Working in the scientific state : John Womersley's early career

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John Ronald Womersley, first Superintendent of the Mathematics Division created at the UK's National Physical Laboratory (NPL) in 1945, is best known to historians of computing for appointing Alan Turing to lead a project to design an electronic digital computer. Although Turing dissociated himself from the project in 1947 and Womersley left the NPL in 1950, the NPL's Electronic Division completed the Pilot ACE computer in 1951 [Copeland 2005]. This machine is remembered for its unique design and excellent performance, but Womersley has received little credit for this achievement. He is sometimes dismissed as a second-rate mathematician who failed to effectively lead the project he had set under way. This negative impression is reinforced by biographical accounts of Turing, who apparently had little respect for him.

Beyond this, Womersley barely features in the historical literature. The background to the establishment of the Mathematics Division has been described by Mary Croarken [Croarken 1990], and Brian Carpenter and Robert Doran have published the fullest biography of Womersley yet to appear, covering the years after Womersley's appointment to the NPL in most detail [Carpenter 2014]. However, they concluded that "Womersley remains unknown" and were unable even to find a publicly accessible photograph of him.

This article focuses on Womersley's early career, drawing on unexploited sources to present a detailed account of his intellectual and professional formation and describe how, from relative humble origins, he arrived in 1945 in a key position at the heart of the UK's scientific state.[1] Unlike many better-known computer pioneers, Womersley was not a research scientist working in a university environment; instead, his career took place within a series of institutions created in the early twentieth century to facilitate the application of science in support of the UK's military and industrial aims. This led to a great expansion of opportunities for the scientifically educated whose increasing professionalization was recognized by, among other things, the creation of the National Union of Scientific Workers in 1917 [MacLeod 1979]. In this context, Womersley is better understood as a scientific worker than as a traditional scientist, and to criticise his relative lack of scientific achievement is rather to miss the point. Rather than being driven by a scientific vocation, he used his technical and personal skills and abilities to build a career within the new state-sponsored scientific organizations, and the route he took through the UK's computational landscape of the 1930s and early 1940s passed through some relatively unfamiliar locations and connections.

[1] Particularly useful have been files describing the work of the War Office's Research Department and the Ministry of Supply's Advisory Council on Scientifc Research and Technical Development held in the UK National Archives (TNA), and the papers of Frank Smithies held at St John's College, Cambridge (SJC-FS).

1 Shirley Institute (1930 – 1937)

Womersley was born in the small Yorkshire town of Morley, where his father managed a grocery store, on 20 June 1907. He was educated at the local grammar school and in 1925 was awarded both a Cambridge Open Scholarship and a Royal Scholarship in Physics. He chose to study at Imperial College in London and graduated with a first-class BSc in Mathematics in 1928. This was followed by a period of post-graduate study leading to the award of the masters-level Diploma of Imperial College in May 1930. He then took up a post as a mathematician at the Shirley Institute in Didsbury, a suburb of Manchester. In April 1931, he married Jean Isobel Jordan, a Londoner, and the couple set up house close to the Institute, in Manchester's Fallowfield district.

The Shirley Institute was home to the British Cotton Industry Research Association (BCIRA). During World War 1, in response to fears that the UK was falling behind its Continental competitors in the industrial exploitation of scientific research, the UK Government established the Department of Scientific and Industrial Research (DSIR). One of its first initiatives was to encourage the creation of industry-specific research associations and BCIRA, set up in 1919, was one of the first of these, building on earlier efforts within the textile industry. BCIRA intended the Shirley Institute to be a place where "all the sciences involved in the great [cotton] industry would be found represented and working in the closest co-operation". Funds were raised, a large Victorian building in 13 acres of grounds was purchased, and the institute and its laboratories were opened by the Duke of York in March 1922.

Womersley joined the Institute as a junior assistant in the spinning department and in his seven years there worked on "theoretical and practical work on the drafting of fibrous materials, stability of spinning spindles, and diffusion problems."[2] His first published work described a pair of nomograms enabling textile workers to calculate the fluidity of cellulose solutions. Scales representing the values of measured variables were printed in such a way as to "[reduce] the calculation of fluidity to the simple process of placing a ruler on a diagram" [Womersley 1935, p. 165].

An interest in automating calculation also formed a part of a collaboration with G. A. R. Foster, who by 1936 had developed instruments to analyse the properties of cotton materials and devices for calculating standard deviations and correlation coefficients for large numbers of observations. An automatic yarn regularity tester combined one of these, an arithmometer calculator, with a photographic regularity tester in such a way as to render the testing process automatic.[3] Unfortunately, the papers documenting this work do not make clear what Womersley's contribution was, but the work would have given him some practical experience of digital calculating instruments.

A second collaboration, with the physicist Frederick Peirce, was more significant. Womersley extended Peirce's work on the geometry of cloth structure by applying differential geometry to the description of cloth deformation. The resulting papers [Peirce 1937, Womersley 1937] were reprinted in 1978 and again in 2023, when Womersley's contribution was described as follows: "The greatness of Womersley's work is that it provided a template for research fifty years in the future, when later mathematical results and computational methods had become available. That work is still incomplete,

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[2] J.R. Womersley, "Womersley, John Ronald," CV enclosed with letter to H.H. Goldstine, 21 May 1953, American Philosophical Society, Herman H. Goldstine papers, Mss.Ms.Coll.19, box 10.
[3] See [Anderson et al, 1945]. This paper was privately issued in April 1937.

as no routine method of modelling drape is yet available. When it is, perhaps Womersley will be better remembered" [Lloyd 2023, p. 910].

This project involved significant amounts of numerical calculation, and to carry this out Womersley spent some weeks in March 1936 at the Nautical Almanac Office (NAO) working with its superintendent Leslie Comrie, Britain's leading expert in machine computation, and his deputy Donald Sadler. Peirce's paper described another nomogram but explained that for greater accuracy it had been decided to replace observation by calculation, a task "carried out by Womersley, with the aid of calculating machines and sound methods of interpolation" [Peirce 1937, p. 56]. Womersley's work may have involved more than this, however: Comrie described him as coming "particularly in order to exploit the National for differential equation work",[4] while Sadler later recalled work on the solution of "certain very awkward simultaneous equations", noting that "the simplest method of solution was a large-scale model" and that Womersley had built a "computing instrument" for the purpose when he returned to Manchester.[5]

During this visit Comrie invited Womersley to dine at his home in Greenwich with Douglas Hartree, professor of physics at Manchester University and well known in computational circles for masterminding the construction of the UK's first differential analyser.[6] Comrie surmised that Hartree and Womersley had already met, as there were close links between the University and the Shirley Institute, and at around this time they developed a method to solve certain partial differential equations on the analyser. Hartree briefly described the work at the International Congress of Mathematicians in Oslo in July and in 1937 a joint paper appeared in the Proceedings of the Royal Society [Hartree 1937; Hartree and Womersley 1937].[7] Womersley's collaboration with Hartree was probably more extensive than these bare facts reveal, however, and he later remarked that Hartree knew "more than anyone else in England" about this early phase of his career.[8]

In this period Womersley also applied for membership of the London Mathematical Society. He was "admitted into the Society" at its meeting on 18 June 1936, coincidentally the same meeting at which Turing's paper "On Computable Numbers" was "taken as read" [Anon 1936]. There is no evidence that Womersley or Turing were present at the meeting, but Womersley later noted that he had read Turing's paper in "1937 or 1938."[9] It has seemed unlikely to some that a working mathematician like Womersley should have come across or been interested in Turing's paper, but he was at this time actively involved with mechanical computation and it is natural that a paper discussing "computable numbers" should have caught his eye.

Alongside these mathematical activities, Womersley also "learnt to be a statistician" at the Shirley Institute, under the influence of L.H.C. Tippett [Darwin 1958; Tippett 1982]. After studying statistics with Karl Pearson at University College London and R.A. Fisher at the Rothamsted Agricultural Station, Tippett joined the Shirley Institute in 1925 to work on the application of statistics in industrial processes. Egon Pearson [Pearson 1973] described Tippett's appointment as a "pioneer venture", statisticians not being appointed in other DSIR research associations until the 1930s. In 1930 Tippett

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[4] L.J. Comrie, letter to D. Hartree, 24 Feb 1936, Cambridge University Library, Royal Greenwich Observatory Archives, GBR/0180/RGO 16/15.
[5] See [Sadler 1948]. Sadler noted that Womersley's "computing instrument" was still in use at the Shirley Institute in 1948.
[6] L.J. Comrie, letter to D. Hartree, 6 Mar 1936, Cambridge University Library, Royal Greenwich Observatory Archives, GBR/0180/RGO 16/15.
[7] I thank Christopher Hollings for tracing reference [Hartree 1937].
[8] J.R. Womersley, letter to F. Smithies, 25 May 1942, SJC-FS A/A73.
[9] J.R. Womersley, "A.C.E. project – origins and early history," 26 Nov. 1946, TNA DSIR 10/385.

used Fisher's methods to analyse variation in textiles using variances [Tippett 1930]. Womersley appears not to have published the results of any statistical work while at the Shirley Institute, but in 1941 he used a similar approach in an important report for the Ministry of Supply, described below. The pair stayed in touch after Womersley left the Institute, for example having lunch together when Tippett visited London in 1943.[10]

In this period, then, Womersley's interests expanded beyond the limits of the Shirley Institute, as he gained wide experience of the industrial application of mathematics and statistics, made contact with leading figures in the field of mechanical computation, had published work of lasting significance, and began to make contact with wider professional networks.

2 Research Department, Woolwich (1937 – 1942)

In February 1937 Womersley took up a post in the War Office's Research Department at Woolwich Arsenal, working in the ballistics analysis group under the Director of Ballistics Research, Alwyn Crow.[11] It is not clear exactly what prompted this move.[12] New posts were created as the ballistics group more than doubled in size between 1935 and 1938, in part to support an expanded rocketry research programme, and proximity to the NAO at Greenwich may have been an additional factor. A deputy director of the ballistics group, Charles Arthur Clemmow, joined the LMS at exactly the same time as Womersley and although this may just be coincidence, it hints at the possibility of earlier contacts with the Research Department.

Womersley worked on rockets and internal ballistics, the core activities of the Department, but he also continued his involvement with mechanical computation, specifically in the design of a differential analyser.[13] The origins of this project are vague, but Womersley's early involvement in it suggests that experience of the Manchester analyser may have been a factor in his move to the Research Department. In 1939 Crow described the machine as "small scale," reporting that "the designs are nearing completion, and construction has already begun." Consultations had been held with Hartree and with staff from the Post Office Research Department at Dollis Hill and it was planned to use the machine to "extend and generalise the solutions of the differential equations of internal ballistics."[14] Womersley was no doubt involved in the discussions with Hartree and, in the light of post-war events, the possibility that he made contact with the Dollis Hill group at this period is intriguing.

In the pre-war period Womersley also discussed with "C.L. Norfolk, a telephone engineer who had specialised in totalisator design" the possibility of building a "Turing machine" using automatic telephone equipment, a project that was quickly abandoned as "too slow to be effective." In June 1938 he used Department monies to buy "a uniselector and some telephone relays" for unspecified "spare-time experiments" but the demands of his ballistics work meant that this project was also abandoned.[15]

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[10] F. Smithies, letter to his mother, 14 June 1943, SJC-FS C/C4.
[11] See [HMSO 1938] and "Research Department Telephone Directory 1937," reproduced in J.S. Crew, "The Armament Research Establishment," 1953, TNA DEFE 15/31.
[12] Carpenter and Doran [Carpenter 2014] write, without giving details, that Womersley "was recruited for military research."
[13] Womersley, "Womersley, John Ronald."
[14] See section "Differential Analyser" in "Research Department Directors' Review 1939", p. 64, TNA DEFE 15/2232.
[15] Womersley, "A.C.E. project – origins and early history".

When war broke out, the Research Department was transferred to the newly-formed Ministry of Supply, rocketry research was moved to a new organisation led by Crow, and Clemmow took charge of the ballistics branch. Woolwich Arsenal, situated on the Thames estuary to the east of London, was a prime target for German bombers and much of the establishment was dispersed around the country in October 1939. The ballisticians were evacuated in the autumn of 1940,[16] and the research group moved to Kenmare House in Trumpington Street, Cambridge. The Womersleys took a house in the village of Great Shelford, just south of Cambridge.

In 1939 the Ministry of Supply had leased Cambridge University's Mathematical Laboratory and its equipment, including a differential analyser, for the use of the Ordnance Board's Exterior Ballistics Department [Croarken 1992]. These links were strengthened by the creation at the start of 1940 of the Ministry's Advisory Council on Scientific Research and Technical Development. The Council's work was largely carried out through committees, and the Ballistics Committee included among its membership Cambridge scientists Ralph Fowler, director of the Mathematical Laboratory John Lennard-Jones, and Geoffrey Taylor alongside Clemmow, Crow, and Colonel A.H. Phillips, the Ordnance Board's Superintendent of External Ballistics.[17]

In May 1941, Clemmow noted that the Ballistics Branch was still attempting to "obtain complete solutions of the [internal] ballistic problem, and use has been, and is being, made of the Differential Analyser in this connection."[18] Given his experience, it is likely that Womersley was involved in this work, presumably using the Cambridge analyser as the Woolwich machine was at some point "destroyed by enemy action."[19]

Womersley's best-documented and, in terms of his future career, most significant piece of work for the Research Department was, however, a statistical analysis of test results for new guns and batches of cordite. This was rather different from the mainstream of the department's work, but addressed the stated objective of the Ballistics Directorate "to develop improved and more economical methods of cordite proof," in particular by reducing the amount of explosive used.[20] As Womersley later recalled [Anon 1942, p. 134], "soon after the outbreak of war […] he realized the availability in the Research Department of hundreds of thousands of past observations which had cost the the taxpayers a great deal of money, and he felt that such a vast mass of observations should be examined again with a view to a better interpretation of past experience." Accordingly, he embarked on an extensive analysis of this material.

The work gained momentum in the spring of 1941. In June, Clemmow described it as "a new piece of work, which he had had in mind for many years, but had only started in the last few months," an account slightly at odds with Womersley's recollections. Noting that data about 20,000 firings had already been analysed, he described as an "important result" the possibility of "allowing wider tolerances on the weighing of adjusted propellant charges," which, as Fowler pointed out, meant that "important economies could be effected" in the use of cordite, and stated that a report on the work

[16] Crew, "The Armament Research Establishment". See also notes in the file "Keeping of Historical Records," TNA DEFE 15/13.
[17] For the terms of reference and constitution of the committee, see "Minutes of the first meeting of the Advisory Council," TNA WO 195/43.
[18] "Summary of investigations in progress in the Ballistics Branch of the Research Department", 28 May 1941, TNA WO 195/878.
[19] Womersley, "Womersley, John Ronald."
[20] "Research Department Priority List 1939," TNA DEFE 15/58.

was in preparation.[21] The report was Womersley's responsibility and he was relieved of all his ballistics work to enable him to focus on it.[22]

Womersley presented his completed report to the Ballistics Committee on 20 November.[23] For help with the calculations required, an extra-mural contract had been set up with Scientific Computing Service Ltd., the firm that Comrie had started after his departure from the NAO in 1936. A number of outside experts attended the meeting, including the mathematician E.A. Milne and statistician E.S. Pearson, and both Pearson and Hartree drew attention to the possibility of using Womersley's methods in other areas.[24] The committee later reported that it was impressed by the report and made a number of practical recommendations.[25]

3 Statistical quality control

Womersley's report appeared at an opportune moment. Although the use of statistical methods in agriculture and industry had been discussed sporadically since the early 1930s within the Royal Statistical Society (RSS) and DSIR's research establishments, it took the perceived crisis in the production of war materials in the early 1940s to bring the issue to prominence.[26] As statistician Bernard Dudding noted [Dudding 1943]:

> The disorganization of normal activities caused by the war […] had the effect of greatly stimulating the interest of Engineers in the use of statistical methods. This interest was aroused by reports made by members of a British mission to the United States of the utilization of the methods for aiding efficient production and inspection in the ordnance factories there.

One member of the mission was Charles Darwin, Director of the NPL. His primary responsibility, to set up a scientific liaison office in Washington, meant that he soon became familiar with a wide range of American work. He visited key locations including Bell Laboratories and the US Army's Ballistics Research Laboratory and various arsenals, an experience which turned him into a keen advocate of the use of statistical quality control in production. After he reported on his trip to DSIR's Advisory Council in March 1942, the Department began to interest itself in the subject. Darwin and Council member Sir John Greenly met the Minister of Production, Oliver Lyttleton, in May to discuss "the advantages to be gained by applying statistical methods of quality control in industry," and a briefing meeting for the directors of DSIR's research associations was held at the end of June.[27]

More immediately, the Institutions of Civil, Electrical, and Mechanical Engineers organized a joint meeting in April to discuss the "application of statistical control to the quality of materials and manufactured products" [Anon 1942]. Attended by 720 people, the meeting was addressed by the Minister of Supply, Sir Andrew Duncan, and Darwin gave a general introduction to the proceedings, reporting specifically on his American experiences.Womersley attended the meeting and, speaking from the floor, gave a brief account of his statistical work at the Research Department.

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[21] "Summary of investigations in progress in the Ballistics Branch of the Research Department"; "Ballistics Committee: Minutes of the Fourth meeting", 10 June 1941, TNA WO 195/930.
[22] J.R. Womersley, letter to F. Smithies, 28 May 1942, SJC-FS A/A73.
[23] J.R. Womersley, "A statistical analysis of measurements of muzzle velocity and maximum pressure at cordite proof and gun proof," 6 November 1941, TNA WO 195/1333.
[24] "Ballistics Committee: Minutes of the Sixth meeting," 20 November 1941, TNA WO 195/1508.
[25] "Ballistics Committee: Summary of work done during 1941," TNA WO 195/1568.
[26] See [Pearson 1973] for an overview of the early work and [Edgerton 2011, ch. 5] for a discussion of the political importance of production in 1941-2.
[27] Advisory Council for Scientific and Industrial Research, Minute Books 1937-1942, TNA DSIR 1/9.

4 S.R.17 : Quality Control in the Minstry of Supply (1942 – 1945)

The engineers' meeting increased Government awareness of the benefits of statistical quality control, and in mid-1942 Womersley moved from the Research Department to the Ministry of Supply's Directorate of Scientific Research (DSR) in London to lead a group set up to provide advice to industries producing warlike materials. This was not a simple transfer from one job to another, however, but resulted from lengthy negotiations between Womersley and the Ministry, and particularly from his contacts with the mathematician Frank Smithies.

Born and educated in Edinburgh, Smithies did a PhD at St John's College, Cambridge, and after spending 1936-38 in Princeton working with John von Neumann, returned to a fellowship at St John's.[28] In the summer of 1940, John Cockcroft found him a wartime job in DSR working under its deputy director, Dr. E.T. Paris. Smithies described DSR as a kind of scientific broker, maintaining a flow of information between scientists and the armed forces. In the autumn of 1940 he worked with Patrick's Blackett's group on predictors for anti-aircraft guns [Budiansky 2013], and in October 1940 was appointed secretary of a new "P.D. Committee" set up to advise on problems relating to rocketry.[29]

Womersley became acquainted with Smithies in early 1941. On 3 February Smithies visited Clemmow in Cambridge with a query about ballistics, and on the following day Womersley appeared in his office in London. Smithies took him to see Paris and K. N. Moss, professor of Mining at Birmingham University, most likely to discuss ballistics. Womersley visited again on 5 March with "a number of small enquiries" and was introduced to more of Smithies' DSR colleagues.[30]

Smithies' obituarist [Ringrose 2004] wrote that Smithies and Womersley met "after Womersley had asked the Ministry to arrange for additional support with statistical computations. At the same time, through transatlantic contacts, the Ministry was receiving quantities of literature on the subject, and was not sure what to do with it; Smithies was asked to deal with the matter. He began by forwarding material to departments that he believed should find it useful. At first, those who responded with requests for help were referred, unoffically, to Womersley." This probably refers to a later period, however: although Cockcroft sent Smithies some American material in the autumn of 1940, this probably related to Blackett's work. In June 1941 Colonel Phillips noted that the Ordnance Board was trying to obtain information on the American system of proof and sampling; in response, Paris promised to try to obtain material through Darwin's liaison office in Washington, suggesting that even by mid-1941 transatlantic literature on statistics was not arriving in any quantity.[31]

By the spring of 1941 Womersley was working solely on statistics, and on 16 May he visited Smithies to "put up a suggestion about applying statistical methods to other fields than cordite proof." It is not clear why he took these ideas to Smithies. Although Smithies would have absorbed something of the statistico-probabilistic atmosphere around Blackett's group, he was not a statistician. In February

[28] Smithies was at Princeton at the same time as Turing, but his diaries record little interaction beyond an occasional walk or game of Go.
[29] "Ministry of Supply, Advisory Council on Scientific Research and Technical Development, Minutes," 26 September 1940, TNA WO 195/371.
[30] F. Smithies, diary for 2 Nov 1940 – 31 Aug 1941, SJC-FS J/J7.
[31] "Ballistics Committee: Minutes of the fourth meeting," 10 June 1941, TNA WO 195/930.

1941, however, he did note that members of the P.D. Committee had indulged in a "long wrangle […] on statistical questions" about the effectiveness of aerial mines.[32]

Womersley's proposal nevertheless received a warm reception. In the following weeks Smithies discussed it within DSR and had reports of "favourable reactions about statistical applications" from the Chief Inspector of Armaments. He wrote to his family that "I have also been stirring up another field of mathematical activity, though in this case it is more a matter of making other people realize possibilities than doing any work myself. However, I think some fruits are coming of it".[33]

After May Smithies's time was taken up with other responsibilities, but Womersley began to expand the Research Department's statistical activities, as he explained in April 1942:

> Since its first investigations two years ago the Research Department of the Ministry had built up a small organization for its own use, and this was now in friendly contact with three Inspection Departments. This small central nucleus was at present extremely busy on work of this kind but was frequently able to make contact with the production side. [Anon 1942, p. 135]

Smithies attended the Ballistics Committee meeting in November 1941 at which Womersley presented his report, and DSR soon got more actively involved in statistics. On 9 December Paris held a meeting of "interested parties in the Ministry of Supply to discuss [Womersley's] paper and possible applications thereof".[34] Womersley was present, and despite having to gatecrash the meeting Smithies ended up taking responsibility for statistics within DSR:

> The reason why I had to muscle in on last Tuesday's meeting was that the branch that called it didn't know that I was interested in the subject. The upshot was, as I expected, that I got the baby to look after; however, I have been greatly interested in that baby since it was born.[35]

Smithies initially focused on network building and did not carry out any statistical work himself. On 12 December he attended a meeting of the Institute of Production Engineers on statistical methods, and on 16 December visited the NPL's Metrology department for a discussion about tolerances, later putting Womersley in touch with the group.[36] In January he wrote that his life had "acquired a slightly more statistical tinge than of yore. I find myself making contact with such people as Dudding of the G.E.C., E.S. Pearson, usw." [37]

In the following months, Smithies regularly visited the Womersleys for tea in Great Shelford and the pair met frequently in London. He discussed the organization of statistical work within DSR with Paris and, after a meeting on 3 April with Womersley, sent him "a long screed about statistics". Paris met the pair on 16 April "to discuss the future of statistics," a meeting that Smithies considered "[w]ent off quite well," and finally on the afternoon of April 30, following a series of informal discussions with Womersley, Smithies "[d]rafted a scheme for a statistical service and put it up to

[32] "Minutes of the third meeting of the P.D. Committee," 11 February 1941, TNA WO 195/634.
[33] F. Smithies, diary, SJC-FS J/J7, and letter to Violet Smithies, 26 May 1941, C/C4.
[34] "Ballistics Committee: Minutes of the seventh meeting," TNA WO 195/1648.
[35] F. Smithies, letter to his mother, 11 December 1941, SJC-FS C/C4.
[36] F. Smithies, diary 31 Aug 1941 – 5 Jul 1942, SJC-FS J/J8.
[37] F. Smithies, letter to C.A.B. Smith, 5 January 1942, SJC-FS A/A58.

Paris."[38] In May Smithies produced another screed, this time for the Select Committee on National Expenditure who had asked the Ministry of Supply what they were doing about quality control.

In response to this pressure and interest, Paris decided to set up a centralised statistical advisory service in the Ministry of Supply by transferring Womersley's "small organization" to DSR. The Research Department raised objections to this plan: Clemmow and the Chief Superintendent initially wanted the statistical work to stay in the Department and, although soon accepting the idea of a central section, claimed that Womersley could not be spared because of his other responsibilities. Pointing out that he had been relieved of all his non-statistical work the year before, Womersley expressed his own point of view to Smithies:

> As you know, my one desire is that wherever this work may be, I should take control of it, because I honestly believe that no one else can do it quite so well.[39]

In the end Paris prevailed and after a number of administrative meetings and negotiations over his salary Womersley was "properly installed" on 1 July 1942 in Berkeley Court, a requisitioned block of flats opposite Baker Street tube station.[40] He was now head of S.R.17, the Ministry of Supply's Advisory Service on Statistical Methods and Quality Control.[41] This brought with it promotion to the Senior Scientific Officer grade, confirmed in January 1943, and in June 1944 he was further promoted to Assistant Director.[42]

As this was going on, Womersley made contact with the community of professional statisticians and was elected to the RSS in May 1942. Some fellows, including Dudding and Tippett, were concerned lest statistical quality control become the concern of "narrow specialized groups […] organized by the engineering bodies" and "divorced from the main field of statistics". They persuaded the RSS to reactivate its Industrial Applications Group, and in late 1942 an organizing committee was formed with Womersley as one its members [Dudding 1943, p. 65]. Over the next couple of years he chaired a number of the group's meetings, including one in May 1944 on work that used variances to analyse machine tool performance and resulted from "the joint efforts of the personnel of a manufacturing organization, the statistical department of a Ministry and a professional computing service," [Dudding 1944] a collaboration that clearly illustrates the similarities between the work of S.R.17 and Womersley's earlier work for the Research Department.

One of Womersley's first tasks was to recuit staff for S.R.17, later described as "mainly comprising actuaries, with a sprinkling of young mathematicians" [Bissell 2000]. A significant appointment was Smithies' friend George Barnard, a mathematician who joined at the end of the year.[43] By the spring of 1943, about a dozen people worked in S.R.17. Roughly half were engaged in analysis of production methods and introducing methods of quality control, while three people carried out theoretical study and three more supervised quality control procedures in factories and firms.[44]

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[38] F. Smithies, diary, SJC-FS J/J8.
[39] This paragraph draws on two letters from Womersley to Smithies, 25, 28 May 1942, SJC-FS A/A73.
[40] F. Smithies, diary, SJC-FS J/J8.
[41] The group was initially known as S.R.1(e) but for clarity it is referred to as "S.R.17" throughout this paper.
[42] These are the dates recorded in Smithies' diaries. Womersley gave slightly conflicting chronologies in CVs written in the 1950s.
[43] Barnard worked for Plessey and was involved in trade union activity. His left-wing reputation led to his vetting by M.I.5 before his appointment to S.R.17 was confirmed. He had met Womersley in May, when Smithies took him to Great Shelford for tea.
[44] "Ministry of Supply: Review of Research and Development", May 1943, TNA SUPP 23/11.

The recruitment drive then intensified. On 12 March Womersley gave a lecture on quality control to the Institute of Actuaries Students' Society, as a result of which "several young actuaries [were] placed at the Ministry of Supply in posts connected with Quality Control" [Coe 1945].[45] In May Smithies visited Cambridge mathematician Oscar Irwin "to see […] about the supply of statisticians for Womersley".[46] Irwin taught statistics during the war and gave interested graduates, such as David Lindley, an introductory course before they joined S.R.17.[47] By February 1944 S.R.17 had expanded to around 40 "trained statisticians" engaged, in Womersley's words, in "planning experiments for industrial and service trials, advising on and initiating quality control methods [and] advising Government Inspectorates on the use of statistical methods."[48] Barnard led a research group, many of whom went on to academic careers, studying "problems to which there was no standard solution" and producing series of technical reports [DeGroot 1988].

The most immediately significant of S.R.17's publications was a practical and highly successful guide to the use of statistical techniques in industry, written by E.H. Sealy and published in September 1943. Womersley described this as "a simple operational guide for those who wish to begin using Quality Control in the machine shop and have no prior statistical knowledge" and commented that Sealy "made full use of the experience [his colleagues] have gained in the direct introduction of Quality Control in engineering firms" [Sealy 1943]. After the war, Sealy's guide was reissued and much of S.R.17's research, especially in the novel area of sequential sampling, was made public. At the first post-war meeting of the RSS's Research Section, Womersley expressed his pleasure that:

> an enterprise in which he had taken a little part was giving this new or rejuvenated Section its first fruits. He hoped this would be the first of a number of papers publishing openly what had been done in secret. [Barnard 1946, p. 22]

Recollections of Womersley as head of S.R.17 are uniformly positive, especially those of George Barnard, who recalled [Barnard 2008, p. 41] that "Womersley provided the new unit with a sense of direction, firm support, and the warmth of his personality", later commenting that he was "the most brilliant scientific entrepreneur and manager I have ever known. He recognised that his own mathematical ability was not of the first order, but he could foresee better than most first class mathematicians what lay in store".[49]

5 Planning a Central Mathematics Station

Womersley's next appointment, as Superintendent of a new Mathematics Division at the NPL, came after an lengthy period of planning in the later years of the war. Provision of the computational resources needed to wage a scientific war was fragmented and largely ad hoc. In 1943 the Admiralty expanded the NAO and formed a stop-gap Admiralty Computing Service, but was unwilling to provide computational services to other departments in the long term. Some, notably the air ministries and GC&CS at Bletchley Park, had significant computing establishments of their own while others made use of Comrie's SCS, and university resources such as the differential analysers in Manchester

[45] The meeting was chaired by William Phillips, who had presented a paper on binary calculation to the Institute of Actuaries in 1936. Phillips later used this fact and his acquaintance with Womersley to claim a significant role in the early development of the Pilot ACE, but although Womersley and Phillips stayed in touch to a limited extent there seems to be little evidence supporting these claims.
[46] F. Smithies, letter to his mother, 5 May 1943, SJC-FC C/C4.
[47] [Pearson 1973, p. 177, McConway 2014].
[48] "Minutes of First Meeting of Interdepartmental Technical Committee on a Proposed Central Mathematical Station", 11 Feb 1944, TNA DSIR 17/301.
[49] G.A. Barnard, letter to M.G. Croarken, 5 Feb 1996, SJC-FS A/A6.

and Cambridge had also been pressed into service. The Admiralty eventually asked DSIR formally to consider centralization and an interdepartmental meeting was held in January 1944 to investigate the possibility of "a central organisation to undertake computational work for Government Departments."

As Croarken has described [Croarken 1990], the creation of a centre for scientific calculation was an important goal, but statistics were also important in DSIR's deliberations. Early in 1943 E. D. van Rest and F. Garwood wrote to DSIR secretary Edward Appleton describing the use of statistics in DSIR's research laboratories and recommending that after the war a "central section" be set up to encourage the use of statistical methods throughout the Department. They also noted that "many more firms contracting with the Ministry of Supply are becoming interested in the subject" of quality control.[50] In reply, Appleton promised that the proposal would be considered in the context of Darwin's "scheme for a mathematics section." Darwin himself was a vocal advocate for statistical quality control and viewed statistics as an essential part of any central establishment. In March he informed DSIR's Advisory Council that he was "inclining more and more to the opinion that a Mathematical Department should be established at the National Physical Laboratory," emphasizing that this view arose from "what he had previously mentioned to the Council about Statistical Control and Production."[51] In May a conversation with Lennard-Jones caused him to wonder if the best way to provide a central mathematical service might simply be to extend the Cambridge laboratory; in this scenario, however, he noted that "I should certainly want the statistical side here [at NPL] where it belongs."[52] The basis for this position was NPL's mission to bring science to industry, a connection also made by van Rest and Garwood.

Darwin re-emphasized the importance of statistics at the meeting in January 1944. Although discussion focused on "the need for a central computing organization," he noted that "[t]he question of statistics in industry had become of great importance, and he had formed the opinion that there ought to be a department, or a sub-department, of the N.P.L. which was master of that subject. It would be a natural thing to make it a section of a central mathematical organization such as was contemplated." Although Womersley was present, DSR Director H.J. Gough spoke for the Ministry of Supply, saying that quality control was of great interest to the Ministry and would be of great importance in the future.[53]

A committee to discuss the details of the proposed organization was then set up. Chaired by Darwin, its membership included Hartree and Womersley, and at its first meeting Womersley described the work carried out by S.R.17, suggesting that industry would be keen to continue with quality control after the war and that DSIR would be a more appropriate peacetime location for the work than the Ministry of Supply. Echoing his earlier interest in mathematical machines and instruments, he commented that there "was much scope for the development of labour saving devices," later proposing "the acquisition of […] an integrating periodograph and a correlation periodograph." At a later meeting Darwin outlined the scope of a central mathematical station, noting that "[s]tatistical science would be included as one of the most important functions," particularly in "advising and

[50] "Proposal that D.S.I.R. should set up a central statistical section," 18 Jan. 1943, TNA DSIR 17/300. Van Rest was later associated with S.R.17 and deputized for Womersley in the latter's absence [Barnard 1985, p. 41].
[51] Advisory Council for Scientific and Industrial Research, Minutes of the Special Meeting of Council, 10 March 1943, TNA DSIR 1/10.
[52] C.G. Darwin, memo to Appleton, 6 May 1943, TNA DSIR 17/300.
[53] "Memorandum on a meeting on the need for a central computing organisation," 20 January 1944, TNA DSIR 17/299.

overseeing methods" of statistical quality control in production engineering. Womersley suggested that "about seven officers would be required for the inception of the statistical work."[54]

At the beginning of March Womersley discussed a draft of the committee's report with Smithies and Barnard, and shortly afterwards sent Darwin a list of objectives which formed the statistical part of the new organization's research programme.[55] Not only did Darwin's interest in quality control shape his proposals for the central station, but he relied on S.R.17, and Womersley in particular, for detailed input on the statistical side of the proposal. The committee's final report described the services to be provided by the Division as falling into "two fairly distinct categories," namely general mathematical computation and statistics, the latter further divided between "descriptive statistics" and "statistical science." While the former was the responsibility of other departments, the latter covered the application of statistics particularly to industry and production engineering, and the development of new theory and methods to enable this to take place.[56] In effect, the new Division was formed by melding S.R.17 with the Admiralty Computing Service, and many of the staff of these sections were transferred to NPL in 1945.

Once Treasury approval had been obtained, DSIR moved to appoint a Superintendent of the new Division. In May, Womersley had told Smithies that Hartree was "putting him forward" for the post, but interviews did not take place until September.[57] The two candidates for the post, Womersley and Sadler (who had succeeded Comrie as superintendent of the NAO), represented the two aspects of the division's structure. Sadler [Sadler 2008] later recalled that "Womersley had the ability to speak well and he made a powerful speech at the meeting, on behalf of a statistical organisation (mainly on quality control)."[58] While this emphasizes the importance of statistics to NPL's plans, Womersley had been extensively involved with mathematical computation in his earlier career and, unlike Sadler, his experience covered the full range of the new Division's work. Following his appointment, Womersley spent increasing amounts of time in planning and preparatory work before officially taking up the Superintendency on 1 April 1945.

6 Conclusion

By 1945, Womersley's education, mathematical ability, and talent for networking and management had taken him from relatively obscure origins to a position of considerable responsibility at the heart of the British scientific civil service. His decision to go to Imperial College rather than Cambridge for his undergraduate education prefigured, even if it did not necessarily determine, the course of this career. Formed in 1907, Imperial was part of the British state's response to anxieties about its inadequate provision of scientific and technical education compared to its Continental rivals. Rather than in University laboratories and seminar rooms, Womersley's career up to 1950 took place in institutions set up to address these and related concerns, particularly concerning the military and industrial applications of science.

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[54] DSIR Interdepartmental Technical Committee on a Proposed Central Mathematical Station, minutes of first and second meetings, 11 and 24 Feb 1944, TNA DSIR 17/301 and 17/302.
[55] F. Smithies, diary 11 Jun 1943 – 22 Mar 1944, SJC-FS J/J10; C.G. Darwin, memo to H. Wooldridge, 21 March 1944, TNA DSIR 17/300.
[56] C.G. Darwin, "Report of Interdepartmental Technical Committee on a Proposed Central Mathematical Station", 3 April 1944, TNA DSIR 17/304.
[57] F. Smithies, 23 Mar 1944 – 4 Dec 1944, SJC-FS J/J11.
[58] D.H. Sadler, "A Personal History of the Nautical Almanac Office," 2008, Cambridge University Library, Royal Greenwich Observatory Archives, GBR/0180/RGO 94/9.

Given this background, Womersley is better understood as a scientific worker than as a scientist of the traditional type. Some scientific workers, like Tippett, built a career by staying in one such institution for an extended period. In contrast, Womersley's career was marked by a restlessness and a habit of using substantial achievements in one job as a stepping stone to his next position, characteristics that his obituarists pay tribute to. He had a talent for administration and attracted many tributes for his ability to encourage and support new work in others. He was also diligent in involving himself in the professional life of the disciplines he engaged with, most notably in his committee work for the Royal Statistical Society.

It is tempting to think that Womersley's career path was determined by his lower middle class origins. The example of Smithies, whose father was an engineer at one point blacklisted for his trade union activities, undermines such a simplistic conclusion. Smithies' path to a Cambridge fellowship was funded largely by scholarships, and he remained there for the remainder of his peacetime career, though it is interesting to note that his role in the Ministry of Supply was, like Womersley's, predominantly bureaucratic rather than the kind of consultancy undertaken by Hartree, Turing, and other prominent scientists during the war. Perhaps the difference between Womersley and Smithies' career paths simply reflects the latter's greater mathematical ability, but one wonders how Womersley's career might have developed had he chosen to do his undergraduate degree at Cambridge rather than at Imperial. On the other hand, perhaps this decision itself reflected an intellectual or social diffidence or lack of confidence.

A paucity of source material makes it hard to get a detailed impression of Womersley's personality. Occasional expressions of pride and confidence in his achievements have survived, and he was delighted later to have recruited Turing to the ACE project. But at the same time, there is an persistent undercurrent of insecurity, particularly about money. The combination of pride and insecurity is clearly visible in his postwar correspondence with Herman Goldstine, which provides rare examples of Womersley writing in a personal capacity.[59]

In retrospect, 1945 appears as the apogee of Womerlsey's career. Despite considerable success at the NPL, he cut a somewhat muted figure there. His undoubted success in getting the ACE project started was undercut by significant absences from work and a deteriorating relationship with Turing, and the statistical side of the Division's work seems not to have developed as he and Darwin had hoped, being later transferred back to the Ministry of Supply. After leaving the NPL, he took on a series of jobs in industry, which ended up with the family emigrating to the United States when he took up a position at the Wright Air Development Center in Dayton, Ohio [Carpenter 2014]. Although this latter period of his career saw significant achievements, one feels that Womersley failed to build on the platform created by his earlier success. Sadly, he fell ill with cancer in 1957 and died the following year.

7 Bibliography

S.L. Anderson, B. Cavaney, G.A.R. Foster, and J.R. Womersley, "An automatic sliver and roving regularity tester and an automatic yarn regularity tester", *Journal of the Textile Institute Transactions*, vol. 36, no. 10, pp. 253-266, Oct. 1945, doi: 10.1080/19447024508659721.

[59] For this correspondence, see American Philosophical Society, Herman H. Goldstine papers, Mss.Ms.Coll.19, box 10.

Anon., “Historical Note,” *Journal of the Textile Institute Proceedings and Abstracts*, vol. 1, no. 1, pp. 2-4, 1910, doi: 10.1080/00405001008630633.

Anon., “Reports of proceedings of meetings,” *Journal of the London Mathematical Society*, vol. 11, no. 4, pp. 273-275, Oct. 1936.

Anon., “Discussion on the application of statistical control to the quality of materials and manufactured products,” *Proceedings of the Institute of Mechanical Engineers*, vol. 147, pp. 125-144, Jan.-Jun. 1942.

G.A. Barnard, “Sequential Tests in Industrial Statistics”, *Supplement to the Journal of the Royal Statistical Society*, vol. 8, no. 1, pp. 1-26, 1946.

G.A. Barnard and R.L. Plackett, “Statistics in the United Kingdom, 1939-45,” in A.C. Atkinson and S.E. Fienberg, Eds., *A Celebration of Statistics*, New York, NY: Springer-Verlag, 1985, pp. 31-55.

D. Bissell, “Wilfrid Alan Pridmore (1921-2000)”, *Journal of the Royal Statistical Society. Series D (The Statistician)*, vol. 49, no. 4, pp. 615-617, 2000.

S. Budiansky, *Blackett’s War*, New York, NY: Vintage, 2013.

B.A. Carpenter and R.W. Doran, “John Womersley: Applied mathematician and pioneer of modern computing,” *IEEE Annals of the History of Computing*, vol. 36, no. 2, pp. 60-70, 2014, doi: 10.1109/MAHC.2014.25.

N.E. Coe, “Report 1942-43,” *Journal of the Institute of Actuaries Students’ Society*, vol. 5, no. 4, p. 220.

B. J. Copeland, *Alan Turing’s Electronic Brain: The Struggle to Build the ACE, the World’s Fastest Computer*, Oxford, UK: Oxford University Press, 2005.

M. Croarken, *Early Scientific Computing in Britain*. Oxford, UK: Clarendon Press, 1990.

M.G. Croarken, “The emergence of computing science research and teaching at Cambridge, 1936-1949,” *IEEE Annals of the History of Computing*, vol. 14, no. 4, pp. 10-15, 1992, doi: 10.1109/85.194050.

C.G. Darwin, “Obituary: Mr. J. R. Womersley,” *Nature*, vol. 181, no. 4618, p. 1240, 3 May 1958, doi: 10.1038/1811240a0.

M.H. DeGroot, “A conversation with George A. Barnard,” *Statistical Science*, vol. 3, no. 2, pp. 196-212, 1988.

B.P. Dudding, “The Industrial Applications Group of the Royal Statistical Society: First Session, 1942-43”, *Journal of the Royal Statistical Society*, vol. 106, no. 1, pp. 64-67, Jan. 1943, doi: 10.1111/j.2397-2335.1943.tb01519.x.

B.P. Dudding, “The Industrial Applications Group of the Royal Statistical Society: Second Session, 1943-44”, *Journal of the Royal Statistical Society*, vol. 107, no. 1, pp. 60-63, Jan. 1944, doi: 10.1111/j.2397-2335.1944.tb01591.x.

D. Edgerton, *Britain’s War Machine: Weapons, Resources and Experts in the Second World War*, Allen Lane, 2011.

D.R. Hartree, “The application of the differential analyser to the solution of partial differential equations”, in *Comptes Rendus du Congrès International des Mathématiciens, Oslo 1936, Tome II: Conférences de Sections*, Oslo, Norway: A.K. Brøggers Boktrykkeri, 1937, p 231.

D.R. Hartree and J.R. Womersley, “A method for the numerical or mechanical solution of certain types of partial differential equations”, *Proc. Royal Society London, Series A*, vol. 161, no. 906, pp.353-366, Aug. 1937.

HMSO, *The British Imperial Calendar and Civil Service List*, London: His Majesty’s Stationary Office, 1938.

D.W. Lloyd, “Nomination and commentary on ‘The application of differential geometry to the study of deformation of cloth under stress’, by Womersley J.R.”, *Journal of the Textile Institute*, vol. 114, no. 6, pp. 910-911, Jun. 2023, doi: 10.1080/00405000.2023.2207358.

R. MacLeod and K. MacLeod, “The contradictions of professionalism: Scientists, trade unionism and the First World War,” *Social Studies of Science*, vol. 9, no. 1, pp. 1-32, Feb. 1979, doi: 10.1177/030631277900900101.

K. McConway, “Obituary: Dennis V. Lindley 1932-2013,” Institute of Mathematical Statistics, 2014.

E.S. Pearson, “Some historical reflections on the introduction of statistical methods in industry,” *Journal of the Royal Statistical Society. Series D (The Statistician)*, vol. 22, no. 3, pp. 165-179, Sep. 1973.

F.T. Peirce, “The geometry of cloth structure”, *Journal of the Textile Institute Transactions*, vol. 28, no. 3, pp. 45-96, Mar. 1937, doi: 10.1080/19447023708658809.

J.R. Ringrose, (2004), “Obituary: Frank Smithies (1912–2002),” *Bulletin of the London Mathematical Society*, vol. 36, pp. 841-853, 2004.

D.H. Sadler, “Computing Methods”, *Journal of the Institute of Actuaries Students’ Society*, vol. 8, no. 2, pp. 65-77, Oct. 1948 doi: 10.1017/S0020269X00003480 .

E.H. Sealy, *A First Guide to Quality Control for Engineers*, London: HMSO, Sep. 1943.

L.H.C. Tippett, “Statistical methods in textile research. The analysis of complex variations”, *Journal of the Textile Institute Transactions*, vol. 21, no.3, pp. 105-123, 1930, doi: 10.1080/19447023008661509.

L.H.C. Tippett, “The Making of an Industrial Statistician,” in *The Making of Statisticians*, J. Gani, Ed., *The Making of Statisticians*, NewYork: Springer-Verlag, 1982, pp. 182-187.

J.R. Womersley, “Two nomograms for calculating the fluidity of cellulose solutions,” *Journal of the Textile Institute Transactions*, vol. 26, no.5, pp. 165-170, May 1935, doi: 10.1080/19447023508661650. First published in *Shirley Institute Memoirs*, vol. 13, pp. 95-100, 1934.

J.R. Womersley, “The application of differential geometry to the study of deformation of cloth under stress”, *Journal of the Textile Institute Transactions*, vol. 28, no. 3, pp. 97-113, Mar. 1937, doi: 10.1080/19447023708658810.