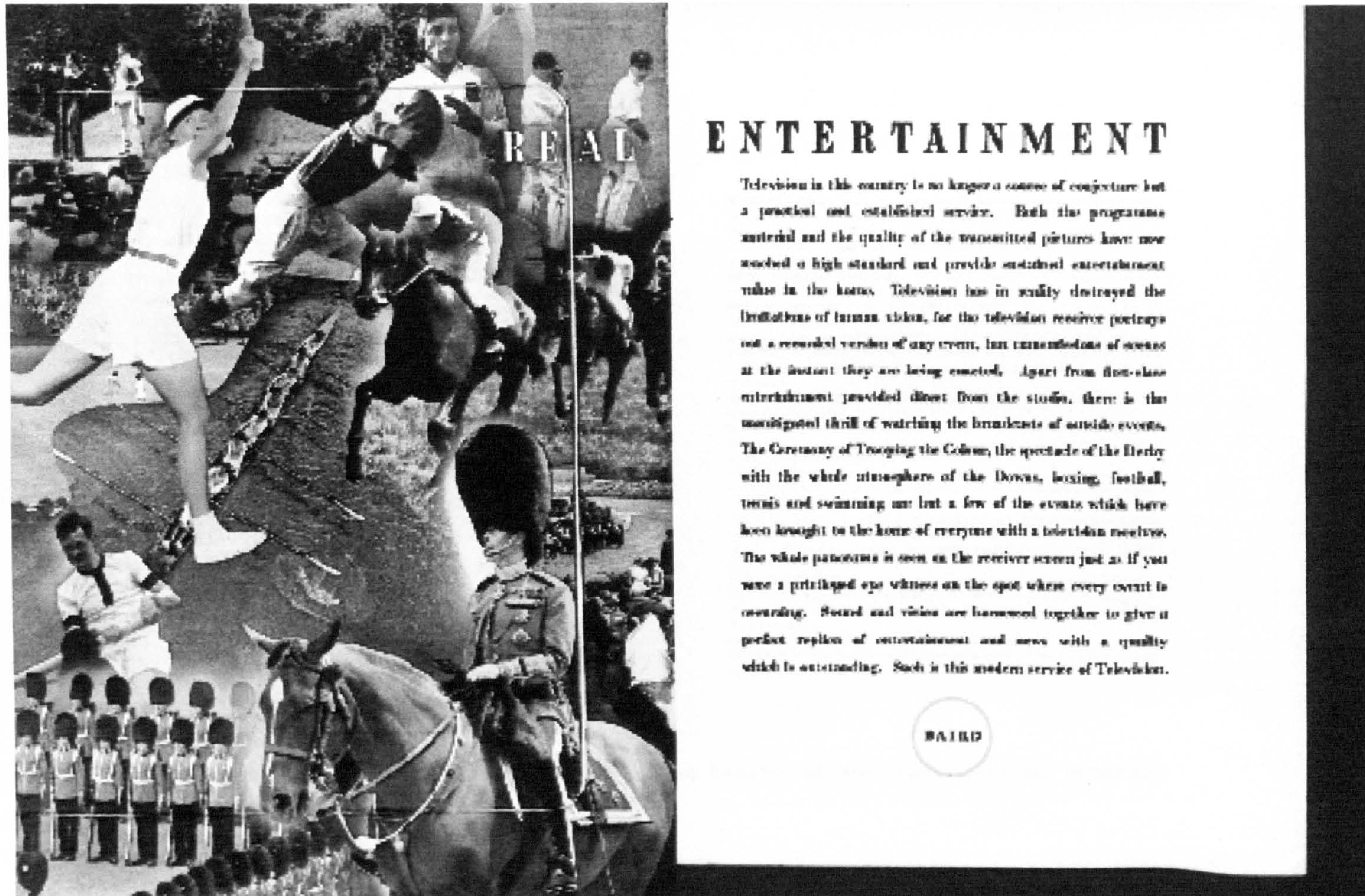
The Baird Theatre Television
Amplifier and Speaker Unit

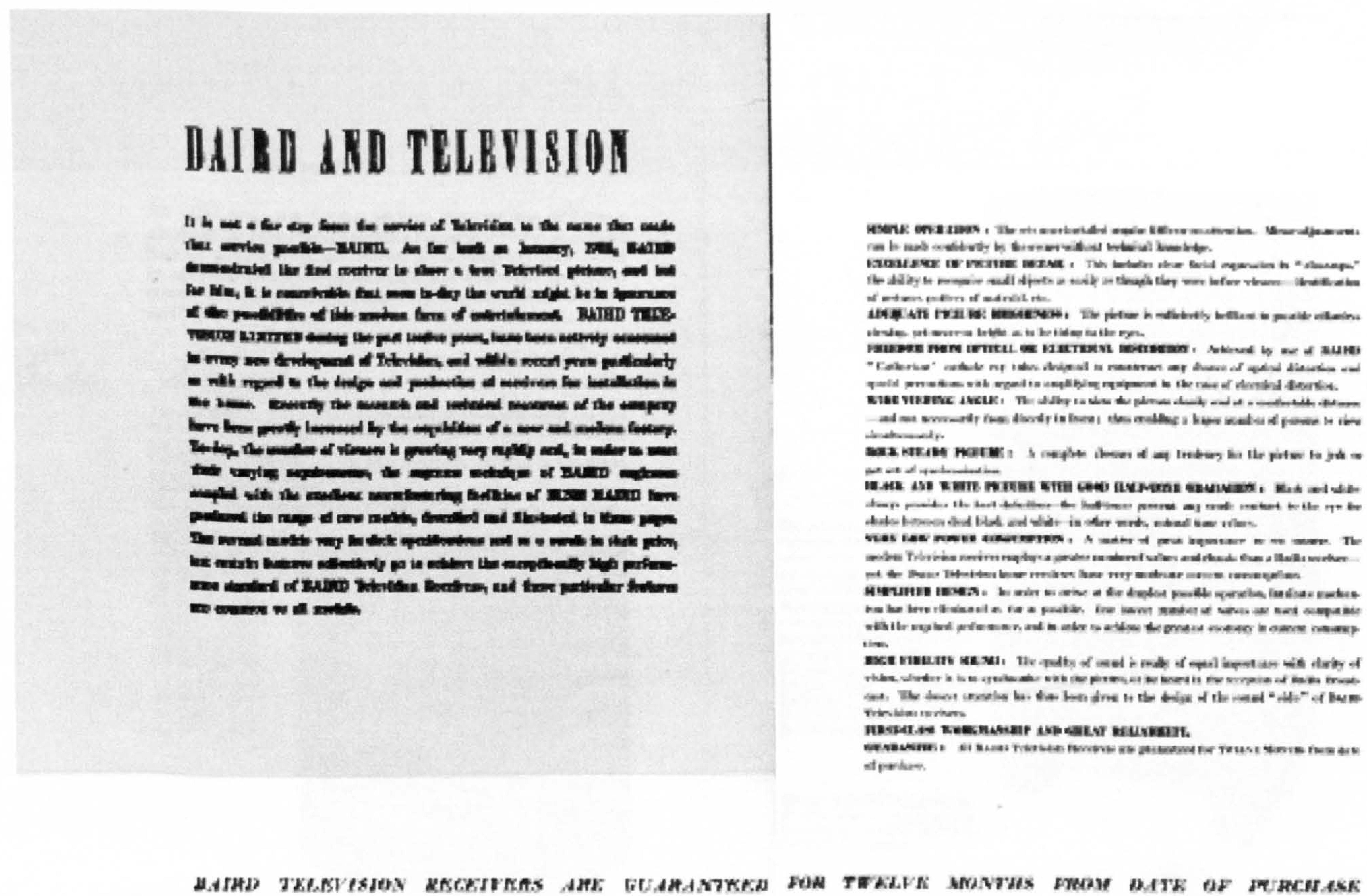
Appendix 3

Baird Television Receiver

Catalogue 1938-1939




REAL
ENTERTAINMENT
Television in this country is no longer a matter of conjecture but a practical and established service. Both the programme material and the quality of the transmitted pictures have now reached a high standard and provide sustained entertainment value in the home. Television has in reality destroyed the limitations of human vision, for the television receiver portrays not a recorded version of any event, but transmissions of scenes at the instant they are being enacted. Apart from first-class entertainment provided direct from the studio, there is the unmitigated thrill of watching the broadcasts of outside events. The Ceremony of Trooping the Colour, the spectacle of the Derby with the whole atmosphere of the Downs, boxing, football, tennis and swimming are but a few of the events which have been brought to the home of everyone with a television receiver. The whole panorama is seen on the receiver screen just as if you were a privileged eye witness on the spot where every event is occurring. Sound and vision are harnessed together to give a perfect replica of entertainment and news with a quality which is outstanding. Such is this modern service of Television.
BAIRD



BAIRD AND TELEVISION

It is not a far step from the service of Television to the name that made that service possible—BAIRD. As far back as January, [illegible], BAIRD demonstrated the first receiver to show a true Televised picture, and but for him, it is conceivable that even to-day the world might be in ignorance of the possibilities of this modern form of entertainment. BAIRD TELEVISION LIMITED during the past twelve years, have been actively concerned in every new development of Television, and within recent years particularly so with regard to the design and production of receivers for installation in the home. Recently the research and technical resources of the company have been greatly increased by the acquisition of a new and modern factory. To-day, the number of viewers is growing very rapidly and, in order to meet their varying requirements, the superior technique of BAIRD engineers coupled with the excellent manufacturing facilities of [illegible] BAIRD have produced the range of new models, described and illustrated in these pages. The several models vary in their specifications and as a result in their price, but certain features collectively go to achieve the exceptionally high performance standard of BAIRD Television Receivers, and these particular features are common to all models.

SIMPLE OPERATION: [illegible]

EXCELLENCE OF PICTURE DETAIL: [illegible]

ADEQUATE PICTURE BRIGHTNESS: [illegible]

FREEDOM FROM OPTICAL OR ELECTRICAL DISTORTION: [illegible]

WIDE VIEWING ANGLE: [illegible]

ROCK STEADY PICTURE: [illegible]

BLACK AND WHITE PICTURE WITH GOOD HALF-TONE GRADATION: [illegible]

VERY LOW POWER CONSUMPTION: [illegible]

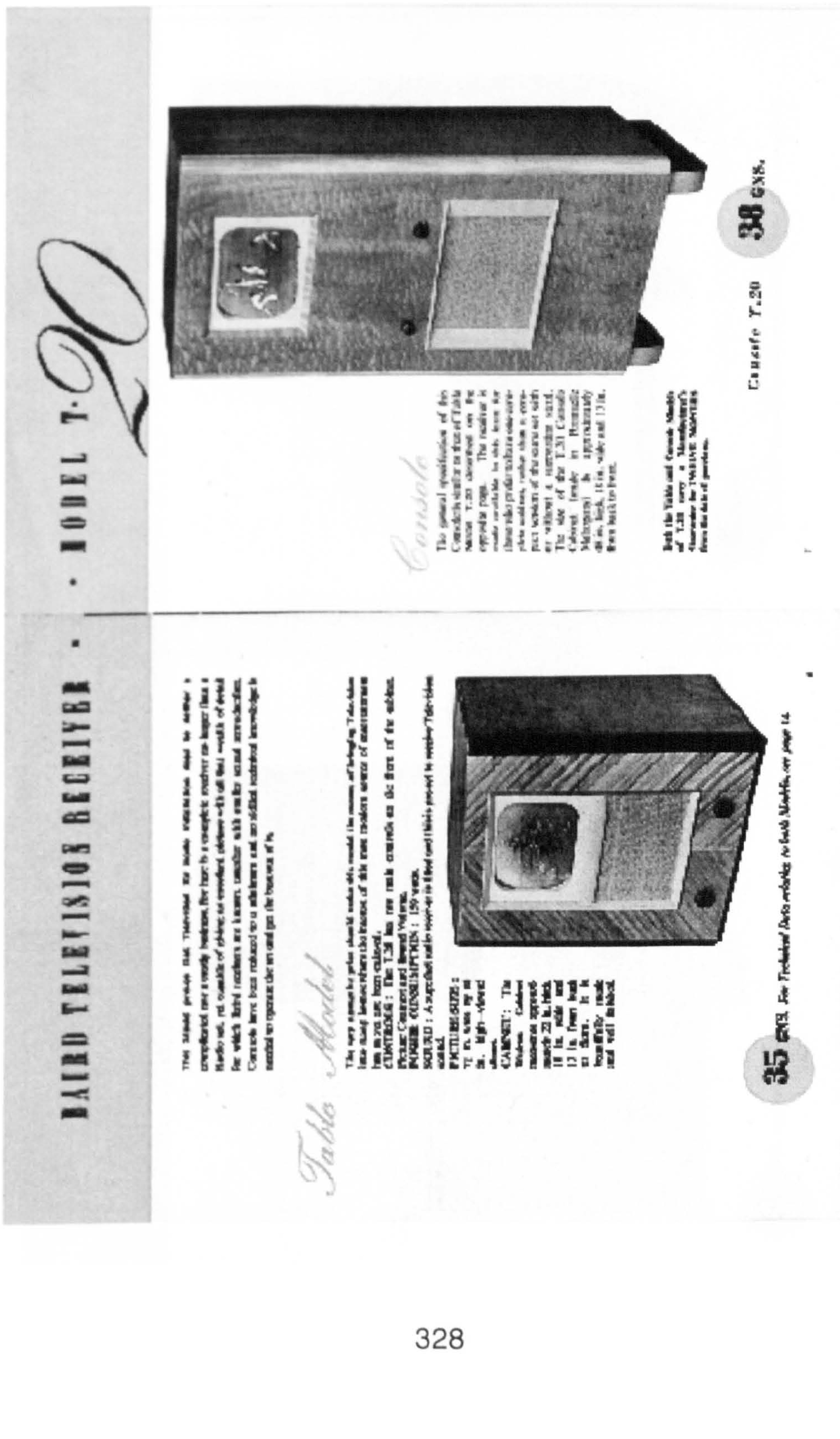
SIMPLIFIED DESIGN: [illegible]

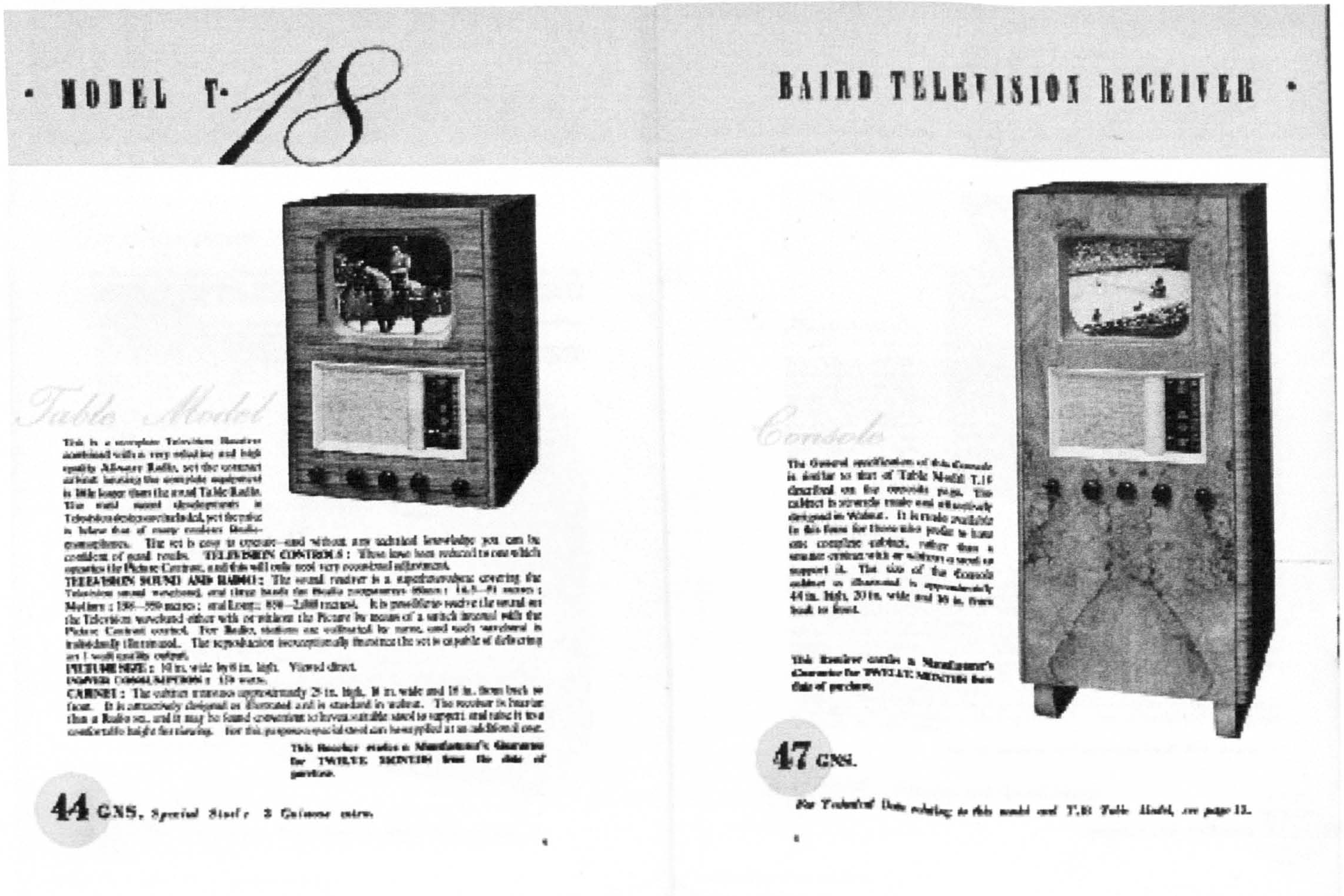
HIGH FIDELITY SOUND: [illegible]

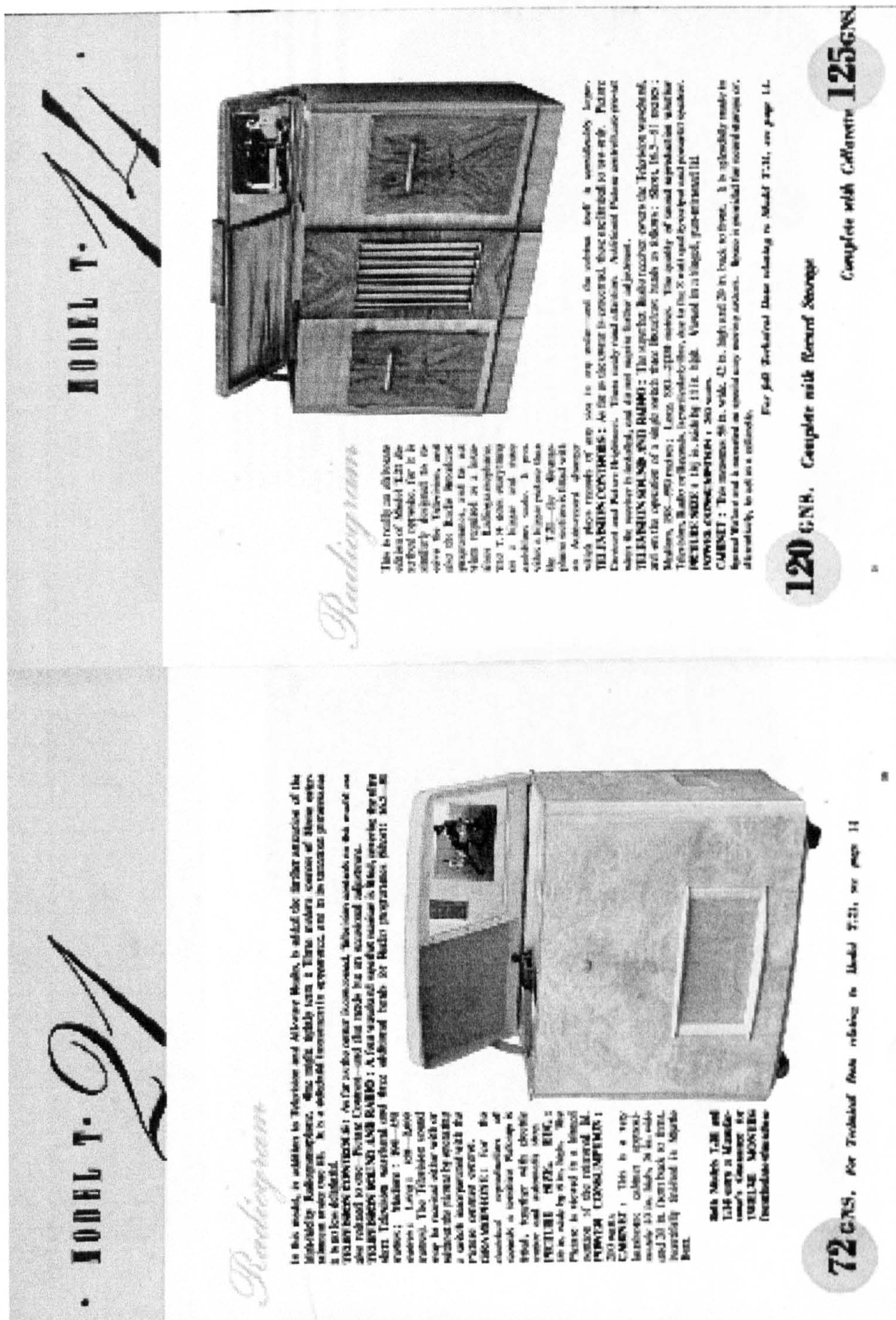
FIRST-CLASS WORKMANSHIP AND GREAT RELIABILITY.

GUARANTEE: [illegible]

BAIRD TELEVISION RECEIVERS ARE GUARANTEED FOR TWELVE MONTHS FROM DATE OF PURCHASE


BAIRD TELEVISION RECEIVER · · MODEL T·20
Table Model
Console
35 GNS.
Console T.20
38 GNS.


• MODEL T-18
BAIRD TELEVISION RECEIVER •
Table Model
44 GNS.
Console
47 GNS.
For Technical Data relating to this model and T.18 Table Model, see page 12.


MODEL T-21
Radiogram
72 GNS.
MODEL T-14
Radiogram
120 GNS. Complete with Record Storage
Complete with Cellarette 125 GNS.


CABINET MODEL T-23
PROJECTION MODEL T-19
CONTROLS.
PICTURE BRIGHTNESS, and SOUND VOLUME.
POWER CONSUMPTION.
SOUND.
PICTURE SIZE.
CABINET.
This Receiver carries a Manufacturer's Guarantee for TWELVE MONTHS from the date of purchase.
60 GNS.
TELEVISION CONTROLS:
TELEVISION SOUND AND RADIO:
PICTURE SIZE:
POWER CONSUMPTION:
CABINET:
This Receiver carries a Manufacturer's Guarantee for TWELVE MONTHS from the date of purchase.
150 GNS.

Appendix 4

Public Records Office, London

Cinema Television Files of Interest

These files serve to illustrate other areas of war work by Cinema Television under the supervision of Captain West at the Lower Sydenham factory. It should be noted that in many cases the defunct name 'Baird Television' is used to describe the work of Cinema Television.

In the minutes of the 26th meeting of the Coordination of CRT Development, on 21 April 1943 it was reported that TRE Malvern were unhappy with GEC figures on the Skiatron while Cinema Television were happy to accept TRE's suggestions. [1]

A Report [2] described the unsuccessful findings by Baird Television, between 1944 and 1945, of experiments using a metal detector to locate embedded foreign bodies in the lung of the human body. Sensitivity was found to be very low using coil detection methods as used by Baird Television in their other very successful mine detector work.

Dr Lee and Mr Lemays of Group Admiralty Research Laboratories (ARL) visited Baird TV Ltd, Worsley Bridge, at the invitation of T. M. C. Lance

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1 **Minutes of the 26th meeting for the Coordination of CRT Development.** 21 April 1943. PRO Call AVIA 7/1231. Public Records Office. London.

2 **Report on detecting fragment of metal embedded in a human body.** PRO Call AVIA 22/873. 1944-1944. Public Records Office. London.

on 25 June 1940, (previous visit 6 December 1939) to see progress on image convertors and to check if criterion of threshold sensitivity used to test these instruments is comparable with Admiralty Research Laboratory. [3]
It was recorded that Samson and Lance demonstrated image convertors.
It was also indicated that Dr Samson had made up to this date 150 Farnsworth image dissectors.

Image Convertors

a) The Philips type was shown with the anode and cathode at right angles to one another. Clear images were obtained but very powerful magnetic fields were required to focus the image over the whole anode. Small fields focused images over a small area only. It was noted that the use of permanent magnets had apparently not yet been tried.
Image convertor type (b) was shown:

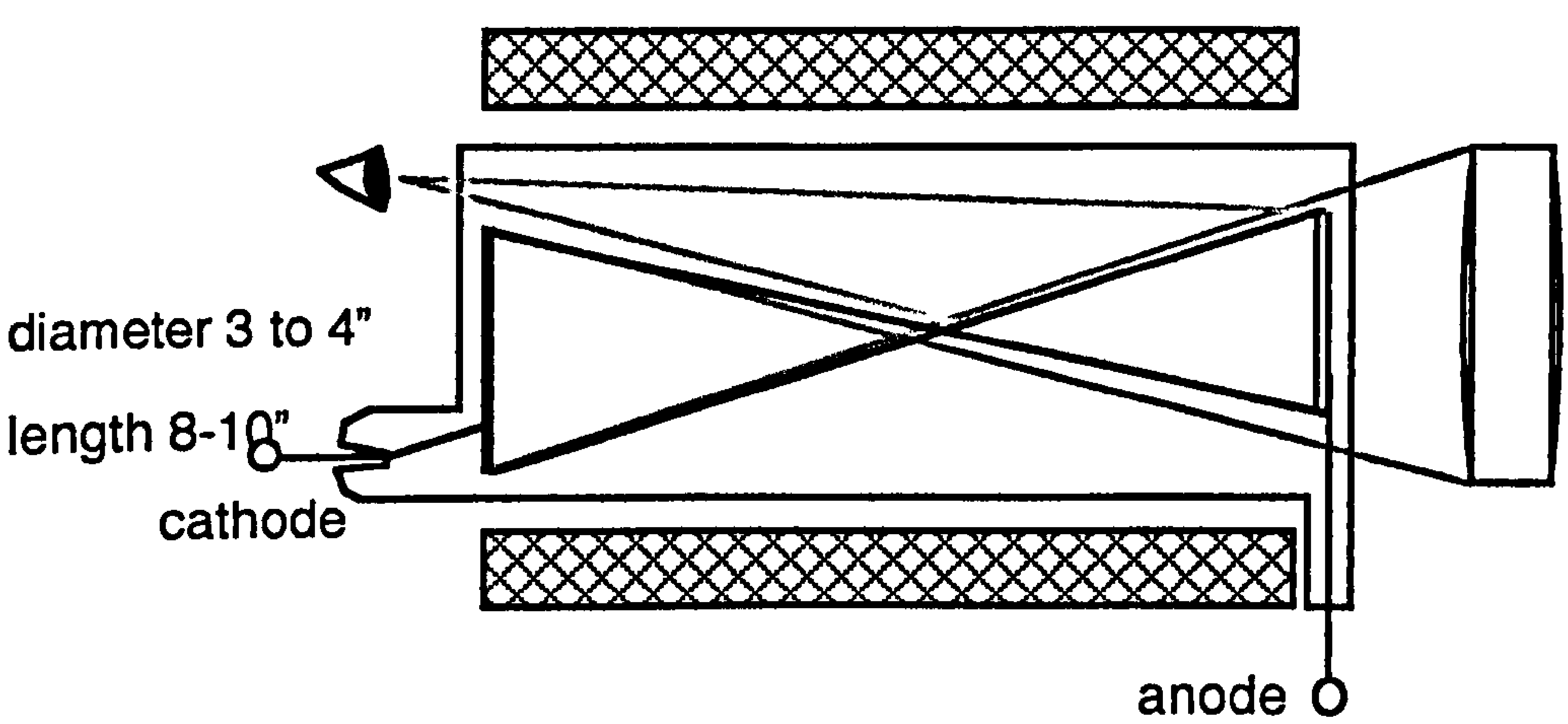

Figure i: Type (b) Image Convertor

With reference to (Fig i) the device has optical flats at both ends. The obstruction caused by the anode enables only 20% of the incident light to be used.

3 **Admiralty report on progress on image convertors.** PRO Call ADM 204/1432. 25 January 1940. Public Records Office. London.

Image convertor type (c) was shown:

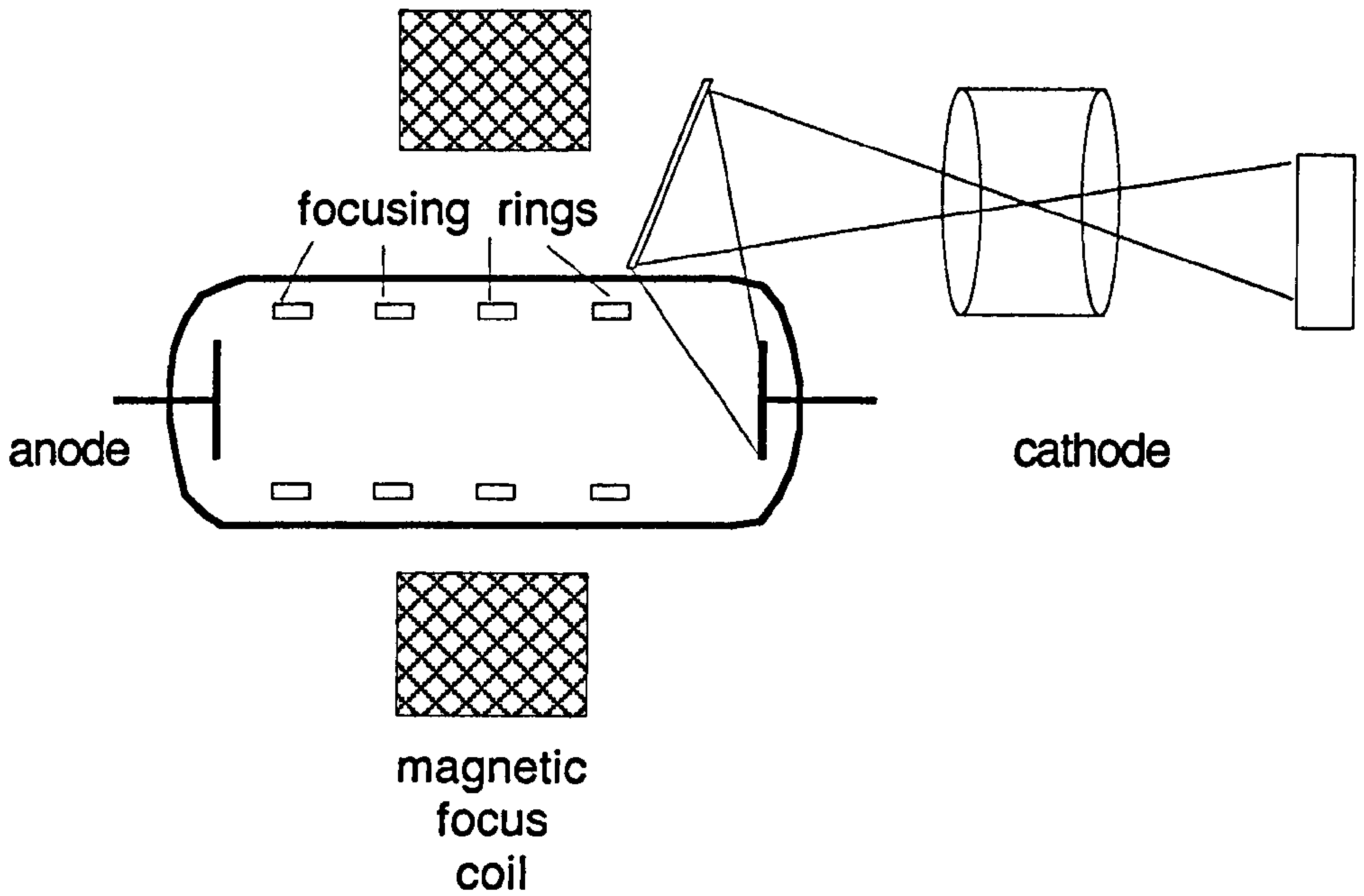

Figure ii: Image Convertor type (c)

The introduction of 4 focus rings at graded potentials of between 0 to 5000 volts, shown in Figure (ii), eliminated the ionisation glow experienced with these types of devices at high potentials. Figure (iii) illustrates a modification suggested by Dr Lee to avoid the inclusion of the inclined mirror.

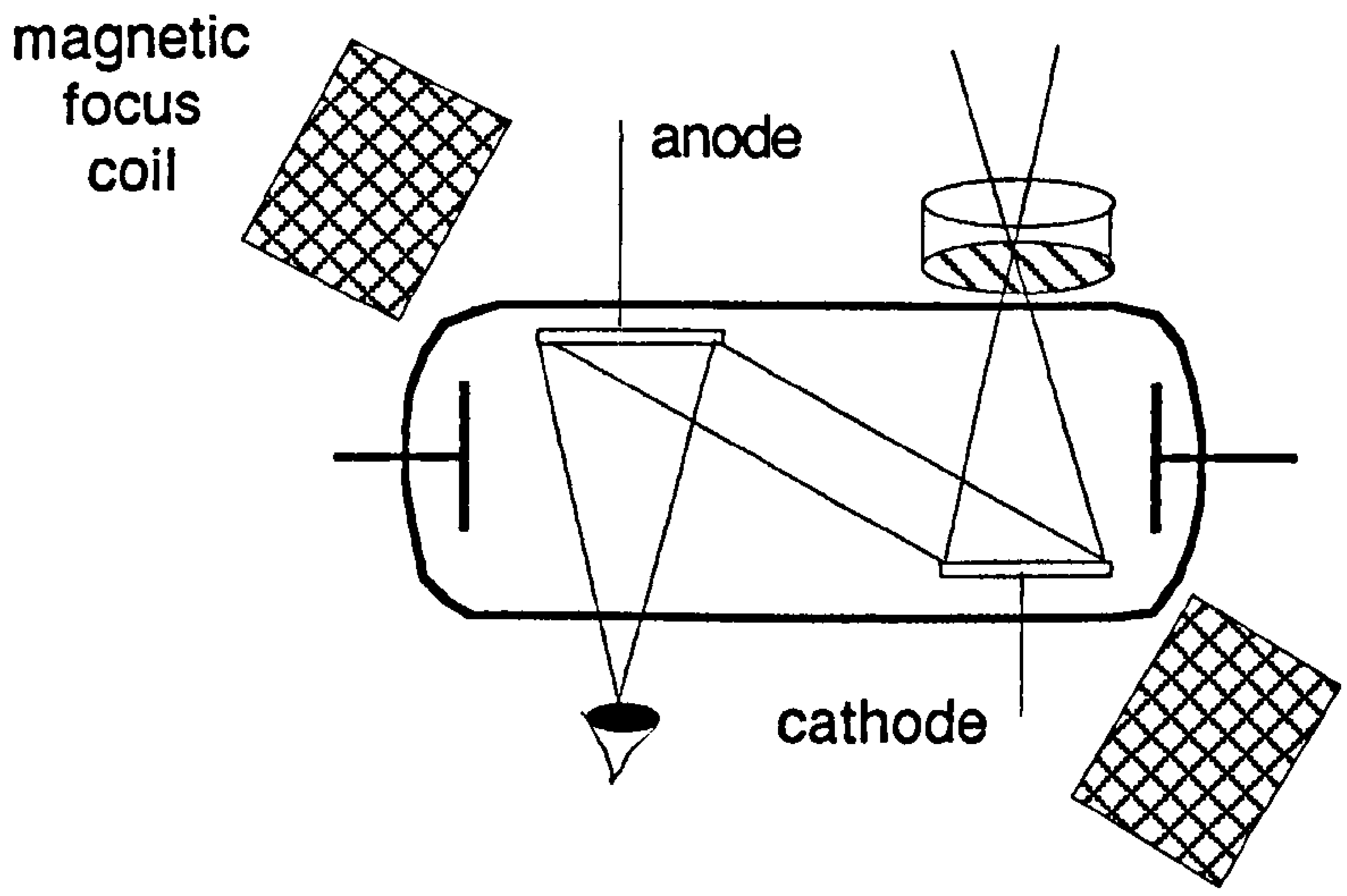

Figure iii: Dr Lee's suggested modification

Multipliers

Dr Sommer demonstrated multiplier tubes with new surfaces: New surfaces alloys with sensitivities of 80 μA per lumen which is 3 times the sensitivity of ordinary caesium surfaces. The sensitivity to daylight was shown to be 30 times greater than caesium and to a mercury arc lamp was shown to be 300 times greater. Quantum efficiency of 20 % compared to caesium.
(Note: Antimony high gain Silver Caesium or Bismuth approximating the sensitivity curve of the eye.) An eleven stage multiplier with a new high sensitivity photocathode giving 10,000 fold magnification of 2.5 times per stage and 4 times at last stage was demonstrated. This device could detect a light flux of 5×10^{-6} Lumen on 15 square cm.

Finance

Lance suggested that some financial support was required for the research they had done for the Admiralty and mentioned that another Service Department (Woolwich Arsenal) were paying them. Suggestions were made by the Admiralty Research Laboratories that alternative arrangement may be made where Bairds were asked to produce so many tubes of specified performance at an agreed price. Mr Lance stated that the staff levels had been reduced to half by order of the receiver, and also by people taking posts in Government departments. Further leakage in latter direction was unlikely as the staff had now been 'reserved' by Woolwich.

Further Action

Firm made decisive advances in construction of image convertors and in anticipation of further improvements it was agreed that ARL revisit in about a fortnight when they hoped to have ready a tube to Dr Lee's suggestions.

Baird Television Company: British Patents

The following list of 328 British patents were granted between 14 July 1930 and 1 July 1940, in the name of the scientists and engineers of Baird Television Ltd, (also Television Ltd, and Baird Development Ltd). This list does not include British patents (listed separately in Appendix 6) in which John Logie Baird is named as the inventor or co-patentee. The majority of the patents concern various aspects of television (Class 40(3), later Group XL). The Groups introduced in 1931 were compilations of several of the existing classes containing related subjects as follows:

Class	**Title**
11	Artists' instruments
37	Measuring electricity etc
38(1)	Electric couplings etc
38(3)	Electric motor control systems etc
39(1)	Electric lamps, arcs etc
40(2)	Phonographs, gramophones etc
40(3)	Electric telegraphs [includes television]
40(5)	Telephones etc
57	Governors etc
88(2)	Music etc
97(1)	Optical systems etc
98(1)	Photographic [including movie] cameras etc

Group	**Title**
XI	Electric heating, lamps, stoves.
XX	Photography, scientific instruments.
XXI	Excavating and mining, fire fighting, life-saving, subaqueous building, warfare.
XXIII	Abrading, brushing & cleaning, glass, hand tools, stone, wood.
XXV	Chains & ropes, operating doors, hinges, locks & fastenings.
XXVIII	Compressing & conveying gases, injectors, pipes, recirculating pumps.
XXX	Conveyors, lifts, railways, railway signals.
XXXIV	Bearings, brakes, wheels
XXXV	Dynamo-electric machines, electric converters & transformers, supply & transmission systems.
XL	Arc lamps, telegraphs & television, thermionic valves, wireless.

Patent No.	Class/Group	Date	Title	Patentee	Company
GB355896	40(3)	Jul 14, 1930	Television.	Banks, G. B.	Baird Television Ltd
GB358916	40(3)	Jul 14, 1930	Television.	Wilson, J. C	Baird Television Ltd
GB359639	40(3)	Sep 6, 1930	Television.	Collier, T. W., and Byron, D. H.	Baird Television Ltd
GB375825	40(3), 40(5)	Apr 1, 1931	Valves.	Bingley, F. J.	Baird Television Ltd
GB377045	40(3)	Nov 3, 1931	Television.	Collier,T. W.	Baird Television Ltd
GB380109	39(1),40(3)	Jun 2, 1931	Arc lamps.	Banks, G. B.	Baird Television Ltd
GB380234	40(3)	Aug 25, 1931	Television.	Banks, G. B.	Baird Television Ltd
GB381254	40(3)	Jul 14, 1931	Television.	Wilson, J. C.	Baird Television Ltd
GB381696	97(1)	Sep 18, 1931	Photometric apparatus.	Richards, C. L. and Benson, E. B. R.	Baird Television Ltd
GB381882	40(3)	Apr 29, 1932	Television.	Wilson, J. C.	Baird Television Ltd
GB383771	40(3)	Dec 22, 1931	Television.	Bingley, F. J.	Baird Television Ltd
GB384346	40(3),40(5).	Jun 22, 1931	Synchronous movements; valve circuits.	Jacomb, W. W.	Baird Television Ltd
GB387881	40(3)	Apr 29, 1932	Television.	Jacomb, W. W.	Baird Television Ltd
GB391897	40(4)	Dec 4, 1931	Transmitting Music etc.	Boulding, R. S. H.	Baird Television Ltd
GB391931	40(3)	Feb 9, 1932	Electro-optical light valves.	Jacomb, W. W.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB393960	40(3)	Dec 9, 1931	Television.	Wilson, J. C., and Wright, E. E.	Baird Television Ltd
GB398512	40(3)	Mar 15, 1932	Television.	Banks, G. B. and Wilson, J. C.	Baird Television Ltd
GB399154	40(3)	Mar 24, 1932	Television.	Richards, C. L.	Baird Television Ltd
GB401311	39(1),40(3)	Apr 4, 1932	Television.	Banks, G. B.	Baird Television Ltd
GB401561	39(1)	Mar 7, 1933	Thermionic valve holders.	Wilson, J. C.	Baird Television Ltd
GB403155	40(3)	Jul 13, 1932	Light valves.	Jacomb, W. W.	Baird Television Ltd
GB404281	40(3)	Jul 7, 1932	Scanners.	Wilson, J. C.	Baird Television Ltd
GB404642	40(3)	Jul 16, 1932	Television.	Jacomb, W. W.	Baird Television Ltd
GB410546	40(3)	Dec 16, 1932	Electro-optical light valves.	Jacomb, W. W. and Collier, T. W.	Baird Television Ltd
GB410678	40(3)	Oct 18, 1933	Television.	Wilson, J. C.	Baird Television Ltd
GB415155	40(5)	Mar 2, 1933	Valve Circuits.	Reveley, P. V.	Baird Television Ltd
GB415796	40(5)	Mar 3, 1933	Valve amplifying circuits.	Wilson, J. C.	Baird Television Ltd
GB420091	40(3)	May 25, 1933	Television.	Banks, G. B.	Baird Television Ltd
GB421065	39(1)	Jun 13, 1933	Cathode-ray tubes.	Bray, T. E.	Baird Television Ltd
GB423247	40(3)	Aug 4, 1933	Television.	West, A. G. D.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB423508	40(3)	Aug 1, 1933	Television.	Banks, G. B. and Collier, T. W.	Baird Television Ltd
GB423748	40(3)	Aug 15, 1933	Television.	Wilson, J. C. and Bray, T. E.	Baird Television Ltd
GB423863	40(3)	Aug 1, 1933	Television.	Jacomb, W. W.	Baird Television Ltd
GB424199	40(3)	Aug 12, 1933	Television transmitters.	Wilson, J. C.	Baird Television Ltd
GB424657	40(3)	Sep 19, 1933	Television.	Jacomb, W. W.	Baird Television Ltd
GB424887	40(3), XX	Aug 22, 1933	Television.	Banfield, A. C.	Baird Television Ltd
GB424961	40(3)	Aug 4, 1933	Television.	West, A. G. D.	Baird Television Ltd
GB425615	40(3), XX	Sep 15, 1933	Television.	West, A. G. D.	Baird Television Ltd
GB426356	40(3)	Oct 24, 1933	Television.	Banks, G. B. and Wilson, J. C.	Baird Television Ltd
GB428371	40(5)	Nov 6, 1932	Valve circuits for wireless reception.	Pugh, D. W.	Baird Television Ltd
GB428525	39(1)	Feb 26, 1934	Cathode-ray tubes.	Banks, G. B.	Baird Television Ltd
GB428557	40(3),40(5)	Dec 30, 1933	Valve generating circuits.	Lance , T. M. C. and Johnstone, D. M.	Baird Television Ltd
GB428805	40(3)	Dec 30, 1933	Television.	Wilson, J. C.	Baird Television Ltd
GB429832	40(3)	Nov 11, 1933	Television.	Lance, T. M.C. and Johnstone, D. M.	Baird Television Ltd
GB430262	40(5)	Dec 16, 1933	Aerials.	Lance, T. M. C. and Pugh, D. W.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB431340	40(3)	Jan 3, 1934	Television.	Wilson, J. C.	Baird Television Ltd
GB431567	40(5)	Jan 5, 1934	Valve generating circuits.	Lance, T. M. C.	Baird Television Ltd
GB435196	40(5)	Mar 19, 1934	Valve generating circuits.	Johnstone, D. M.	Baird Television Ltd
GB435574	40(5)	Apr 11, 1934	Valve amplifying circuits.	Johnstone, D. M.	Baird Television Ltd
GB435637	40(3)	Jul 5, 1934	Television.	Percy, J. D.	Baird Television Ltd
GB436108	40(3),40(5)	Jul 31, 1934	Television.	West, A. G. D.	Baird Television Ltd
GB436650	40(3)	Mar 13, 1934	Television.	Banks, G. B.	Baird Television Ltd
GB436809	40(3)	May 1, 1934	Television.	Lance, T. M. C.	Baird Television Ltd
GB437021	40(3)	Jan 23, 1934	Television.	Wilson, J. C.	Baird Television Ltd
GB437460	40(5)	May 9, 1934	Valve circuits for wireless reception.	Pugh, D. W.	Baird Television Ltd
GB437507	38(1)	May 23, 1935	Plug couplings.	Cave, N.	Baird Television Ltd
GB437988	97(1)	Aug 28, 1934	Optical polarisers.	Reveley, P. V.	Baird Television Ltd
GB438285	40(5)	Aug 31, 1934	Valve generating circuits.	Wilson, J. C.	Baird Television Ltd
GB438533	40(3)	Jun 18, 1934	Television.	Wilson, J. C.	Baird Television Ltd
GB439103	40(5)	Aug 31, 1934	Valve circuits for wireless reception.	Pugh, D. W.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB439579	40(3), XX	Jul 10, 1934	Television.	West, A. G. D.	Baird Television Ltd
GB439652	40(3), 40(5)	Aug 3, 1934	Television.	Merdler, L. R.	Baird Television Ltd
GB439977	40(3),40(5), XXXIX	Jun 19, 1934	Valve circuits; wireless and television receiving systems.	Starr, A. T.	Baird Television Ltd
GB439994	40(3)	Aug 24, 1934	Television.	Bray, T. E.	Baird Television Ltd
GB440912	38(2)	Nov 6, 1934	Converting.	Brown, A. J.	Baird Television Ltd
GB441150	40(3)	Aug 24, 1934	Impedance networks.	Wilson, J. C.	Baird Television Ltd
GB441235	98(1),XXI	Jan 17, 1935	Aeronautical photography.	Stoyanowsky, A. T.	Baird Television Ltd
GB441410	40(3)	Jul 26, 1934	Television.	Wilson, J. C.	Baird Television Ltd
GB441505	40(3)	Aug 28, 1934	Electro optical light valves.	Wright, E. E.	Baird Television Ltd
GB442686	40(5)	Oct 13, 1934	Valve generating circuits.	Merdler, L. R.	Baird Television Ltd
GB443031	40(3)	Aug 24, 1934	Television receivers.	Lance, T. M. C. and Pugh, D. W.	Baird Television Ltd
GB443032	40(3)	Aug 24, 1934	Television receivers.	Lance, T. M. C. and Pugh, D. W.	Baird Television Ltd
GB443788	39(1)	Sep 5, 1934	Cathode-ray tubes.	Wilson, J. C.	Baird Television Ltd
GB444133	40(3), 40(5)	Dec 24, 1934	Valve generating circuits.	Johnstone, D. M.	Baird Television Ltd
GB444360	40(3)	Feb 19, 1935	Television.	Graham, G. E. G.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB444774	40(5)	Feb 8, 1935	Wireless receiving apparatus.	Merdler, L. R.	Baird Television Ltd
GB445313	40(5)	Dec 24, 1934	Valve amplifying and generating circuits.	White, G. W.	Baird Television Ltd
GB446354	40(3)	Jan 8, 1935	Television.	Wilson, J. C.	Baird Television Ltd
GB446432	40(3)	Nov 2, 1934	Television.	Willans, P. W.	Baird Television Ltd
GB446585	39(1),40(3)	Nov 6, 1934	Television.	Johnstone, D. M.	Baird Television Ltd
GB446778	39(1),40(5)	Jan 30, 1935	Valve amplifying and detecting circuits.	Forman, J. R. H.	Baird Television Ltd
GB451663	40(3)	Feb 8, 1935	Television.	Wilson, J. C.	Baird Television Ltd
GB451786	38(2)	Feb 13, 1935	Phase changing.	Willans, P. W.	Baird Television Ltd
GB453847	40(3)	Mar 18, 1935	Impedance networks.	Merdler, L. R.	Baird Television Ltd
GB453848	39(1),40(3)	Mar 18, 1935	Television receivers.	Bray, T. E.	Baird Television Ltd
GB454383	40(3)	Mar 29, 1935	Television.	Lance, T. M. C.	Baird Television Ltd
GB454601	40(3), XX	Apr 5, 1935	Cathode-ray tubes.	Wilson, J. C.	Baird Television Ltd
GB454602	39(1),40(3)	Apr 5, 1935	Television transmitters.	Wilson, J. C.	Baird Television Ltd
GB454794	98(2)	Apr 5, 1935	Photographic developing compositions.	Banfield, A. C.	Baird Television Ltd
GB454945	40(5)	Apr 9, 1935	Valve circuits for wireless reception.	Merdler, L. R.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB454973	39(1)	Apr 15, 1935	Electron multipliers optical light valves.	Wright, E. E.	Baird Television Ltd
GB455048	40(3),40(5)	Apr 9, 1935	Valve circuits.	Tingley, G. R.	Baird Television Ltd
GB455146	40(3)	May 10, 1935	Telecine disc.	Lance T. M. C.	Baird Television
GB455237	39(1)	Apr 15, 1935	Cathode-ray tubes.	Wilson, J. C.	Baird Television Ltd
GB455238	98(2), XIII	Apr 5, 1935	Photographic drying apparatus.	Banfield, A. C.	Baird Television Ltd
GB455298	40(5)	Apr 17, 1935	Valve circuits for wireless reception.	Johnstone, D. M.	Baird Television Ltd
GB455972	40(3)	Apr 30, 1935	Television.	Wilson, J. C.	Baird Television Ltd
GB455973	39(1), IV, XX	Apr 30, 1935	Cathode-ray tubes.	Jarrard, W. J.	Baird Television Ltd
GB456138	40(5)	May 3, 1935	Valve generating circuits.	Forman, J. R. H.	Baird Television Ltd
GB456582	40(3),40(5)	May 11, 1935	Television.	Chapter, C. F.	Baird Television Ltd
GB456640	40(5)	May 17, 1935	Valve generating circuits.	Tingley, G. R. and Pugh, D. W.	Baird Television Ltd
GB456666	40(5)	May 17, 1935	Valve generating circuits.	Tingley, G. R. and Pugh, D. W.	Baird Television Ltd
GB457129	40(3)	May 22, 1935	Television.	Tingley, G. R.	Baird Television Ltd
GB457800	40(3),40(5)	Jun 5, 1935	Television.	West, A. G. D.	Baird Television Ltd
GB457812	40(3)	Jun 6, 1935	Television.	McConnell, E. D.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB457827	40(5)	Jun 7, 1935	Valve amplifying circuits.	Willans, P. W., and Brown, A. J.	Baird Television Ltd
GB457886	40(3),40(5)	Apr 8, 1936	Valve amplifying circuits.	Wilson, J. C.	Baird Television Ltd
GB458133	40(5)	Jun 18, 1935	Valve circuits for wireless reception.	Merdler, L. R.	Baird Television Ltd
GB458791	40(3)	Jun 27, 1935	Television.	Lance, T. M. C., Pattinson, E. H. Foden-.	Baird Television Ltd
GB458861	40(5)	May 27, 1935	Valve circuits.	White, G. W., Brown, A. J., and Willans, P. W.	Baird Television Ltd
GB459171	97(1)	Jul 3, 1935	Optical polarisers.	Reveley, P. V.	Baird Television Ltd
GB459178	40(3)	Jul 4, 1935	Television.	Wilson, J. C.	Baird Television Ltd
GB459300	40(5)	Jul 5, 1935	Valve circuits for wireless reception.	Merdler, L. R. and Scott, M.	Baird Television Ltd
GB459506	38(2)	Jul 5, 1935	Converting.	Wilson, J. C.	Baird Television Ltd
GB459668	106(1)	Jul 12, 1935	Calculating apparatus.	Wright, E. E.	Baird Television Ltd
GB459723	40(3),40(5)	Jul 13, 1935	Valve amplifying circuits.	Lance, T. M. C. and Willans, P. W.	Baird Television Ltd
GB459860	39(1),XXXV	Jul 15, 1935	Cathode-ray tubes; permanent magnets.	Szegho, C.	Baird Television Ltd
GB460198	40(5)	Jul 22, 1935	Wireless signalling.	Merdler, L. R.	Baird Television Ltd
GB460199	40(5)	Jul 22, 1935	Valve amplifying circuits.	Brown, A. J.	Baird Television Ltd
GB460204	40(3),XX, XXXVIII	Jul 22, 1935	Television.	Bray, T. E.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB460221	40(5)	Jul 23, 1935	Wireless receiving systems.	Merdler, L. R.	Baird Television Ltd
GB460222	40(3),40(5)	Jul 23, 1935	Valve modulating circuits.	Brown, A. J.	Baird Television Ltd
GB460445	39(1)	Jul 27, 1935	Cathode-ray tubes.	Szegho, C.	Baird Television Ltd
GB460579	39(1)	Jul 29, 1935	Discharge apparatus.	Szegho, C. and Lance, T. M. C.	Baird Television Ltd
GB461197	39(1)	Aug 14, 1935	Cathode-ray tubes.	Jones, V. A.	Baird Television Ltd
GB461273	40(3),40(5)	Aug 14, 1935	Television.	Johnstone, D. M.	Baird Television Ltd
GB461312	39(1)	Aug 14, 1935	Cathode-ray tubes.	Jones, V. A.	Baird Television Ltd
GB461434	39(1),40(5)	Aug 16, 1935	Photoelectric cells.	Johnstone, D. M.	Baird Television Ltd
GB461749	40(5)	Aug 23, 1935	Wireless signalling.	Johnstone, D. M.	Baird Television Ltd
GB461983	40(5)	Aug 27, 1935	Valve generating circuits.	Merdler, L. R.	Baird Television Ltd
GB461999	39(1)	Aug 29, 1935	Cathode-ray tubes.	Szegho, C., and Anderson, W. P.	Baird Television Ltd
GB462247	40(5)	Sep 4, 1935	Valve amplifying circuits.	Brown, A. J.	Baird Television Ltd
GB462683	39(1),II	Sep 12, 1935	Cathode-ray tubes.	Gilbert, A. H. and Merdler, L. R. and Tingley, G. R.	Baird Television Ltd
GB462684	39(1),XXXV	Sep 12, 1935	Cathode-ray tubes.	Gilbert, A. H. and Merdler, L. R.	Baird Television Ltd
GB463061	39(1)	Sep 20, 1935	Electron multipliers.	Forman, J.R.H.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB463971	40(3)	Oct 8, 1935	Television.	Merdler, L. R.	Baird Television Ltd
GB463972	39(1),40(3),40(5)	Oct 8, 1935	Television; cathode-ray tubes.	Tingley, G. R.	Baird Television Ltd
GB463973	40(3),XXXV	Oct 8, 1935	Television.	Merdler, L. R.	Baird Television Ltd
GB464037	40(5)	Oct 10, 1935	Valve circuits for wireless reception.	Merdler, L. R.	Baird Television Ltd
GB464828	40(3)	Oct 23, 1935	Television.	Willans, P. W.	Baird Television Ltd
GB464979	40(3)	Oct 23, 1935	Television.	Willans, P. W.	Baird Television Ltd
GB465055	40(3)	Oct 29, 1935	Television.	Wright, E. E.	Baird Television Ltd
GB465147	40(5)	Nov 5, 1935	Valve generating circuits.	Johnstone, D. M.	Baird Television Ltd
GB465276	40(5)	Nov 4, 1935	Valve circuits for wireless reception.	Johnstone, D. M.	Baird Television Ltd
GB465887	40(5)	Nov 15, 1935	Valve amplifying circuits.	White, G. W.	Baird Television Ltd
GB465892	40(3), XXXV	Nov 16, 1935	Television.	Merdler, L. R.	Baird Television Ltd
GB466419	40(3)	Nov 23, 1935	Television.	Merdler, L. R.	Baird Television Ltd
GB466426	39(1),XXIII	Nov 27, 1935	Cathode-ray tubes.	Johnson, A . H.	Baird Television Ltd
GB466715	40(5)	Dec 2, 1935	Valve modulating circuits.	White, G . W	Baird Television Ltd
GB467188	40(3)	Dec 11, 1935	Television transmitters.	Lance, T. M. C.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB468837	40(3)	Jan 13, 1936	Television.	Graham, G. E. G.	Baird Television Ltd
GB469409	39(1)	Jan 24, 1936	Electron Multipliers.	King, E, B.	Baird Television Ltd
GB470785	40(3)	Feb 21, 1936	Television.	Jones, V. A.	Baird Television Ltd
GB470920	40(3),40(5)	Feb 24, 1936	Television receivers.	Merdler, L. R.	Baird Television Ltd
GB470921	37	Feb 24, 1936	Wire resistances.	Merdler, L. R.	Baird Television Ltd
GB470922	40(5)	Feb 24, 1936	Valve generating circuits.	Johnstone, D. M.	Baird Television Ltd
GB471191	39(1)	Feb 29, 1936	Cathode-ray tubes.	Lance, T. M. C., Jones, V. A., and Willans, P. W.	Baird Television Ltd
GB471526	39(1)	Mar 4, 1936	Cathode-ray tubes.	Jones, V. A.	Baird Television Ltd
GB471539	39(1)	Mar 5, 1936	Cathode-ray tubes.	Szegho, C. and Johnstone, D. M.	Baird Television Ltd
GB472274	40(3)	Mar 20, 1936	Television.	Dovaston, G.	Baird Television Ltd
GB472401	40(5)	Mar 20, 1936	Valve circuits.	Jones, V. A.	Baird Television Ltd
GB472485	39(1)	Mar 23, 1936	Electron multipliers.	Lance, T. M. C.	Baird Television Ltd
GB472645	40(3),40(5)	Mar 26, 1936	Valve generating circuits.	Tingley, G. R.	Baird Television Ltd
GB472686	38(4)	Mar 28, 1936	Auto control systems.	Willans, P. W.	Baird Television Ltd
GB472762	40(3)	Mar 28, 1936	Television.	Jones, V. A.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB472980	40(3)	Apr 2, 1936	Television.	Jones, V. A.	Baird Television Ltd
GB473006	39(1)	Apr 4, 1936	Cathode-ray tubes.	Jones, V. A.	Baird Television Ltd
GB473348	39(1)	Apr 9, 1936	Image dissectors.	Jones, V. A.	Baird Television Ltd
GB473554	39(1)	Apr 14, 1936	Cathode-ray tubes.	Szegho, C.	Baird Television Ltd
GB473895	40(5)	Apr 21, 1936	Valve amplification circuits.	Bentley, L. C.	Baird Television Ltd
GB473896	40(5)	Apr 21, 1936	Wireless receiving apparatus.	Merdler, L. R.	Baird Television Ltd
GB474296	39(1)	Apr 28, 1936	Discharge apparatus.	Lance, T. M. C.	Baird Television Ltd
GB474391	39(1)	Apr 30, 1936	Cathode-ray tubes.	Szegho, C.	Baird Television Ltd
GB474399	39(1),40(3)	May 1, 1936	Television receivers.	Merdler, L. R.	Baird Television Ltd
GB474616	39(1)	May 4, 1936	Discharge apparatus.	Sommer, A.	Baird Television Ltd
GB474683	40(5)	May 4, 1936	Valve generating circuits.	Willans, P. W.	Baird Television Ltd
GB474684	39(1),40(5)	May 4, 1936	Wireless receiving circuits. thermionic valves.	Merdler, L. R.	Baird Television Ltd
GB474776	40(3)	May 7, 1936	Television.	Reveley, P. W.	Baird Television Ltd
GB474834	39(1)	May 11, 1936	Electrode materials.	King, E. B.	Baird Television Ltd
GB475046	40(3)	May 11, 1936	Televison receivers.	Merdler, L. R., and Gilbert, A. H.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB475047	39(1)	May 11, 1936	Cathode-ray tubes.	Jones, V. A., and Willans, P. W.	Baird Television Ltd
GB475048	40(5)	May 11, 1936	Generating circuits using vacuum apparatus.	Forman, R. J. H.	Baird Television Ltd
GB475100	39(1)	May 12, 1936	Photoelectric devices.	Denisoff, A. K.	Baird Television Ltd
GB475517	39(1),40(3)	May 21, 1936	Television.	Jones. V.	Baird Television Ltd
GB475735	65(1)	Apr 23, 1936	Stays.	Treasure, E. J.	Baird Television Ltd
GB475807	39(1)	May 25, 1936	Photoelectric cells.	King, E. B.	Baird Television Ltd
GB476233	39(1)	Jun 4, 1936	Cathode-ray tubes.	Johnstone, D.	Baird Television Ltd
GB476256	38(3)	Jun 6, 1936	Inductances.	Pugh, D. W.	Baird Television Ltd
GB476430	38(5)	Jun 8, 1936	Contact-members for switches.	Pugh, D. W.	Baird Television Ltd
GB476437	98(1)	Jun 8, 1936	Fluorescent screens.	Hodgson, B., and Williams, W. O.	Baird Television Ltd
GB476947	39(1)	Jun 18, 1936	Cathode-ray tubes.	Merdler, L. R., and Tingley, G. R.	Baird Television Ltd
GB476948	40(3)	Jun 18, 1936	Television receivers.	Willans, P. W.	Baird Television Ltd
GB477355	40(3)	Jun 26, 1936	Television receivers.	Jones, V., and Lance, T. M. C.	Baird Television Ltd
GB477397	40(3),40(5)	May 25, 1936	Television; valve detecting circuits.	Merdler, L. R.	Baird Television Ltd
GB477406	40(3),XX	Jun 26, 1936	Cathode-ray tubes; fluorescent screens.	Szegho, C., and Tomes, G. A. R.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB477539	39(1)	Jul 2, 1936	Cathode-ray tubes.	Gilbert, A. H.	Baird Television Ltd
GB477540	40(3)	Jul 2, 1936	Television.	Willans, P. W.	Baird Television Ltd
GB477815	40(5)	Jul 7, 1936	Valve amplifying circuits.	Willans, P. W.,and Brown, A. J.	Baird Television Ltd
GB477897	40(3)	Jul 8, 1936	Television.	Gilbert, A. H.	Baird Television Ltd
GB477906	40(5)	Jul 9, 1936	Valve circuits for wireless reception.	Merdler, L. R.	Baird Television Ltd
GB479458	40(3)	Aug 6, 1936	Television.	Lance, T. M. C., and Austin, B. B.	Baird Television Ltd
GB479750	39(1)	Jul 10, 1936	Cathode-ray tubes.	Willans, P. W.	Baird Television Ltd
GB479760	40(5)	Aug 10, 1936	Valve generating circuits.	Johnstone, D. M.	Baird Television Ltd
GB479761	39(1)	Aug 10, 1936	Cathode-ray tubes.	Szegho, C.	Baird Television Ltd
GB479935	40(5)	Jul 13, 1936	Valve generating circuits.	Johnstone, D. M., and Jones. V.	Baird Television Ltd
GB480263	39(1)	Aug 19, 1936	Electron multipliers.	Jones. V., and Lance, T. M. C.	Baird Television Ltd
GB480275	39(1)	Aug 20, 1936	Cathode-ray tubes; electron multipliers.	Johnstone, D. M., and Szegho, C.	Baird Television Ltd
GB480691	39(1)	Aug 25, 1936	Cathode-ray tubes	Jones. V.	Baird Television Ltd
GB481516	39(1)	Sep 11, 1936	Cathode-ray tubes	Gilbert, A. H.	Baird Television Ltd
GB482959	39(1), XXXVI	Oct 8, 1936	Cathode-ray tubes; resistance coatings	Willans, P. W.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB484574	39(1)	Nov 5, 1936	Cathode-ray tubes.	Jones, V.	Baird Television Ltd
GB484575	39(1)	Nov 5, 1936	Cathode-ray tubes.	Johnstone, D. M.	Baird Television Ltd
GB485863	97(1),98(1)	Nov 25, 1936	Range-finders; cameras.	Reason, R. E., and Kapella Ltd	Baird Television Ltd
GB486017	40(5)	Nov 27, 1936	Valve generating circuits.	Tingley, G. R.	Baird Television Ltd
GB487328	39(1)	Dec 17, 1936	Electron multipliers.	Lance, T. M. C., and Graham, G. E. G.	Baird Television Ltd
GB487329	39(1), 40(3)	Dec 17, 1936	Cathode-ray tubes.	Johnstone, D. M.	Baird Television Ltd
GB488497	97(1)	Jan 7, 1936	Kinematograph apparatus.	Bland, H. Barker-, and Owen, L. E.	Baird Television Ltd
GB489102	40(3)	Jan 19, 1937	Television.	Willans, P. W.	Baird Television Ltd
GB489282	39(1),XXII,XX XVI	Jan 22, 1937	Cathode-ray tubes; making electrodes.	Jones, V. A., and Nuttall, T. C.	Baird Television Ltd
GB489715	40(3)	Feb 2, 1937	Television transmitters.	Brown, A. J.	Baird Television Ltd
GB489716	40(3),40(5)	Feb 2, 1937	Television; modulating systems	Brown, A. J.	Baird Television Ltd
GB489717	40(3)	Feb 2, 1937	Television transmitters.	Jones, V. A, and Nuttall, T. C.	Baird Television Ltd
GB490230	39(1)	Feb 10, 1937	Electron multipliers.	(Fernseh Akt.-Ges)	Baird Television Ltd
GB490230	39(1)	Feb 10, 1937	Electron multipliers.	(Fernseh Akt.-Ges)	Baird Television Ltd
GB490533	39(1)	Feb 16, 1937	Cathode-ray tubes.	Jones, V. A.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB491886	40(3)	Mar 12, 1937	Cathode-ray tubes.	Gilbert, A. H.	Baird Television Ltd
GB491887	39(1)	Mar 12, 1937	Cathode-ray tubes.	Jones, V. A.	Baird Television Ltd
GB492284	39(1)	Mar 16, 1937	Cathode-ray tubes.	Jones, V. A.	Baird Television Ltd
GB492662	39(1)	Mar 23, 1937	Television transmitters.	Jones, V. A.	Baird Television Ltd
GB492665	38(4)	Mar 23, 1937	Supply system for vacuum and low-pressure discharge apparatus.	Merdler, L. R.	Baird Television Ltd
GB493048	39(1),40(5)	Mar 30, 1937	Electron multipliers; modulating circuits.	Nuttall. T. C.	Baird Television Ltd
GB493049	40(3)	Mar 30, 1937	Television.	Willans, P. W., and Nuttall. T. C.	Baird Television Ltd
GB493050	40(5)	Mar 30, 1937	Valve amplifying circuits.	Willans, P. W.	Baird Television Ltd
GB493279	40(3),40(5)	Jan 20, 1938	Television transmitters; valve circuits.	Nuttall, T. C.	Baird Television Ltd
GB493304	40(3)	Apr 6, 1937	Television transmitters.	McConnell, E.D., and Bruce, H. G.	Baird Television Ltd
GB493864	40(5)	Apr 15, 1937	Wireless receiving systems.	Johnstone, D. M.	Baird Television Ltd
GB494586	39(1)	Apr 27, 1937	Discharge apparatus.	Tingley, G. R.	Baird Television Ltd
GB494677	40(3),40(5)	Apr 28, 1937	Television receivers; valve generating circuits.	Gilbert, A. H.	Baird Television Ltd
GB494685	40(5)	Apr 29, 1937	Valve generating circuits.	Tingley, G. R.	Baird Television Ltd
GB495331	40(3)	May 10, 1937	Television.	Jones, V. A.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB495413	40(5)	May 14, 1937	Valve amplifying circuits.	Cox, W. A.	Baird Television Ltd
GB495822	40(4)	May 20, 1937	Distributing television.	Merdler, L. R.	Baird Television Ltd
GB496398	39(1),40(5)	Jun 1, 1937	Electron multipliers and circuits therefor.	Jones, V. A., and Nuttall. T. C.	Baird Television Ltd
GB496778	39(1)	Jun 4, 1937	Cathode-ray tubes.	Szegho, C., and Tomes, G. A. R.	Baird Television Ltd
GB498824	39(1)	Jul 13, 1937	Cathode-ray tubes.	Willans, P. W.	Baird Television Ltd
GB499660	39(1)	Jul 26, 1937	Electrode materials.	Sommer, A. H.	Baird Television Ltd
GB499755	40(3),40(5)	Jul 27, 1937	Television transmitters.	Jones, V. A., and Nuttall. T. C.	Baird Television Ltd
GB499785	39(1)	Jul 29, 1937	Discharge apparatus.	Jones, V. A., and Samson, K. A. R.	Baird Television Ltd
GB499828	39(1)	Jul 28, 1937	Cathode-ray tubes.	Lance, T. M. C.	Baird Television Ltd
GB500217	40(3)	Aug 5, 1937	Electric signal amplifiers; reproducing music.	Johnstone, D. M.	Baird Television Ltd
GB501535	40(3)	Aug 31, 1937	Cathode-ray tubes.	Nuttall, T. C.	Baird Television Ltd
GB501753	40(3)	Sep 3, 1937	Television.	Merdler, L. R.	Baird Television Ltd
GB502351	40(3)	Sep 14, 1937	Television receivers.	Ridgeway, D. V.	Baird Television Ltd
GB502472	40(3)	Sep 17, 1937	Electron multipliers.	Colls, J. A.	Baird Television Ltd
GB502686	39(1),40(3),40(5)	Sep 22, 1937	Electron multipliers and circuits therefor.	Anderson, E. G. O.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB503259	40(3)	Oct 7, 1937	Television.	Gilbert, A. H.	Baird Television Ltd
GB503762	39(1)	Oct 7, 1937	Television.	Jones, V. A.	Baird Television Ltd
GB504188	39(1)	Oct 20, 1937	Cathode-ray tubes.	King, E. B.	Baird Television Ltd
GB505197	40(3),XXXV	Nov 5, 1937	Television; automatic control systems.	Dovaston, G., and Graham, G. E. G.	Baird Television Ltd
GB507583	39(1)	Dec 16, 1937	Cathode-ray tubes.	Dovaston, G., and Graham, G. E. G.	Baird Television Ltd
GB508038	40(3),40(5)	Dec 24, 1937	Valve circuits; television receivers.	Truefitt, E. V.	Baird Television Ltd
GB508058	40(5)	Dec 24, 1937	Valve circuits; television receivers.	Truefitt, E. V.	Baird Television Ltd
GB508552	39(1)	Dec 31, 1937	Cathode-ray tubes.	Daniels, L. C. and Marcus, G. E.	Baird Television Ltd
GB509430	40(5)	Jan 17, 1938	Valve circuits.	Tingley, G. R.	Baird Television Ltd
GB509478	40(5)	Jan 17, 1938	Valve circuits.	Tingley, G. R.	Baird Television Ltd
GB510171	40(3)	Jan 27, 1938	Valve circuits.	Nuttall, T. C.	Baird Television Ltd
GB510530	40(3)	Feb 2, 1938	Television transmitters.	Jones, V. A., and Nuttall, T. C.	Baird Television Ltd
GB510531	40(3),40(5)	Feb 2, 1938	Valve generating circuits.	Merdler, L. R.	Baird Television Ltd
GB510881	40(5)	Feb 7, 1938	Valve circuits.	Nuttall, T. C.	Baird Television Ltd
GB511048	39(1),40(3)	Feb 11, 1938	Cathode-ray tubes.	(Fernseh Akt.- Ges)	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB511362	39(1)	Feb 16, 1938	Cathode-ray tubes.	Jones, V. A.	Baird Television Ltd
GB512327	40(5)	Mar 4, 1938	Valve amplifying circuits.	Terry, P. E. A. R.	Baird Television Ltd
GB512421	40(3)	Mar 1, 1938	Television transmitters.	(Fernseh Akt.- Ges)	Baird Television Ltd
GB512519	40(5)	Mar 2, 1938	Valve generating circuits.	Nuttall, T. C.	Baird Television Ltd
GB512795	40(3),40(5)	Mar 15, 1938	Television receivers.	Ridgeway, D. V.	Baird Television Ltd
GB512999	40(3)	Mar 28, 1938	Television.	(Fernseh Akt.- Ges)	Baird Television Ltd
GB513099	39(1)	Apr 1, 1938	Cathode-ray tubes.	Denisoff, A. K., and Jones, V. A.	Baird Television Ltd
GB513628	39(1)	Jan 19, 1938	Discharge apparatus.	Jones, V. A.	Baird Television Ltd
GB514270	39(1)	Apr 29, 1938	Cathode-ray tubes.	Denisoff, A. K.	Baird Television Ltd
GB514271	40(3)	Apr 29, 1938	Television receivers.	Nuttall, T. C.	Baird Television Ltd
GB514335	39(1)	May 3, 1938	Electron multipliers.	(Fernseh Akt.- Ges)	Baird Television Ltd
GB514401	40(3),40(5)	May 4, 1938	Valve amplifying circuits.	Nuttall, T. C.	Baird Television Ltd
GB514554	40(3)	May 10, 1938	Television.	Nuttall, T. C.	Baird Television Ltd
GB514643	40(3)	May 11, 1938	Television.	Willans, P. W.	Baird Television Ltd
GB515800	40(5)	Jun 13, 1938	Valve amplifying circuits.	Maitland, C. E.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB515801	39(1)	Jun 13, 1938	Cathode-ray tubes.	Jones, V. A.	Baird Television Ltd
GB515843	40(3),XXXV	Jun 13, 1938	Television.	Nuttall, T. C.	Baird Television Ltd
GB515947	40(3),40(5)	Jun 14, 1938	Television; thermionic oscillators.	Tingley, G. R.	Baird Television Ltd
GB516351	39(1)	Jun 20, 1938	Cathode-ray tubes.	Jones, V. A.	Baird Television Ltd
GB516637	39(1)	Jul 2, 1938	Cathode-ray tubes.	Merdler, L. R.	Baird Television Ltd
GB516785	39(1)	Jul 7, 1938	Electron multipliers.	(Fernseh Akt.- Ges)	Baird Television Ltd
GB517427	39(1)	Jul 27, 1938	Discharge apparatus.	Denisoff. A. K., and Spiers. J. M. S.	Baird Television Ltd
GB517428	40(3)	Jul 27, 1938	Television.	Bentley, L. C.	Baird Television Ltd
GB517482	39(1)	Jul 29, 1938	Cathode-ray tubes.	Jones, V. A.	Baird Television Ltd
GB517483	39(1)	Jul 29, 1938	Cathode-ray tubes.	Jones, V. A.	Baird Television Ltd
GB517514	39(1)	Jun 14, 1938	Image intensifiers.	Chapter, C. F.	Baird Television Ltd
GB517597	39(1)	Aug 8, 1938	Cathode-ray tubes.	Tingley, G. R.	Baird Television Ltd
GB517598	97(1)	Aug 8, 1938	Projection screens.	Bentley, L. C.	Baird Television Ltd
GB517888	40(5)	Aug 15, 1938	Wireless receiving systems.	Maitland, C. E.	Baird Television Ltd
GB522139	39(1)	Dec 7, 1938	Cathode-ray tubes.	Samson, K. A. R.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB522465	39(1)	Dec 14, 1938	Cathode-ray tubes.	Szegho, C. S.	Baird Television Ltd
GB522752	39(1)	Dec 15, 1938	Cathode-ray tubes.	Sommer, A.	Baird Television Ltd
GB522774	39(1)	Mar 15, 1939	Electrode materials.	Sommer, A.	Baird Television Ltd
GB524038	40(3),40(5)	Jan 20, 1939	Circuit arrangements for television.	Nuttall, T. C.	Baird Television Ltd
GB525791	39(1),40(3)	Mar 1, 1939	Television; cathode-ray tubes.	Tomes, G. A. R.	Baird Television Ltd
GB526320	39(1),XV	Mar 13, 1939	Luminescent materials.	Denisoff. A. K., and Spiers. J. M. S.	Baird Television Ltd
GB526622	39(1)	Mar 23, 1939	Image dissectors; electron multipliers.	Jones, V. A.	Baird Television Ltd
GB530260	39(1)	Jun 6, 1939	Electron multipliers.	Graham, G. E. G.	Baird Television Ltd
GB530591	39(1),40(3)	Jun 28, 1939	Light modulating; cathode-ray tubes.	Wllans, P. W.	Baird Television Ltd
GB531828	39(1)	Jul 10, 1939	Cathode-ray tubes; Image dissectors.	Wllans, P. W.	Baird Television Ltd
GB532074	40(5)	Aug 16, 1939	Valve generating circuits.	Ridgeway, D. V.	Baird Television Ltd
GB532259	39(1)	Jul 20, 1939	Electrode materials.	Sommer, A.	Baird Television Ltd
GB532525	39(1)	Jul 24, 1939	Cathode-ray tubes.	Samson, K. A. R.	Baird Television Ltd
GB533650	39(1),XXXVI	Aug 17, 1939	Cathode-ray tubes.	Szegho, C. S.	Baird Television Ltd
GB535477	39(1)	Oct 9, 1939	Cathode-ray tubes.	Ridgeway, D. V.	Baird Television Ltd

Patent No.	Class/Group	Date	Title	Patentee	Company
GB536662	97(1),XVI	Jan 5, 1940	Winding means for film and like strips.	Mills, F. J. B.	Baird Television Ltd
GB537832	40(5)	Jan 5, 1940	Photoelectric controlled thermionic valve relays.	Bentley, L. C.	Baird Television Ltd
GB538845	39(1)	Feb 16, 1940	Photoelectric cathodes.	Sommer, A.	Baird Television Ltd
GB540739	39(1)	Apr 26, 1940	Photoelectric surfaces.	Sommer, A.	Baird Television Ltd
GB541567	39(1)	Jun 1, 1940	Discharge apparatus.	Samson, K. A. R.	Baird Television Ltd
GB541596	39(1)	Jun 21, 1940	Cathode-ray tubes.	Hamburger, G. L., and Peirce, H. S.	Baird Television Ltd
GB541785	39(1)	Jun 7, 1940	Photoelectric cells.	Tomes, G. A. R.	Baird Television Ltd
GB541794	39(1)	Jun 14, 1940	Photoelectric cells.	Tomes, G. A. R.	Baird Television Ltd
GB541899	98(2)	Jun 14, 1940	Photographic film processing apparatus.	Collier, T. W.	Baird Television Ltd
GB541937	39(1)	Jun 14, 1940	Photoelectric cells.	Tomes, G. A. R.	Baird Television Ltd
GB542035	40(5)	Jun 21, 1940	Valve amplifying circuits.	McConnell, E. D.	Baird Television Ltd
GB542820	40(3),40(5)	Aug 28, 1940	television contrast amplifying systems.	no named inventor	Baird Television Ltd
GB587875	40(5),XXXVI	Jul 1, 1940	Radiolocation.	West S. S.	Baird Television Ltd

John Logie Baird's British Patents

This following list of 175 British patents were granted between 26 July 1923 and 10 April 1945, in the name of John Logie Baird, of Television Ltd, Baird Development Company Ltd, Baird Television Ltd and J. L.Baird Ltd. The majority of the patents concern various aspects of television (Class 40(3), later Group XL). The Groups introduced in 1931 were compilations of several of the existing classes containing related subjects as follows:

Class	Title
11	Artists' instruments
37	Measuring electricity etc
38(1)	Electric couplings etc
38(3)	Electric motor control systems etc
39(1)	Electric lamps, arcs etc
40(2)	Phonographs, gramophones etc
40(3)	Electric telegraphs [includes television]
40(5)	Telephones etc
57	Governors etc
88(2)	Music etc
97(1)	Optical systems etc
98(1)	Photographic [including movie] cameras etc

Group	Title
XI	Electric heating, lamps, stoves.
XX	Photography, scientific instruments.
XXI	Excavating and mining, fire fighting, life-saving, subaqueous building, warfare.
XXIII	Abrading, brushing & cleaning, glass, hand tools, stone, wood.
XXV	Chains & ropes, operating doors, hinges, locks & fastenings.
XXVIII	Compressing & conveying gases, injectors, pipes, recirculating pumps.
XXX	Conveyors, lifts, railways, railway signals.
XXXIV	Bearings, brakes, wheels
XXXV	Dynamo-electric machines, electric converters & transformers, supply & transmission systems.
XL	Arc lamps, telegraphs & television, thermionic valves, wireless.

Patent No.	Class/Group	Date	Title	Patentee	Company
GB222604	40(3)	Jul 26, 1923	Television apparatus	Baird, J. L., and Day, W. E. L.	
GB230576	40(3)	Dec 29, 1923	Copying telegraphs	Baird, J. L., and Day, W. E. L.	
GB235619	40(3)	Mar 12, 1924	Television apparatus	Baird, J. L., and Day, W. E. L.	
GB236978	40(3)	Mar 17, 1924	Television apparatus	Baird, J. L., and Day, W. E. L.	
GB253957	40(3)	Jan 1, 1925	Television apparatus	Baird, J. L.	
GB265640	40(3)	Aug 6, 1925	Television	Baird, J. L.	
GB266564	40(3)	Sep 1, 1925	Television.	Baird, J. L.	Television Ltd.
GB266591	40(3)	Sep 1, 1925	Copying telegraphs; television	Baird, J. L.	
GB267056	39(1)	Sep 1, 1925	Vacuum tubes.	Baird, J. L.	Television Ltd.
GB267378	40(3),40(5)	Sep 1, 1925	Television	Baird, J. L.	
GB269219	40(3)	Oct 21, 1925	Television	Baird, J. L.	
GB269658	40(3)	Jan 20, 1926	Television.	Baird, J. L.	Television Ltd.
GB269834	40(3)	Oct 21, 1925	Television; synchronous movements.	Baird, J. L.	
GB270222	40(3)	Oct 21, 1925	Television; light sensitive devices.	Baird, J. L.	
GB275318	40(3)	May 3, 1926	Television; synchronous movements.	Baird, J. L.	Television Ltd.
GB284770	37	Nov 3, 1926	Liquid resistances.	Baird, J. L.	Television Ltd.
GB285738	97(1)	Oct 15, 1926	Optical apparatus.	Baird, J. L.	Television Ltd.
GB288882	40(3)	Oct 15, 1926	Television	Baird, J. L.	Television Ltd.
GB289104	40(2),40(3)	Oct 15, 1926	Television.	Baird, J. L.	Television Ltd.
GB289307	40(3)	Oct 15, 1926	Television.	Baird, J. L.	Television Ltd.

Patent No.	Class/Group	Date	Title	Patentee	Company
GB291121	40(3)	Nov 30, 1926	Television.	Baird, J. L.	Television Ltd.
GB291634	40(3),40(5)	Dec 3, 1926	Television; synchronous movements.	Baird, J. L.	
GB292185	40(3)	Dec 21, 1926	Television.	Baird, J. L.	Television Ltd.
GB292365	11,97(1)	Dec 22, 1926	Stereograms.	Baird, J. L.	Television Ltd.
GB292632	40(3)	Jan 26, 1927	Television.	Baird, J. L.	Television Ltd.
GB294267	40(3)	Jan 21, 1927	Television.	Baird, J. L.	Television Ltd.
GB295210	40(3)	Aug 9, 1927	Television.	Baird, J. L.	Television Ltd.
GB297014	40(3)	Mar 10, 1927	Television.	Baird, J. L.	Television Ltd.
GB298582	40(5)	May 11, 1927	Secret and selective signalling systems.	Baird, J. L.	Baird Television Development Co. Ltd.
GB299076	40(3)	Jun 20, 1927	Copying-telegraphs.	Baird, J. L.	Baird Television Development Co. Ltd.
GB299402	40(3)	May 20, 1927	Television.	Baird, J. L.	Baird Television Development Co. Ltd.
GB300183	40(3)	May 7, 1927	Light-sensitive cells.	Baird, J. L.	Baird Television Development Co. Ltd.
GB300517	40(3)	May 18, 1927	Synchronous movements	Baird, J. L.	Baird Television Development Co. Ltd.
GB300592	40(2)	May 13, 1927	Optical apparatus	Baird, J. L.	Baird Television Development Co. Ltd.
GB301097	40(3)	May 26, 1927	Synchronous movements	Baird, J. L.	Baird Television Development Co. Ltd.
GB301364	40(5)	May 28, 1927	magnetic and electrostatic instruments	Baird, J. L.	Baird Television Development Co. Ltd.
GB301847	38(3)	Jun 7, 1927	Constant speed control systems.	Baird, J. L.	Baird Television Development Co. Ltd.
GB302187	40(3)	Jun 11, 1927	Television.	Baird, J. L.	Television Ltd.
GB303771	40(3)	Jul 5, 1927	Television.	Baird, J. L.	Television Ltd.
GB306158	40(3)	Aug 17, 1927	Television.	Baird, J. L.	Television Ltd.

Patent No.	Class/Group	Date	Title	Patentee	Company
GB309965	40(3)	Oct 19, 1927	Television.	Baird, J. L.	Television Ltd.
GB312406	40(3)	Nov 30, 1927	Television.	Baird, J. L.	Television Ltd.
GB312560	40(3)	Nov 30, 1927	Television.	Baird, J. L.	Television Ltd.
GB314591	40(3)	Jan 4, 1928	Television.	Baird, J. L.	Television Ltd.
GB317143	40(3)	May 15, 1928	Television.	Baird, J. L.	Television Ltd.
GB318278	40(3)	May 31, 1928	Television.	Baird, J. L.	Television Ltd.
GB318295	40(3)	Jun 2, 1928	Light sensitive cells.	Baird, J. L.	Television Ltd.
GB319304	40(3)	Jun 20, 1928	Television	Baird, J. L.	Television Ltd.
GB319307	40(3)	Jun 20, 1928	Television	Baird, J. L.	Television Ltd.
GB320627	40(3)	Apr 16, 1928	Television	Baird, J. L.	Television Ltd.
GB320628	38(3),57	Apr 16, 1928	Speed maintaining systems	Baird, J. L.	Television Ltd.
GB320639	40(3)	Apr 16, 1928	Synchronous movements.	Baird, J. L.	Television Ltd.
GB320687	40(2),40(3),40(5)	Jun 20, 1928	Television	Baird, J. L.	Television Ltd.
GB320909	40(2),40(3)	Apr 25, 1928	Television	Baird, J. L.	Television Ltd.
GB321138	40(3)	May 31, 1928	Television	Baird, J. L.	Television Ltd.
GB321196	38(1)	May 4, 1928	Vacuum tubes.	Baird, J. L.	Television Ltd.
GB321389	40(3)	Jun 5, 1928	Television	Baird, J. L.	Television Ltd.
GB321441	40(3)	Jun 11, 1928	Television	Baird, J. L.	Television Ltd.
GB321930	39(1)	Jun 20, 1928	Vacuum tubes.	Baird, J. L.	Television Ltd.
GB321961	40(3)	Jun 20, 1928	Television.	Baird, J. L.	Television Ltd.

Patent No.	Class/Group	Date	Title	Patentee	Company
GB322481	40(3)	Jun 6, 1928	Television.	Baird, J. L.	Television Ltd.
GB322776	40(3)	Jun 9, 1928	Television	Baird, J. L.	Television Ltd.
GB322822	40(3)	Jul 11, 1928	Television	Baird, J. L.	Television Ltd.
GB322823	40(3)	Jul 11, 1928	Television	Baird, J. L.	Television Ltd.
GB323817	40(3)	Oct 10, 1928	Television	Baird, J. L.	Television Ltd.
GB323818	40(3)	Oct 12, 1928	Television	Baird, J. L.	Television Ltd.
GB324029	40(3)	Oct 3, 1928	Television. - characters.	Baird, J. L.	Television Ltd.
GB324049	40(3)	Oct 10, 1928	Television	Baird, J. L.	Television Ltd.
GB324399	40(3),40(3)	Oct 26, 1928	Television	Baird, J. L.	Television Ltd.
GB324904	40(3)	Oct 4, 1928	Television	Baird, J. L.	Television Ltd.
GB324949	40(3)	Nov 5, 1928	Television	Baird, J. L.	Television Ltd.
GB324955	40(3)	Nov 7, 1928	Synchronous movements.	Baird, J. L.	Television Ltd.
GB325524	40(3)	Aug 21, 1928	Television.	Baird, J. L.	Television Ltd.
GB325527	40(3)	Sep 21, 1928	Television.	Baird, J. L.	Television Ltd.
GB325854	40(3)	Oct 26, 1928	Television.	Baird, J. L.	Television Ltd.
GB326192	40(3)	Nov 5, 1928	Television.	Baird, J. L.	Television Ltd.
GB326230	40(3)	Dec 5, 1928	Television.	Baird, J. L.	Television Ltd.
GB326251	40(3)	Oct 10, 1928	Television.	Baird, J. L.	Television Ltd.
GB328616	40(3),40(3)	Jan 31, 1929	Television.	Baird, J. L.	Television Ltd.
GB328691	40(3)	Feb 4, 1929	Television.	Baird, J. L.	Television Ltd.

Patent No.	Class/Group	Date	Title	Patentee	Company
GB329664	40(3)	Feb 19, 1929	Television.	Baird, J. L.	Television Ltd.
GB330220	40(3)	Jan 31, 1929	Television.	Baird, J. L.	Baird Television Ltd.
GB333942	40(3)	May 24, 1929	Television.	Baird, J. L.	Television Ltd.
GB336655	40(3)	Jul 17, 1929	Television; synchronous movements.	Baird, J. L.	Television Ltd.
GB346834	XL	Jan 18, 1930	Television.	Baird, J. L., and Richards, C. L.	Television Ltd.
GB347254	XL	Jan 21, 1930	Television receivers.	Baird, J. L.	Television Ltd.
GB347741	XL	Jan 29, 1930	Television receivers.	Baird, J. L.	Television Ltd.
GB348211	XL	Feb 14, 1930	Television receivers.	Baird, J. L.	Television Ltd.
GB348638	XL	Feb 7, 1930	Television.	Baird, J. L.	Television Ltd.
GB359054	XL	Sep 13, 1930	Discharge lamps.	Baird, J. L.	Television Ltd.
GB359981	XL	Jul 30, 1930	Television.	Baird, J. L.	Television Ltd.
GB360942	XL	Aug 6, 1930	Television transmitters.	Baird, J. L.	Television Ltd.
GB365241	XL	Nov 12, 1930	Television.	Baird, J. L.	Baird Television Ltd.
GB371520	XL	Feb 18, 1931	Television.	Baird, J. L.	Baird Television Ltd.
GB373196	XL	Feb 18, 1931	Television.	Baird, J. L.	Baird Television Ltd.
GB374114	XL	Mar 4, 1931	Television.	Baird, J. L.	Baird Television Ltd.
GB374564	XL	Apr 9, 1931	Television.	Baird, J. L.	Baird Television Ltd.
GB375900	XL	Apr 9, 1931	Television.	Baird, J. L.	Baird Television Ltd.
GB381898	XL	May 30, 1932	Television.	Baird, J. L.	Baird Television Ltd.
GB391924	XL	Feb 2, 1932	Television.	Baird, J. L.	Baird Television Ltd.

Patent No.	Class/Group	Date	Title	Patentee	Company
GB392730	XL	Apr 29, 1932	Television.	Baird, J. L.	Baird Television Ltd.
GB399552	XL	Apr 7, 1932	Television.	Baird, J. L.	Baird Television Ltd.
GB408332	XL	Oct 12, 1932	Synchronous movements.	Baird, J. L.	Baird Television Ltd.
GB408596	XL	Oct 6, 1932	Television.	Baird, J. L.	Baird Television Ltd.
GB412941	XL	Jan 3, 1933	Alternating current motors.	Baird, J. L., and Wilson, J. C.	Baird Television Ltd.
GB415036	XL	Feb 14, 1933	Television.	Baird, J. L.	Baird Television Ltd.
GB415744	XL	Feb 27, 1933	Television transmitters.	Baird, J. L.	Baird Television Ltd.
GB418527	XL	May 25, 1933	Television.	Baird, J. L.	Baird Television Ltd.
GB418759	XL	Jun 2, 1933	Television.	Baird, J. L.	Baird Television Ltd.
GB423101	XL	Jul 21, 1933	Television; valve generating circuits.	Baird, J. L.	Baird Television Ltd.
GB423854	XL	Jun 1, 1933	Television.	Baird, J. L.	Baird Television Ltd.
GB424632	XL	Jul 21, 1933	Cathode-ray tubes.	Baird, J. L.	Baird Television Ltd.
GB424633	XL	Jul 21, 1933	Television.	Baird, J. L.	Baird Television Ltd.
GB430569	XL	Nov 18, 1933	Television.	Baird, J. L.	Baird Television Ltd.
GB430570	XL	Nov 18, 1933	Television.	Baird, J. L.	Baird Television Ltd.
GB430900	XL	Sep 25, 1933	Television.	Baird, J. L.	Baird Television Ltd.
GB431339	XL	Jan 3, 1934	Television.	Baird, J. L.	Baird Television Ltd.
GB431458	XL	Jan 3, 1934	Television.	Baird, J. L.	Baird Television Ltd.
GB432635	XL	Jan 22, 1934	Kinematograph apparatus.	Baird, J. L.	Baird Television Ltd.
GB433552	XL	Feb 16, 1934	Television.	Baird, J. L.	Baird Television Ltd.

Patent No.	Class/Group	Date	Title	Patentee	Company
GB433720	XL	Feb 20, 1934	Television.	Baird, J. L.	Baird Television Ltd.
GB433853	XL	Nov 21, 1933	Television.	Baird, J. L.	Baird Television Ltd.
GB433935	XL	Jan 22, 1934	Television.	Baird, J. L.	Baird Television Ltd.
GB434527	XL	Nov 28, 1933	Television.	Baird, J. L.	Baird Television Ltd.
GB435103	XL	Dec 15, 1933	Television.	Baird, J. L.	Baird Television Ltd.
GB437339	XL	May 15, 1935	Television.	Baird, J. L.	Baird Television Ltd.
GB437340	XL	Jun 26, 1935	Television.	Baird, J. L., Reveley, P. V.	Baird Television Ltd.
GB438903	XL	Jun 14, 1934	Television.	Baird, J. L.	Baird Television Ltd.
GB438989	XL	Sep 8, 1934	Television.	Baird, J. L.	Baird Television Ltd.
GB439434	XX,XL	Aug 8, 1934	Television.	Baird, J. L.	Baird Television Ltd.
GB439771	XL	Sep 25, 1934	Television receivers.	Baird, J. L.	Baird Television Ltd.
GB440386	XL	Oct 13, 1934	Cathode-ray tubes.	Baird, J. L.	Baird Television Ltd.
GB440577	XX	Sep 5, 1934	Optical systems.	Baird, J. L.	Baird Television Ltd.
GB440917	XL	Dec 19, 1934	Television.	Baird, J. L.	Baird Television Ltd.
GB442963	XL	Dec 19, 1934	Cathode-ray tubes.	Baird, J. L.	Baird Television Ltd.
GB452378	XX	Feb 20, 1935	Kinematograph apparatus.	Baird, J. L.	Baird Television Ltd.
GB454588	XL	Apr 4, 1935	Television.	Baird, J. L.	Baird Television Ltd.
GB454589	XL	Apr 4, 1935	Television.	Baird, J. L.	Baird Television Ltd.
GB459177	XL	Jul 4, 1935	Television.	Baird, J. L.	Baird Television Ltd.
GB460197	XL	Jul 22, 1935	Television.	Baird, J. L.	Baird Television Ltd.

Patent No.	Class/Group	Date	Title	Patentee	Company
GB461242	XL	Jul 9, 1935	Arc Lamps.	Baird, J. L.	Baird Television Ltd.
GB467195	XL	Dec 12, 1935	Television.	Baird, J. L.	Baird Television Ltd.
GB469673	XL	Jan 30, 1936	Television.	Baird, J. L.	Baird Television Ltd.
GB470347	XL	Feb 13, 1936	Television.	Baird, J. L.	Baird Television Ltd.
GB470480	XL	Feb 13, 1936	Cathode-ray tubes.	Baird, J. L.	Baird Television Ltd.
GB473150	XX	Apr 9, 1936	Reflectors.	Baird, J. L.	Baird Television Ltd.
GB473303	XL	Apr 9, 1936	Television.	Baird, J. L.	Baird Television Ltd.
GB473323	XL	Apr 9, 1936	Television.	Baird, J. L.	Baird Television Ltd.
GB473980	XL	Apr 23, 1936	Television.	Baird, J. L.	Baird Television Ltd.
GB487157	XX	Dec 15, 1936	Projection screens.	Baird, J. L.	Baird Television Ltd.
GB489964	XL	Feb 8, 1937	Electro-optical light valves.	Baird, J. L.	Baird Television Ltd.
GB507165	XX	Dec 10, 1937	Kinematograph apparatus.	Baird, J. L.	Baird Television Ltd.
GB508039	XL	Dec 24, 1937	Television.	Baird, J. L.	Baird Television Ltd.
GB509392	97(1)	Dec 10, 1937	Kinematograph projectors.	Baird, J. L.	Baird Television Ltd
GB509758	XX	Nov 16, 1937	Kinematograph apparatus.	Baird, J. L.	Baird Television Ltd.
GB512855	XL	Mar 22, 1938	Television transmitters.	Baird, J. L.	Baird Television Ltd.
GB544413	39(1)	Sep 7, 1940	Cathode-ray tubes.	Baird, J. L.	
GB545078	40(3)	Sep 7, 1940	Television.	Baird, J. L.	
GB545462	XX	Oct 23, 1940	Colour television.	Baird, J. L.	
GB545491	40(3)	Oct 23, 1940	Colour television.	Baird, J. L.	

Patent No.	Class/Group	Date	Title	Patentee	Company
GB545603	XX	Oct 23, 1940	Colour television.	Baird, J. L.	
GB546470	XX	Jan 13, 1941	Colour television.	Baird, J. L.	
GB547441	39(1)	Feb 27, 1941	Cathode-ray tubes.	Baird, J. L.	
GB552582	XX	Jul 11, 1941	Stereoscopic and colour television.	Baird, J. L.	
GB555167	XX	May 13, 1942	Colour television; optical systems.	Baird, J. L.	
GB557837	97(1)	Mar 4, 1942	Optical projection apparatus.	Baird, J. L.	
GB557992	40(3)	Jul 11, 1942	Colour television.	Baird, J. L.	
GB559549	98(2)	Aug 18, 1942	Film processing tanks.	Baird, J. L.	
GB562168	39(1)	Jul 25, 1942	Cathode-ray tubes.	Baird, J. L.	
GB562334	40(3)	Oct 10, 1942	Colour television.	Baird, J. L.	
GB562334	39(1)	Jul 23, 1943	Cathode-ray tubes.	Baird, J. L.	
GB573008	40(3)	Aug 26, 1943	Television; photoelectric range finding	Baird, J. L.	
GB578108	97(1)	Apr 25, 1944	Projection screens.	Baird, J. L.	
GB579482	39(1)	Apr 28, 1944	Cathode-ray tubes.	Baird, J. L.	
GB602341	40(3)	Apr 10, 1945	Television systems.	Baird, J. L.	

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