

1984

In memoriam: Alexander Hamilton Church's system of scientific machine rates at Hans Renold, Ltd., c.1901-c.1920

Trevor Boyns

Follow this and additional works at: https://egrove.olemiss.edu/aah_journal

Part of the [Accounting Commons](#), and the [Taxation Commons](#)

Recommended Citation

Boyns, Trevor (1984) "In memoriam: Alexander Hamilton Church's system of scientific machine rates at Hans Renold, Ltd., c.1901-c.1920," *Accounting Historians Journal*: Vol. 30 : Iss. 1 , Article 3.
Available at: https://egrove.olemiss.edu/aah_journal/vol30/iss1/3

This Article is brought to you for free and open access by the Archival Digital Accounting Collection at eGrove. It has been accepted for inclusion in Accounting Historians Journal by an authorized editor of eGrove. For more information, please contact egrove@olemiss.edu.

**IN MEMORIAM: ALEXANDER
HAMILTON CHURCH'S
SYSTEM OF 'SCIENTIFIC MACHINE
RATES' AT HANS RENOLD LTD.,
c.1901 - c.1920**

Abstract: In 1901, Alexander Hamilton Church wrote a path-breaking article in *The Engineering Magazine*, entitled 'The proper distribution of establishment charges'. This article, published in six parts, is generally considered to have been one of the most important articles on the subject of overhead allocation and Church's system of scientific machine rates is often seen as a precursor of work which eventually resulted in the emergence of standard costing. Around the same time, Church introduced his system at Renold, a firm of British chain manufacturers, where it was used well into the First World War. Towards the end of the war, however, the system was gradually abandoned in favor of standard costing and budgetary control. Using archival and published sources, this paper examines the factors leading to the demise of Church's system at Renold and, in so doing, throws light on the between scientific management, organizational change and the development of successful costing systems.

INTRODUCTION

In the late 19th and early 20th centuries, there developed, in the Anglo-Saxon world, a literature that began to deal with costing generally and, in particular, the issue of overheads (or bur-

Acknowledgments: I would like to thank the Economic and Social Research Council for their funding (grant no. R000237946) which has made possible the archival research underlying this paper, Renold plc for allowing me access to the Renold archive, and the archivists based at Manchester Central Library, especially Judith Baldry, who have facilitated my research into the archive. I would also like to thank the two anonymous referees for their comments on an earlier draft of this paper, and Richard Vangermeersch for generously providing me with copies of material which he acquired when carrying out his own research into Alexander Hamilton Church some 15 years ago.

Submitted September 2000
Revised October 2002
Revised January 2003
Accepted January 2003

den). Some of this burgeoning literature was produced in the form of scholarly texts which were to be used for educational purposes, while a significant role was played by journal articles, in both the accounting and trade press, illustrating ideas and systems favored, or utilized, by the authors and/or the companies that they represented. One important article, published in the *Engineering Magazine* in 1901, was 'The proper distribution of establishment charges', written by Alexander Hamilton Church. Within 20 years, however, articles had begun to appear on the topic of standard costing, a system which is considered to have had a much greater impact during the 20th century than Church's system of scientific machine rates for allocating overheads. Indeed, Johnson and Kaplan [1987, pp. 127-128] have suggested that although manufacturing cost systems designed to trace costs accurately to diverse lines of products, and hence producing information for assessing efficiency and opportunities for product differentiation, such as that of Church, were available by 1910, they had disappeared by the First World War. It is in this light that the experience of Renold is of interest to accounting historians since this chain manufacturing business adopted Church's system at the beginning of the 20th century, but then subsequently abandoned the system in favor of standard costing and budgetary control. This paper therefore adopts something of the genealogical approach advocated by Miller and Napier [1993], since it focuses in the main upon the factors that led to the failure of Church's costing system at Renold, thereby possibly shedding further light on why this system failed to find widespread acceptance.

This paper attempts to fill in many of the gaps in the details associated with the use of Church's system at Renold, thereby correcting a deficiency noted by Johnson and Kaplan [1987, p. 128], and does this by taking up Vangermeersch's challenge to conduct "a careful mining of the excellent archives at the Renold Company in Manchester, England" [1988, p. 103]. Since Vangermeersch made his comment, the Renold archive has been transferred from the headquarters of Renold plc to the archives section of Manchester Central Library, where it occupies 85 shelves of space. The archive, which is extremely limited for the pre-1909 period, is nevertheless very detailed thereafter, and provides an extremely rich source of material not only for accounting historians but also for anyone interested in the development of scientific management practices in Britain. The differential survival of pre- and post-1909 material reflects a major change in the organizational structure of the company and the

impact of scientific management. From around 1909 the company's management began to embrace Taylorism, both at the shop floor level (e.g. introduction of time studies c.1910/11, the use of functional foremen, etc.) and within the higher levels of management. The latter involved a decisive shift from an organization dominated by the owner-entrepreneur, Hans Renold, to one in which committees began to proliferate and play an increasingly more important role in decision-making [for fuller details see Boyns, 2001, pp. 721-722]. The proceedings of all committees, many of which met weekly, were minuted in copious detail, indicating the nature of discussions and who said what. The various sets of minute books have been preserved and provide a major source of information for this study, though the archives also contain large amounts of supporting material, not least the detailed reports, cost investigations, etc., upon which the committee discussions took place and decisions were based. For certain sets of documents there are also explanatory notes and comments, written some years after the event by Charles Renold, which provide additional contextualization. Most significantly from the point of view of this paper, the survival of records relating to the costing and accounting systems for the period c.1908/09 to c.1920 are reasonably full and informative.¹

In this paper, the operation of Church's system at Hans Renold Ltd., the problems which arose, and the success or otherwise of attempts made to overcome them is examined in the light of the development of Church's ideas, as expressed in his various writings over his lifetime.² In this way, the paper throws light on the relationship between the development of costing theory and practice. Given that Hans and Charles Renold have long since been recognized as pioneers of scientific management in Britain [Urwick and Brech, 1953, pp. 162-169; Boyns, 2001], the paper also throws light on this topic and the inter-relationship between developments in organizational structure, new theories of management and costing methods.

¹ The one major drawback to using the collection, however, is that there is, as yet, no complete catalogue, researchers having to rely on a useful, but limited, card index compiled by the company's librarian prior to the transfer of the collection to Manchester Central Library.

² The second article by Church, 'Organisation by Production Factors', although published in the US under Church's own name, was published in Britain under the nom de plume of H.C. Alexander. Although it is the British version of the paper which is cited here, throughout the text and in the bibliography it is referred to as [Church, 1909/10] rather than [Alexander, 1909/10].

THE COSTING CONTEXT IN BRITAIN, c.1880-c.1920

According to Wright [1962, pp. 3-4], the development of scientific costing systems in Britain can be traced back to the work of John Walker [1875], who developed a system of allocating overheads based on prime costs. Writing at the beginning of the 1890s, John Mann Jr. noted that, in theory, direct overheads varied directly with the labor time occupied on a job and inversely to wages paid [Mann, 1891, p. 635]. While noting that the basis of allocation should be labor time rather than wages paid, a view echoed ten years later by Cowan [1901, p. 90], Mann accepted that for “nearly all practical purposes, however, the *direct expenses may be safely applied in proportion to the wages paid*” [1891, p. 635 – italics in original]. He went on to note that, in practice, direct expenses were often loaded on to both materials and labor. By the beginning of the 20th century, however, Mann [1903, p. 207] noted that there were five different methods in use to spread the expense burden over current work: (1) a rate varying with quantity of material handled, i.e. the unit system; (2) a percentage on cost of wages and materials; (3) a percentage on wages alone; (4) a percentage on time; and (5) the tool basis or machine rate.³ It was the third method that was described as being the most popular in Great Britain at the time [Church 1901, p. 727; Mann, 1903, p. 208], though alternative methods, especially the machine rate method, were finding increasing support from some writers.

The writer considered to have been the most influential thinker on the use of machine rates in the early years of the 20th century was Alexander Hamilton Church. For him, both the percentage on wages and hourly burden methods suffered from a crucial failing: they relied on a single factor for the apportionment of overheads — the percentage system relied on wages, and the hourly-burden system on time. While he accepted that either system might work in situations where there was uniformity, Church noted that, in real life, workshops or factories were often complex entities, with different types of machines and different qualities of labor being employed. In such situations, the percentage-on-wages and hourly-burden systems would prove inaccurate in determining product costs. It was in

³ A similar five-fold classification was presented by Mark Webster Jenkinson [1914, p. 569] just before the outbreak of the First World War: (1) a percentage on prime cost; (2) a percentage on the cost of labor; (3) a fixed sum for each hour of time worked by each man; (4) a fixed sum per hour for each machine; and (5) a fixed sum per unit of weight or quantity.

such a context that Church argued that, "we must seek a method capable of recording [cost] with approximate accuracy under the most complex and difficult conditions" [1901, p. 729]. For him, "the business of costs [is] to represent facts and nothing but facts" [Church, 1909/10, p. 26].

Church clearly had an impact. In 1902, shortly after the last part of Church's article was published, Urie [1902] presented a paper to the Glasgow Chartered Accountants Students' Society on the subject of oncost and its apportionment, providing a brief résumé of Church's system. When Bardsley [1902] likewise presented a paper to the Kingston-upon-Hull Students' Society, he mentioned the machine rate method alongside the other alternative methods. Indicating that each method had its pros and cons, Bardsley suggested that a mix of methods may have to be used within the same business, noting that "I find I have to use two or three of these methods" [1902, p. 1092]. Church's refined machine rate system entered the literature then at a time when certain persons were beginning to push for the development of the use of costing systems. Such systems were seen by their advocates as being part of the scientific approach to business, and it was considered that there was a need for their more widespread application in Britain. One critic of the lack of a scientific approach was the chartered accountant, Harvey Preen, whose book, *Reorganisation and Costings – A Book for Manufacturers*, was first published in 1907. In a second, new and enlarged version, published in 1913, Preen began his chapter on costings by emphasizing the importance to manufacturers of 'correct costings'. To stress his point, Preen provided an example of 'wrong costing', namely a 'system' which determined the selling price of a good by merely taking an estimate of direct costs and then added some guessed percentage to represent estimated fixed charges, and a further guessed percentage to represent profit [Preen, 1913, p. 127]. In his 1907 work, Preen had pointed out that 'adding a bit' was unscientific, and that the "necessity for accuracy cannot be too strongly insisted on" [1907, p. 69].

Preen, by pushing for 'scientific costing' [1907, p. 65], was providing portents of what was to come, though he himself never mentions the use of standards or standard costing, a technique which was gathering strength across the Atlantic. However, Preen did point out that "The past is dead and gone, and what has been, has been, and cannot be changed; it is as a guide to the daily present and future that costings are so useful" [Preen, 1907, p. 65]. Preen, in a short chapter entitled 'The Budget System', also referred to the potential use to management of

budgets. However, as revealed in his text, Preen's concept of a budget was essentially as a backward rather than a forward looking document. Indeed, Preen's budget was more in the form of a monthly trading account, though he does suggest that, echoing his view of costing, it would have forward looking connotations [Preen, 1907, pp. 81-82]:

[The budget system is] a method which will enable the manufacturer at the end of each month to know with comparative exactness how the business stands, what has been occurring during the month, to form a fairly reliable estimate of what is likely to occur in the ensuing month, and also, to enable comparisons to be made with the same trading period, and the corresponding month, in the previous year or years.

The key to his 'budget system' was that the information should be quickly available, i.e. within no more than four days of the end of the month, since otherwise the manufacturer could not act with certainty: "If the preparation is delayed, the information becomes ancient history, and its usefulness is greatly impaired" [Preen, 1907, p. 84].

In the years leading up to the First World War in Britain, the costing literature illustrates an ongoing concern that manufacturers should adopt scientific costing systems. While there is most probably a link here with the development of scientific management, the precise nature of this has still to be investigated, not least because the extent of the use of either within British firms is still too little known. It is generally accepted that the concepts that are most closely linked with scientific management, namely standard costing and budgetary control, were developed in the USA during the early decades of the 20th century [Solomons, 1952; Wells, 1978; Epstein, 1978; Sowell, 1973] though Fleischman [2000] has recently questioned the extent of the use of scientific management in American firms. In Britain, although texts on these topics did not begin to appear until the late 1920s or early 1930s [e.g. Downie, 1927; Willsmore, 1932], British practice may not have lagged behind that of America to the extent that has often been suggested in the past. Indeed, there is evidence that, in the immediate aftermath of the First World War, a number of British companies began to exhibit widespread use of budgets and, to a lesser extent, standard costing [Boyns, 1998a,b; Berland and Boyns, 2002]. Amongst these, and possibly the most advanced, was Hans Renold Ltd. [Boyns et al, 2000].

CHURCH'S SYSTEM OF SCIENTIFIC MACHINE RATES

The rationale behind Church's system, as expressed in the title of his first article in 1901, was a concern for 'The proper distribution of establishment charges'. In this first article, Church considered cost to be made up of four components: material; wages; a shop charge; and a general establishment charge. The first three of these elements gave rise to 'works cost', and for Church, following his mentor, Slater Lewis, the crucial distinction was that between shop charges and general establishment charges. While the former were related to production, the latter were not, being more related to selling. Over time, however, Church modified this categorization so that selling expense was separated from other general expenses, the latter being included with factory cost (i.e. material, direct labor and factory expense) as part of 'warehouse cost' [Church, 1923, p. 382]. The addition of selling expense to warehouse cost produced what Church termed 'Sold Cost'. Although Church generally makes some mention of selling costs in his writings, this is usually only in a cursory manner, his main concern throughout being with shop charges and how they should be allocated to jobs or products.

The key to Church's method of allocation is the independent production center, which forms the basic unit of analysis. This could be a machine or a bench at which a hand craftsman might work, and all of the shop charges that could be identified with that production center would be allocated to it on the basis of an hourly (scientific) machine rate. Machine rate systems were not altogether new, having been suggested at least 50 years earlier, but Church considered them to be limited in their approach since they had concentrated merely on allocating interest and depreciation on each machine. For Church, the approach needed to be extended to cover all shop charges, as far as was possible, in a scientific manner. Thus, for each type of expense that could be attributed to a production center, in addition to the interest, depreciation and insurance charges related thereto, an hourly rate would be determined, these then being aggregated to give an overall hourly machine rate, based on the probable number of hours the machine would work under normal conditions. Church realized, however, that while many shop charges could be 'narrowed down', i.e. allocated, to individual production centers, this was not true of all of them:

In an ideal system, it would therefore be expected that this narrowing down should be carried as far as it was practically profitable to do so, and that only such

expenses as were wholly general and could not by any reasonable analysis be connected with definite points of incidence, should be treated as general shop charges, and therefore left to be averaged on the former basis [Church, 1901, p. 733].

In his 1901 paper, the types of expense which he had in mind for allocation by machine rates were those of the building, lighting, power, interest/depreciation/insurance, and overlooking and supervision. However, this paper only outlined the general method, Church noting that space did not permit a full description of how the method should be applied [1901, p. 235]. This formed the basis of his second article in 1909/10, which provided details of how to determine the production factors, i.e. unit values, for each type of expense, and the basis upon which they were to be calculated. Thus, building costs (including items such as capital cost, interest, rent, insurance, depreciation, heating, ventilation and lighting), for example, were to be calculated on the basis of square footage occupied by the machine, whereas power was to be on the basis of a charge per horsepower hour. These unit values would then become components of the overall hourly machine rates and jobs carried out on any machine would then be charged at the appropriate composite hourly rate for that machine. The total rent charge (i.e. the cost allocated against the job) would thus depend on the rate for the machine and the time occupied by the machine on the job, this amount being credited to the monthly shop-charges account, to be offset against the total expenses of the shop, which would usually comprise more than one production center.

Church recognized that the amounts so credited would not match the total monthly expense: it would be deficient to the extent of those shop charges which could not be recovered since they could not be charged to individual production centers, and those not recovered because machines were idle for some of the time. Church considered that such charges remaining unaccounted for would be small, there being "but one or two items, themselves of relatively small amount, remaining to be treated in this way" [Church, 1901, p. 37], the main item not attributable to production centers being that of the overall works foreman. To take account of the unrecovered, or unallocated, expenses, however they might have arisen, Church advocated the use of a supplementary rate which, he argued, if applied as an hourly burden, could be used as a barometer of efficiency, since the higher the supplementary rate, the greater the time machines had spent being idle [Church, 1901, p. 910]. Although the

supplementary rate concept was clarified further in the 1909/10 article, it was the subject of numerous attacks by contemporaries, and its efficacy/rationale has been questioned by accountants and accounting historians [Vangermeersch, 1988]. By 1930, the idea of attempting to allocate the cost of superfluous services to each job or product was abandoned, in favor of charging them directly to profit and loss [Vangermeersch, 1988, p. 51]. The only purpose left for the supplementary rate, therefore, was as a memorandum or indicator of utilization [Church, 1930, p. 178].

Church's overriding concern in his writings was with the proper allocation of shop charges so as to be able to determine the actual cost of production. While his interest in costs largely ended at the door of the workshop, there nevertheless remained the issue of what, in his first article, he labeled 'general establishment charges' (GEC), i.e. those costs, essentially administrative expenses, over and above those incurred in relation to production. These were considered to include "advertising, travelling, drawings, patterns, catalogues, correspondence department, cashiers and bookkeeping, management and all similar expenditure" [1901, p. 371] and were equated by Church with selling costs. By the time of his 1909/10 article, however, Church no longer makes any reference to GEC, rather he talks of general or administrative expenses. These, he argues, apparently in their entirety, can be accurately split between factory administrative expenses and selling administrative expenses. The former can be allocated to manufacturing cost through various production factors, such as those for 'organization' and 'management and supervision', included in the machine rate, while the latter can be included in the selling expense [1909/10, p. 81]. Thus, by the time of his second article, Church seems to have moved to a position where all general or administrative charges can be allocated, albeit some of them going to selling expense.

But how should selling expense be allocated? Church was well aware that they could not be ignored, since "the question of selling expense is so closely connected [to manufacturing]" [1909/10, p. 875]. Even so, he tended to give them short shrift, often stressing that selling and manufacturing expense bore no relation to one another [1901, p. 368; 1909/10, p. 81; 1929, p. 112]. Thus, in his 1930 work, *Overhead Expense*, which extends to 412 pages of text, the only reference to selling expense occurs in the final three pages of the book. In his first article, Church had been somewhat vague about how to deal with them, arguing that any method of allocation would necessarily be

somewhat arbitrary: "It would be better, of course, if the figures pertaining to general charges were as real and reliable as those of the shop charges. But there seems no possible hope of their being made so" [Church, 1901, p. 374]. Noting three possible methods of distributing GEC, i.e. on wages cost only, on works cost, or on an hourly basis according to the number of hours consumed in the production, he declared the last to be the least worst option for "ordinary manufacturing purposes" [Church, 1901, p. 369]. In his 1909/10 article, Church stated strongly that selling expenses were not amenable to any connection with machine rates [1909/10, p. 875], a view that does not seem to have changed throughout the remainder of his writings, in large measure because he viewed selling expenses as "much less amenable to standardization than is manufacturing capacity" [Church, 1930, p. 410]. Throughout his writings, Church expressed the view that since different products gave rise to different types of selling expense, the only sensible thing to do was to treat products in groups, according to the nature of the selling costs they incurred [Church, 1901, p. 371; 1909/10, p. 84; 1930, p. 411]. In his 1930 work, Church does use the term 'selling factors' [1930, p. 411], but indicates that it is hardly worthwhile trying to calculate such factors, since total selling expense can be influenced by vastly changing activities which can vary greatly from period to period.

While the treatment of selling expenses varies little between his early and later works, Church's attitude towards business growth does change significantly. In his 1901 article, as part of the rationale for the adoption of his system, Church stressed the need for up-to-date methods of shop accounting as part of a modern system of organization, especially in circumstances of business growth, whether it be in a business run by a single proprietor or a joint stock company [1901, pp. 509-511]. It can be implied, therefore, that at this early stage, Church considered his system to be of benefit in a growing business. This issue receives little or no attention in Church's subsequent works, save for a few brief words at the end of his 1930 text. On the final page of *Overhead Expense* he notes that "The whole question of an expanding business is also necessarily left out of account" [1930, p. 412]. The rationale given is that rapid expansion of a business causes great changes in the factory and would therefore result in the need for "Frequent recalculation of schedules . . . Enlargement of a department necessarily disturbs all values concerned from service factors to process rates" [1930, p. 412]. This appears to have been a tacit admission that his system of

scientific machine rates could be put under extreme pressure in times of rapid business change.

CHURCH, SCIENTIFIC MANAGEMENT, STANDARD COSTS AND BUDGETING

Church's early writings during the first decade of the 20th century clearly place him as a contemporary of F.W. Taylor. However, as Vangermeersch [1988, p. 102] has pointed out 'open war' existed between Church and L.P. Alford on the one side, and the Taylorists, led by Barth and Gantt, on the other. For Vangermeersch, part of the explanation for this antagonism stems from the lack of concern amongst the 'Taylor imitators' of any concern for the workers, something which appalled Church and which explains why his science of management "was a much broader concept than scientific management" [Litterer, 1961, p. 220]. Like Taylor, Church was concerned with methods of improving the efficiency of management, as revealed in his numerous writings on this topic, and hence his general approach to matters of organization and efficiency were more holistic than simply finding methods of improving performance on the shop floor. Church's costing system was clearly seen by him as part of an organizational structure which helped to improve managerial efficiency.

In the context of the development of scientific management, it is, of course, standard costing which is seen as being the key accounting change. It seems pertinent to ask, in the context of this study, where Church's system fits in to the overall picture. The choice of term 'scientific machine rate' to describe Church's system suggests a possible link to Taylorism, but it is far from clear that there was such a link. In his 1923 work, *The Making of an Executive*, Church set out what scientific method meant to him [1923, pp. 4-5]: "In general the scientific method depends on taking nothing for granted, and becoming familiar not only with broad or practical results, but also with the infinitely small influences and conditions that go to build up results of all kinds, both successful and unsuccessful. In other words, it is mastery of minute details and of fundamental principles that is aimed at".

Clearly Church's machine rate method was scientific in that it attempted to allocate, as accurately as possible through minute study, all shop charges to individual jobs. Church also indicated that 'production factors' provided "a wider economic value to staff organization, inasmuch as they enable standards

to be set up not only as between today and yesterday in the same works, but as between different works in different places" [1909/10, p. 190]. The combination of the scientific method and standards were clearly inter-related:

Only the accumulation of records and of compared experience can make this possible, but it will be allowed that a *general acceptance of the principle of organization by production factors would have the effect of making known the usual or standard values of such factors under conditions of good practice*, and that therefore as soon as the elements of cost, power, durability, space, and attendance of any new machine were determined, *its nominal rate under conditions of efficiency and economical installation and working would also be predeterminable with sufficiently close accuracy*. In so far as such theoretical rates are not realised in actual practice it would suggest a *prima facie* case for enquiry into causes [Church, 1909/10, p. 86 – italics in original].

Despite generally recognized as having provided a backcloth from which standard costs were developed [Vangermeersch, 1988, p. 35; Solomons, 1952, p. 42], Church himself exhibited an aversion to standard costing. In the second edition of *Manufacturing Costs and Accounts*, Church expressed the view that standard costs could not do anything that could not already be done by his standardized scientific machine rate system [1929, pp. 442-443]. Church's stance appears to have been predicated on his concern with determining actual costs: "Nothing which substitutes ratios or mathematical formulae *for the actual record of actual happenings* can be called cost accounting in the true sense, however useful it may be to efficiency engineers" [1929, p. 445 – italics in original].

In contrast, Church was more favorably disposed towards the use of budgets in business. Indeed, as early as 1923 he was expressing the view that they were "One of the most satisfactory methods of controlling expenditure" [Church, 1923, p. 392]. In Church's view, budgets should be based on "a reasonable forecast of the course of business in the coming year" [1923, p. 393] and control was to be effected through a comparison of actual outcomes with those expected [1923, pp. 394-395]. This early advocacy of the use of budgets for control purposes, at a time when the use of budgets in business was still in its infancy [Marquette and Fleischman, 1992], was clearly in marked contrast to Church's antagonistic views towards standard costing.

Having examined the key aspects of Church's scientific

machine rate system, how Church modified some of his views over time, and the links between Church, scientific management, standard costs and budgeting, it is now time to turn our attention to an examination of the development of costing at the Renold company between c.1901 and c.1920.

THE DEVELOPMENT OF THE HANS RENOLD CHAIN-MAKING BUSINESS, c.1901-c.1918

During the first two decades of the 20th century, the business which became Hans Renold Ltd. in 1903 grew rapidly. Turnover, which had more than doubled during the 1890s, from £14,000 in 1890 to £30,000 in 1900, quadrupled during the period 1900 to 1910, reaching £127,000 by the latter date, and rising to £197,000 by the First World War [Renold, c.1914, p. 224]. Even so, the company remained medium sized, not only by international standards but also by that of contemporary British business. Despite trebling since 1903, employment at the company was still only 1,350 on the eve of the First World War, far below the level of more than 5,000 workers employed by the 100th largest British company of 1907 [Wardley, 1999].

The company's rapid growth up to 1914 necessitated a number of important changes within the business, not least the move to new premises. In 1906, recognizing the need for expansion of the works, then located at Brook Street in Manchester, land was purchased at Burnage, five miles south of the city. Initially it was planned to use Burnage as an overflow plant, but the splitting of operations between Brook Street and Burnage generated logistical and managerial problems. These were overcome by erecting a second Burnage building, commenced in the middle of 1913, thereby allowing Brook Street to be vacated by early 1915 [M501 650.0124 HR903/5, Report of chairman's remarks at the annual meeting, 24 February 1915]. The nature of the problems resulting from production on two sites, while not totally responsible for, no doubt had an important influence on, the company's performance in the late 1900s. Most noticeably, at the same time as the company was expanding, in terms of employment and turnover, its profitability was declining: the ratio of profit to turnover halved from an average of 26% between 1903 and 1907 to only 12.1% between 1908 and 1911 [M501 650.0124 HR903/1, Company Minute Book 1, figures calculated from those in directors' reports to annual general meetings of shareholders].

The company was thus still in something of a state of flux

when the First World War broke out and Hans Renold became a member of the Manchester Armaments Output Committee. On 18 August 1915, at which stage 32% of the company's output comprised munitions, the Burnage works became a controlled establishment under the Defence of the Realm Act [M501 650.0124 HR903/5, Appendix to Company's Minute Book, directors' report to 14th AGM, 22 August 1916]. Within a year, 98.5% of the company's output was made up of munitions, especially shells and fuses but also turnbuckles for aircraft and aero-engine parts [M501 650.0124 HR903/3, Directors' Report for year ended 30 June 1919]. The particular problems associated with incorporating fuse manufacture within the company's existing organizational structure led to the formation of a separate Fuse Department, which later became something of a model for subsequent organizational developments after the war. In the directors' report for the financial year ending 30 June 1919, the extent of the company's involvement in war work was illustrated by the fact that throughout the war period the company had manufactured munitions to the value of £1.75m, a task which had only been accomplished by doubling the workforce to a wartime peak of 2,702 in 1917 [M501 650.0124 HR903/3, Directors' Report for year ending 30 June 1919]. The end of the war led to a rapid fall in the number employed by the company: in June 1918 the figure was only 1,995 (of whom 1,127 were women), a year later it was down to 1,500 and in January 1922 fell to a post-war low of 760 [M501 650.0124 HR903/5, Appendix to Company's Minute Book, Directors' Reports to various AGMs].

THE EXPENSE RATE SYSTEM AT HANS RENOLD AND MAJOR CHANGES THEREIN, c.1908 - c.1915

Although Hans Renold was clearly interested in costing matters, as revealed in an entry in his diary recording observations made during his second visit to the U.S. in March and April 1894 [M501 920 RH 891/1], very little is known of the costing system used by him prior to 1900. At the beginning of the 20th century, however, Alexander Hamilton Church was engaged to install a system of costing based on expense rates [M501 657.471 HR913/9, 1915 Expense Rate Report (hereafter referred to as ERR 1915), f. 66; Lawrence and Humphreys, 1947, p. 30]. While Charles Renold, many years after the event, declared that the system had been introduced from America [Renold, 1950, p. 113], Church, who had been born in England

of an American father,⁴ was clearly residing in Manchester around the time that the system was introduced. According to the 1901 Census [www.census.pro.gov.uk], Church was lodging in two rooms at 922 Ashton Old Road, Manchester, where he gave his occupation as "Expert in Organisation of Factories and Engineering Works". He also described himself as an 'employer' rather than an employee, suggesting that he was engaged by Renold in a consultancy capacity, a fact which may explain why the surviving company records of this period contain no reference to him.⁵ How long Church was engaged in implementing his system at Renold is unclear: some commentators have suggested two to three years [Vangermeersch, 1988; Scorgie, 1993] though Urwick [1956, p. 113] has claimed that he might have been there from 1900 to 1905. According to Vangermeersch [1988, p. 7], Church was introduced to Hans Renold by a close friend and fellow Manchester businessman, Leonard Massey. Apparently Church had been introduced to Massey by his company's auditor, Joseph Bell, sometime in the 1890s and, having put into place a costing system there (the precise nature of which is unknown⁶), then moved on to Hans Renold.

Despite the absence of manuscript records for the period to c.1908/09, knowledge of the Hans Renold costing system in the early years of the 20th century can be gleaned from a number of sources, both published [e.g. Renold (1913-14), Renold (c.1914), Allingham (1921-22)] and archival. The 1915 Expense Rate Report, which was submitted to the board of directors by H.G. Jenkins in December 1915, not only presents a picture of the basic nature of the system c.1915, but also provides indications as to how it had changed up to that time. As Table 1 reveals, the system underwent a number of modifications over 15 years, giving rise to five distinct phases, and was finally replaced, towards the end of the First World War or shortly after, by a completely

⁴ Alexander Hamilton Church was born on 28 May 1866 to Richard Stephen Hamilton Church and Jane Grace Quick Clemence. His parents were subsequently married on 23 October 1867, when the former was 69 years old and the latter 28 (details from a copy of the marriage certificate obtained by the author from the General Register Office).

⁵ The main records to have survived from the early years of Hans Renold Ltd. are the directors' minute books. However, those for the period to c.1908/09 unfortunately provide little useful detail on matters other than those relating to legal issues or of a statutory nature, and contain no mention at all of either Church or of the costing system.

⁶ Vangermeersch [1988, p. 7] indicates that the system was used at Masseys from about 1900 through to 1960.

different system comprising standard costing and budgetary control.

TABLE 1

Key Phases in the Development of the Hans Renold Costing System

1901 - March 1908	<i>Church I</i> : Original 'Expense Rate System'.
March 1908 - 28 July 1909	<i>Church II</i> : Modified System, including the addition of Design Expense Rate (known as Old Basis, Burnage).
29 July 1909 - 30 June 1911	<i>Church III</i> ⁷ : Three Factor Machine Rate System (addition of Selling Expense Rates and sub-division of general charges between departmental indirect and general works charges).
June 1911 - December 1914	<i>Church IV</i> : 'C' rate system (rates revised in January 1913 and July 1913). ⁸
January 1915	<i>Church V</i> : based on budgeted expenses; included expense rates for general office services and research, and also a material expense rate to cover stores costs.
Mid-1917	Desire to move to a simpler, more direct system which would produce meaningful figures more rapidly.
April 1918	Trial application of standard costing in the Shell Department.

The original Renold expense rate system echoed closely that developed by Church in his 1901 article in *The Engineering Magazine*.⁹ It was based on the concept of scientific machine

⁷ This set of rates was inaugurated after Hans Renold's visit to the USA in 1909 [ERR, 1915, f. 67].

⁸ It is interesting to speculate on the nomenclature used here. One possibility is that there is a link to Church's 1917 book, *Manufacturing Costs & Accounts*, where his own costing system is described as Method C. A more likely explanation, however, is that it is short for 'compound', since the nature of the revised system enabled the generation of both simple and compound machine and labor rates.

⁹ It is quite possible that Church's 1901 article is, in fact, an attempt to set out the system he was still in the process of developing at Renold. In discussing how to deal with building expense, Church notes that the method being described "was first worked out for and applied to a factory which consisted of two parts, one being an old building of five storeys, and the other a modern shop of three" [1901, p. 31]. A photograph of Renold's Brook Street Works in 1890 [Tripp, 1956, between pp. 16 and 17] shows an older main building, five storeys high, with a newer addition of three storeys.

rates applied to independent production centers, which were charged with all expenses that could be reasonably allocated to them, and any unallocated shop charges at the end of each month were distributed over the jobs completed as a supplementary rate, which was used as an index of shop efficiency [ERR 1915, f. 66]. Having established the rates, they remained "operative from 1901 to March 1908, modified by supplementary rate" [ERR 1915, f. 66]. Beginning in 1908, however, changes began to be made to the Church system at Renold. The extent of Church's input to these changes, if any, is unknown, but it is perhaps not merely a coincidence that his second article, on production factors, appeared in 1909/10. Having benefited from the experience gained from introducing and operating his system at Renold, Church may have felt that his system could now be more fully explained to the engineering fraternity. However, the changes made to the expense rate system at Renold from 1908 do not entirely reflect Church's views as laid out in his 1909/10 article, the company apparently attempting to develop the system in ways which went beyond those advocated by Church.

Two important strands can be discerned in the changes introduced into the Renold expense rate system from 1908: an attempt to improve the allocation method so as to reduce the residual amount left to be allocated through the GEC and a concern with identifying the most effective way of incorporating production factors within the machine rate.

GEC: At Renold, the key element in the expense rate system was the fixing of the 'manufacturing rate', comprising the machine and labor rates, plus other elements which varied over time. In the original system it was found that a GEC of about 34% had to be applied to manufacturing cost to cover "General Works, General Office and selling Expenses" [ERR, 1915, f. 66]. As the company grew, and its management structure became more complex, overheads became much more significant "than they had been when the system was conceived" [Renold, 1950, p. 113]. In an attempt to reduce the amount to be arbitrarily allocated under GEC, the company began to experiment with additional expense rates from 1908. First, in March 1908, design expenses were separated from GEC by use of an hourly design expense rate, and the managing director's salary was charged direct to manufacturing. This resulted in a reduction of GEC to about 26% of manufacturing cost [ERR, 1915, f. 67]. Second, in July 1909, general charges were divided into departmental indirect

and general works, and charged at differential percentages on the sum of machine and labor. Third, also in July 1909, selling rates were introduced in an attempt to take account of all technical and commercial expenses. In January 1915, another major revision occurred. Additional rates were added, namely a material expense rate, to enable the cost of stores to be separated from the general works charge, and a rate to cover general office services and research, and a three-fold categorization of the 'manufacturing rate' was adopted: machine direct rate, labor direct rate, and an indirect rate (covering departmental expenses, inspection, general works services and general office services) (see Figure 1).

Although the selling expense rate was introduced to reduce the incidence of GEC, its implementation was the source of many difficulties. Initially it "was applied as a differential percentage on Factory Cost" [ERR, 1915, f. 70] for the various product groups in the manner stressed by Church [1901], that is, to "ensure that each class and sub-class of product got as nearly its fair share as could be determined" [ERR 1915, f. 70].¹⁰ Towards the end of 1912, however, the issue of using a single rate to cover all technical and commercial expenses came under detailed scrutiny, not least because of the large variations that existed between the estimated and actual expenses for 1911-1912. One means of attempting to resolve this issue was "to have these expenses frequently recalculated as part of a regular routine" [M501 650.0522 HR910/3, Board of Trade meeting, 16 October 1912]. A second way of overcoming part of the problem was to change the basis for allocating these expenses, and alternative methods were discussed, notably charging on the basis of invoice entries¹¹ and treating individual items of technical and commercial expenses in a different manner. In 1914, selling rates were determined on a variety of bases: some costs

¹⁰ A list of the main product classes for late 1912 indicates three main ones, namely, chains, wheels and 'machines and tools', with the first of the three classes being sub-divided into cycle, block, roller, silent liner, other silent chains, common, and mortise gear [M501 650.0522 HR910/3, Board of Trade meeting, 16 October 1912]. The selling rate was designed to cover a number of expenses, including those of the selling office, publication, the cost office, the drawing office, royalties (i.e. patent fees), costs of carriage in, etc.

¹¹ At a meeting of the Board of Trade committee held on 6 December 1912, figures had been produced showing that while the average technical and commercial cost per chain order was 18/-, using the percentage on factory cost method meant that orders were being charged amounts varying between 1/- and £20 [M501 650.0522 HR910/3].

FIGURE 1
Machine Rate Card, Hans Renold Ltd.,
30 March 1917

H.R. 131. 3000. 303/17.		191		191		191	
MANUFACTURING RATE RECORD.				DESCRIPTION			
STATISTICS				MAKER			
Rate Based on Budget				Machine Symbol			
Rate Applies from				DEPT.			
Quantity of Machines in Group				191			
Actual hours worked by Group				191			
Normal hours worked by Group				191			
Normal hours worked per M/c				191			
Cost of Group				A Machine Direct Rate			
Machine Depreciation Rate %				1 Machine Depreciation			
Machine Depreciation for Group				2 Floor Burden			
Group Space (incl. handling)				3 Power			
F.B. Direct = (Gp. Space x £.)				4 Consumption			
F.B. Indirect:Dept'l Hour Rate				TOTAL			
F.B. " Unocc. Space H.R.				B Labour Direct Rate			
HP hour rate				1 Operator's			
Machine HP				2 Reward (Actual/Possible) = %			
Standard Operator's rate				3 Dept'l Supervision			
Ratio of Opert's Hrs. to M/c Hrs.				TOTAL			
1 : 1 :				C Indirect Rates			
1 : 1 :				1 Departmental			
1 : 1 :				2 Inspection			
1 : 1 :				3 General Works Services			
1 : 1 :				4 General Office Services			
1 : 1 :				TOTAL			
1 : 1 :				TOTAL () Mfg. Rate = A + B + C			
ENTERED		COMP.		APPROVED		For Details of Machines Included in Group SEE BACK.	

continued to be allocated as a differential percentage on factory cost, but others were allocated as a differential rate per invoice entry, while those to cover discounts allowed to agents were allocated as a differential percentage on selling value and those to cover royalties on all patent Silent Liner Chains as a flat percentage on selling value. Despite all of the changes, selling expenses continued to cause problems. Thus, at the Head Office meeting of 14 April 1916, Dugdale, in charge of the credit and prices section of the selling department, argued that the table of selling rates was unnecessarily complicated and argued in favor of a flat rate charge, but Jackson, who became Sales Director around this time, objected since, in his opinion, the system currently being used was more equitable [M501 650.0522 HR910/7].

Incorporating Production Factors Within the Machine Rate: The composition of the various components of the Renold 'manufacturing rate' also varied over time. Taking the machine rate as our example, prior to July 1909 it comprised four items: depreciation, power usage, consumption of tools and gas, and floor burden (i.e. the machine's share of the buildings cost based on the square footage occupied) [M501 657.47 HR 908/4, Revised Jan 1908 Cost System – reproduced in Vangermeersch, 1988, pp. 26-27]. In July 1909, however, floor burden was moved to general works expenses, but this experiment proved "not good" [ERR 1915, ff. 69-70] and it was restored to the machine rate in June 1911. Even then, the precise method of including floor burden in the machine rate was the subject of on-going discussions, in particular, as to whether it should be charged on the basis of the bare area occupied, this plus a handling area, or with an addition to cover the space around a group of machines [see, for example, M501 650.0522 HR910/2, Burnage meeting, 8 May 1912].

Up until 1909, the method of establishing the machine rate was normal hours, i.e. the number of hours the machine was expected to run under normal operating conditions. For this purpose, it would appear that the norm was established at 2,000 hours per year [Renold, 1950, p. 113].¹² In 1909, however, a

¹² Given this fact, it is somewhat strange that Solomons [1952, p. 42] should argue that Church's machine rate was based on the assumption that machines were worked at their maximum capacity, while it was Whitmore who had the insight that overheads should be spread on the basis of normal machine usage rather than maximum usage. 2,000 hours per annum was clearly less than the maximum possible at Renold, where a 48 hour working week had been introduced in 1896 [Tripp, 1956, p. 74].

switch was made to using actual hours, a move which helped to bring to the management's attention the fact that certain of the medium and large machines were working only a fraction of the possible time [ERR, 1915, f. 69]. When the system was revised again in June 1911, however, while the power and consumption factors of the machine rate continued to be based on actual hours, those for machine depreciation and floor burden (now added back) were based on normal hours [ERR, 1915, f. 71].

One other key change which affected the Renold expense rate system was the switch to calculating expense rates on the basis of budgeted rather than actual expenses, which occurred in January 1915. The benefits to the company of changing to budgeted figures were claimed to be two-fold:

- (a) Calculation of Expense Rates can be commenced before end of Financial year thereby expediting calculation with consequence of less disruption in Cost Dept.
- (b) The possibility of incorporating anticipated Trade Policy changes into Expense Rates, thereby reducing difference between Valuation of Work Done according to Expense Rates and Actual Expenses – a matter of supreme importance [ERR 1915, f. 3].

EXPLANATIONS FOR THE CHANGES TO THE COSTING SYSTEM

The changes which occurred in Renold's costing system can be viewed from two, inter-related perspectives: influences that were of a much broader nature and impinged on the costing system from outside, and problems inherent within the costing system itself. The former includes factors both external to the firm, such as the activities of competitors, the impact of war, etc., and factors internal to the firm. In this latter respect it needs to be recognized that changes to the costing system were strongly inter-connected with the growth of the business and a movement towards the development of an organizational structure, based on committees and departments, broadly in line with the views of Taylor and other exponents of scientific management. Although external factors will be touched upon *en passant*, in this section we focus our attention on three possible internal explanations for the changes noted to the costing system: organizational developments within Renold; attempts to develop a system of accounting control; and problems inherent in the costing system itself.

The Development of the Organizational Structure: In 1879 Hans Renold took over a bankrupt concern in Salford making common chains for textile machinery and, through the invention of improved products, such as chains suitable for use on bicycles and in cars, the business was gradually developed. Even when the business was converted into a limited liability company in 1903, Hans Renold, as Governing Director, retained all the powers of running the business, including that of hiring and firing directors. Towards the end of the first decade of the 20th century, however, the growth in business size, the need to control two separately located factories, and problems of a falling rate of profit on turnover (which Hans Renold blamed on managerial problems [M501 061.51 HR912/20, draft notes for chairman's speech to OGM, 15 February 1912]) all contributed to a re-assessment of the organizational structure of the business.

While Urwick [1956, pp. 48-49] has suggested that Hans Renold was the first businessman in Britain to adopt Taylorism prior to 1914,¹³ an equal claim could also be made for his son, Charles [Boyns, 2001], who was later to become a significant figure in British management circles from the 1920s through to the 1950s. On completing his MA in Engineering at Cornell University in the USA, Charles Renold joined Hans Renold Ltd., becoming a director of the company in 1906. Together, Charles and Hans began to develop a new organization structure for the business, based around committees and the introduction of scientific management techniques, moves that were accompanied by the development of organization charts.¹⁴ Although Hans Renold clearly recognized the need to devolve power to others within the organization, he does not appear to have been overly keen to do so before 1914 and, indeed, retained his powers as Governing Director until the late 1920s.

The single entrepreneurially controlled business thus began to be replaced by an organizational structure comprising a committee style of management from about 1908/09. However, as

¹³ Hans Renold [1913-14, p. 21] claimed to have met F.W. Taylor on three occasions, presumably during his numerous visits to the USA.

¹⁴ A document [M501 651.01 HR906/3] in Hans Renold's hand, dated 1908, shows a sketch of the new organizational structure which was formalized in a printed chart in November 1909 [M501 651.051 HR913/2 - see Appendix Exhibit 1], predating by eight years what Chandler has claimed to be the first table of organization in a British company, namely that of British Westinghouse for 1917 [Chandler, 1990, pp. 240-241].

Charles Renold pointedly remarked on one occasion, the committees were only advisory to his father [Renold, c.1914, p. 233]. During the second decade of the 20th century, although the committee structure underwent numerous changes, these were clearly motivated by the desire to follow largely the principles of scientific management as espoused by F.W. Taylor.¹⁵ In 1912, Charles Renold and another engineer (possibly Henry W. Allingham) were sent to the U.S. to investigate scientific management [Renold, 1950, pp. 109-110], though the company had already carried out a number of time studies of their own by this time¹⁶ and had been moving towards a functional system of organization for some time.

The succession of organization charts produced from 1908/09 (see Appendix Exhibits 1-3) clearly shows the development of the management structure towards a departmental organization based initially on functions, though from as early as 1912 there were discussions about organizing the business according to product-based departments [M501 650.0522 HR910/2, Head Office meeting, 16 January 1912]. In the event, such a development only occurred towards the end of the war, when experience gained during the war in the organization of the separate Fuse Department provided a model for subsequent organizational developments. Having effected major changes to the organizational structure prior to the First World War, further changes were introduced at the beginning of the war. Thus, between April 1914 and September 1915, the drawing offices were taken out of the manufacturing departments, to become a separate design function, with all manufacturing activity, both of chains and wheels on the one hand and machines and tools on the other, being merged into a 'Making' Department. By January 1917, however, design had been incorporated as one of four functions under 'Making', together with 'current work', 'inspection' and 'plant' (see Appendix Exhibit 2). The most significant change effected during 1916 was the appointment of two

¹⁵ It is clear from the company's minutes, however, that they did not always follow Taylor's ideas to the letter. Thus, for example, a minute for 30 July 1912 contains diagrams showing how the Burnage organization differed from that suggested by Taylor [M501 650.0522 HR910/2].

¹⁶ The company's main use of time studies occurred in the aftermath of the appointment as Production Engineer of Henry W. Allingham in November 1911 but at a Burnage Meeting on 12 June 1911 it is minuted, under the heading of piece rates, that "Mr. C.G.R. reported that the essential point is the time study and the setting of times, and this has not been so successfully carried out at Brook Street as we thought" [M501 650.0522 HR910/1].

functional directors to oversee the two divisions of the business: making and selling. 'Making' was placed under the control of Charles Renold, as Works Director, in which function he was assisted by a Works Council comprising four assistant managers, while W.H. Jackson (Hans Renold's son-in-law), as Sales Director, was placed in charge of selling.¹⁷

A further development at the same time was the appointment of the Finance and Employment Managers, H.G. Jenkins and H.R. Lloyd respectively, as an Economy Committee, with a remit to present "independent reports on matters of economy, either on their own initiative or when specially requested by the Board" [M501 650.0124 HR903/5, Directors' Report to 14th OGM, 22 Aug. 1916]. By July 1920 (see Appendix Exhibit 3), Charles Renold had taken over the role of managing director and, in order to free him from day-to-day responsibilities, three executive directors were in place: R.O. Herford (Hans Renold's nephew) as Works Director; W.H. Jackson as Sales Director; and H.G. Jenkins as Finance Director.

Perhaps not surprisingly, the changes to the company's organizational structure were not effected overnight, nor without some disruption and animosity. Although the company always prided itself on its labor relations, went to great lengths to involve key personnel in the changes and attempted, through meetings and lectures, to 'educate' all of its workforce about the nature of the changes taking place, tensions did occasionally run high, even if strikes were avoided. A particular problem which arose from time-to-time concerned the precise role and responsibilities of superintendents and it appears that some of them occasionally opposed the changes in organizational structure and operated in a way that undermined the effectiveness of such changes. Part of the problem seems to have been the almost continuous nature of change, with previous changes being far from sacrosanct, and sometimes overturned or made redundant within a short period of time. As Hans Renold often stressed, a business is a living organism and must therefore be continuously changing, but a question mark can be raised as to whether the amount of change which was effected at Hans Renold Ltd. between 1909 and 1918 was totally warranted. A generous inter-

¹⁷ The new organizational structure obviously involved a greater devolution of power than had previously been the case and it may be this, given the all-embracing nature of Hans Renold's powers as governing director, that explains the apparently significant role played by the company's solicitor, Mr. Dendy, in relation to organizational changes at this time.

pretation would be that here was a company striving to find an ideal organizational structure without a proven blueprint to guide it. Furthermore, the intervention of war in 1914 clearly came at an inopportune time for the company, generating its own forces for change at a time when existing changes had not been fully worked through. In relation to the changes effected over the previous ten years or so, the company's auditor, Joseph Bell, commented in a report into the organizational structure drawn up in 1918, that he was "of the opinion that a fetish is being made of Organization as such without a clear view being maintained of the part that Organization should bear to the Business as a whole" [M501 650.05 HR 918/3 'Notes on Organisation' (December 1918), f. 12]. In Bell's view, directors should be so free of detailed management as to concentrate on policy "and consider the results of the Management (I do not mean by this financial results alone)" [M501 650.05 HR 918/3 'Notes on Organisation' (December 1918), f. 12].

The key element in the changes made to the organizational structure prior to the outbreak of the First World War was the attempt to centralize control of the business in a Head Office Committee, while at the same time providing heads of departments and superintendents with a high degree of autonomy, providing scope for them to exercise their own initiative. As Jackson pointed out in a speech to a meeting of heads of departments and shareholders following the company's annual general meeting held on 24 February 1915, the fundamental aspect of the centralization policy was the encouragement of individual initiative without weakening central control of policy [M501 650.0124 HR903/5]. Such a design obviously had implications both for the accounting and costing systems, which had to make possible both the exercise of individual initiative and provide for effective central control of business operations.

Attempts to Develop a System of Accounting Control: The move to a departmental structure of organization and the devolving of certain powers, first from Hans Renold to other directors and then, subsequently, to heads of departments, superintendents, etc., clearly brought to the fore the issue of control and, with it, that of responsibility accounting. To help make the new managerial structure effective clearly required adjustments to the accounting system and alterations of the perception of the accounting function within the overall organization. It also increasingly brought to the fore the issue of the link between the costing and the accounting system.

The precise nature of the links, if any, between the costing and accounting systems at Renold prior to 1909 is not known. However, there is abundant evidence that, from that time onwards, they became very close and, by 1915 at the latest, appear to have been fully integrated. As successive organization charts from 1909 reveal, the costing and accounting functions were gradually brought under unified control, initially under W.H. Jackson, Hans Renold's son-in-law, who was appointed as director in charge of the commercial management of the business in 1910. By September 1913 all functions under these heads had been collected together in a single 'Costs & Accounts section', one of six sections making up 'General Services' which, during 1914, was placed under the control of the newly appointed chartered accountant, Herbert G. Jenkins, and his assistant, Percy H. Lightbody.¹⁸

More substantive evidence of a coming together of the costing and accounting systems is provided by two pieces of documentary evidence. The first is a diagram dated 1 May 1913, whose original title, 'Costing System', has been amended to 'System of Accounting', and which shows how items of original information pass through the system, are analyzed, enter into the various expense rates, pass through the cost records and generate either changes in the stock accounts, the equipment inventory or enter into customer invoices [M501 657.47 HR913/1]. The second is a set of accounting charts included in Volume 4 of the company's 'J' books, which comprised a series of standard practice instruction manuals [M501 651.02 HR911/4]. These charts, which initially use numeric codes and subsequently, by 1918, a decimal system of accounts, are suggestive of the use of a single accounting system from which costing information could be drawn as appropriate. Indeed, there is much evidence that information from the accounting system was used to determine and check the accuracy of the expense rates which formed the basis of the costing system.

Pressure for greater integration of the costing and accounting systems came from two main sources: the development of the new organizational structure and the declining profit

¹⁸ Little is known of the background of Jenkins, though he remained with the parent company for 35 years, retiring in 1948 [Tripp, 1956, p. 162]. Lightbody, who had been closely associated with the introduction of the Church system at Renold, left the company in the 1920s to join A.H. Gledhill, and subsequently became president of the Institute of Cost and Works Accountants in 1936-37.

performance of the company. Concern over the latter also led to a number of developments within the financial accounting system itself. Thus, between July 1910 and June 1911 the company began to draw up, first, monthly expenditure statements, then monthly accounts and, subsequently, monthly departmental accounts [M501 650.0522 HR910/1]. In October 1912 it was commented that these last were to be used as part of the routine being established to calculate and check the accuracy of the technical and commercial expense rates on a regular basis [M501 650.0522 HR910/5, Board of Trade meeting, 16 October 1912]. In Spring 1912, the company had begun to consult Joseph Bell on the subject of their accounting system. Bell, who had indirectly been responsible for introducing Church to Hans Renold, appears to have introduced his 'patent' system of accounting into the company around this time [M501 650.0522 HR910/2, Head Office meeting, 7 May 1912], though possibly not until after the Manchester firm of auditors in which he was a partner, Parkinson, Mather & Co., had replaced Handley & Wilde as auditors of Hans Renold Ltd. at the company's AGM held on 5 March 1913. It seems possible that it was Bell who was responsible for the introduction of the charts of accounts previously mentioned, though it cannot be ruled out that this was an innovation attributable to H.G. Jenkins.

The organizational and accounting/costing changes which occurred during the First World War were clearly interlinked. The increased centralization of accounting and costing functions led, in particular, to an enhanced role for budgets. Budgets for expenditure on patents and publicity are referred to in the company minute books as early as 1911 and, in 1912, a Mr. Hutchinson was brought in to control expenditure. Following the appointment of Jenkins as Costing Manager in 1914, however, the use of budgets for control purposes became more widespread and, in 1915, a significant development was the basing of expense rates on budgeted rather than actual expenditure figures (see Table 1). Further developments in 1916 and 1917 not only led to superintendents being held accountable for the performance of their departments but also the provision of the monthly financial accounts to assistant managers, in an attempt to widen their vision, give them a better understanding of what they were doing and make them "feel that their responsibility was more real" [M501 650.0522 HR910/9, Head Office meeting, 12 February 1917].

Despite the many innovations introduced by Jenkins and the closer integration of the accounting and costing systems

during the war, it is clear that Hans Renold was far from happy with the information being thrown up by the system. In May 1916 he had complained that the current financial reports “were not that index of the works that he would like” [M501 650.0522 HR910/7, Head Office meeting, 9 May 1916], in part attributing this to a lack of coordination and understanding between the engineers and accountants.¹⁹ A year later, in July 1917, Hans complained in particular about the fact that information showing superintendents the effects of output on costs was taking too long to reach them. Jenkins responded to the implied criticism of the costing department by blaming the superintendents themselves for delays in the provision of the raw data to the cost office [M501 658.5 HR915/2, Works (‘C’) meeting, 11 July 1917]. Thus, when plans to develop a new scheme of cost and account keeping were put forward in 1917, one desirable feature was considered to be a closer cooperation between the costs department and the works [M501 650.0522 HR910/9, Head Office meeting, 14 September 1917].

This new scheme was linked both with moves to re-structure the business around single product departments and the dissatisfaction which had been developing for some time with the Church system of costing. It was particularly desired that the new system should “provide a quick and reliable index of the financial position, and at the same time reflect the efficiency of working” [M501 650.0522 HR910/9, Head Office meeting, 25 September 1917]. To this end, as Jackson put it, “it was important to get ahead with the preparation of more direct costs wherever this was practicable, and dispense altogether with the use of machine rates &c.” [M501 650.0522 HR910/9, Head Office meeting, 31 July 1917]. The new system was based around the drawing up of monthly balance sheets and profit and loss accounts for each department, with general administrative charges only being charged to the company profit and loss account. With superintendents only responsible for direct costs, it was envisaged that this “will ensure a much livelier interest on the part of superintendents, in the success of their departments” [M501 650.0522 HR910/9, Head Office meeting, 25 September 1917]. Six months later the accounts were being reported to

¹⁹ The existence of tensions between accountants and engineers as professional groups, stemming from their different viewpoints, has been commented on in numerous historical works [e.g. Chatfield, 1977], and Church himself, of course, was an engineer who, at times, expressed negative views towards accountants.

Head Office meetings, together with a 'weekly barometer'.²⁰ Around the same time, during the spring of 1918, the company also began to experiment with the use of standard costing in the Shell Department, Jenkins putting forward a scheme for measuring efficiency based on the comparison of 'actual' with 'ideal' costs, the latter being based on time studies [M501 650.0522 HR910/10, Head Office meeting, 7 May 1918].

Thus, towards the end of the First World War, Hans Renold Ltd. had begun to abandon the system of expense rates introduced by Church in the early years of the 20th century, and to replace it by a system which utilized budgets for control purposes and standard costing. Though it was to be several years before the system was perfected [Boyns et al, 2000], the Church experiment had effectively run its course prior to the end of the First World War.

Problems Inherent in the Costing System: The experience of Hans Renold Ltd. in utilizing Church's system of 'scientific machine rates' indicates two major problems: how to reconcile actual costs with those thrown up by the costing system (a problem which was, in part, linked to the growth in GEC at the company); and how to generate meaningful figures for decision making purposes. Let us deal with each of these separately.

Reconciling Actual Costs and those thrown up by the Costing System: Insofar as they attempted to enable the allocation of ever more classes of overheads directly to production centers, the changes made to the Renold expense rate system from 1908 were clearly in accordance with the development of Church's views as reflected in his 1909/10 article. Nevertheless, and despite going somewhat further than suggested by Church, including the review of rates and their method of calculation on an increasingly frequent basis [ERR, 1915], there arose an increasing concern within the company that the costs thrown up, or attributed, by the system often failed to match the actual

²⁰ The use of the term 'barometer' possibly implies a link back to Church who referred to the supplementary rate as a barometer of efficiency. The Hans Renold Ltd. 'Business Barometer' for the first quarter of 1918 contains weekly figures for outgoings and incomings (both divided into actual and commitments), a statement of the difference between the two, plus data relating to the number of employees and overtime hours worked and their cost. The data on wages and the number of employees are divided as between those paid hourly, weekly and monthly, while incomings are divided into different product groups.

expenses incurred in the business.²¹ Even the conversion, in January 1915, to calculating all rates on the basis of budgeted rather than actual expenditure failed to solve the problems. Thus, while it was considered at the time that the changes between 1908 and 1915 had “considerably purified the calculations and the resultant costs” and that the overall accomplishments were expected to “be a considerable help in the future” [ERR 1915, ff. 1-2], in the words of Charles Renold, they simply led to “confusion worse confounded” [1950, p. 116].

Use of Costs for Decision Making: Problems arose here in relation to two issues: (1) producing a new product; and (2) make-or-buy decisions. Let us examine each of these in turn.

(1) Producing a new product. There is clear evidence in the company's minute books that the expense rate system created problems when contemplating the possibility of launching new products, and that this acted as a spur to changing the system. An illustration of this is provided by the case of the 2¹/₄-inch pitch Liner Silent Chain. The minutes of the Head Office meeting on 18 March 1913 indicate a concern on the part of Hans Renold himself that the company, for commercial reasons connected with the activity of its competitors, needed to produce a large chain of this type [M501 650.0522 HR910/3]. The minutes of the Burnage Committee meeting held on 2 April 1913 make it clear that the problem regarding this chain was that, according to the cost system, the product appeared to cost too much and could not be produced profitably [M501 650.0522 HR910/3]. Although ways were discussed as to how cheaper materials and alternative production methods might be used to reduce the cost, the discussion ultimately focused on what was seen to be the fundamental problem, namely the cost system itself. In particular, the use at the time of the percentage on factory cost method of calculating the selling rate for allocating technical and commercial expenses was seen to weigh too heavily on large chains. Discussions as to how to overcome this problem focused

²¹ In October 1912, for example, it was noted that there were “big variations between estimated and actual Technical and Commercial expenses for 1911-12” [M501 650.0522 HR910/3, Board of Trade Meeting, 16 October 1912]. It was not, however, the case that the expenses thrown up were necessarily less than those actually incurred. Indeed, at the meeting of the board held on 3 December 1915, at which Jenkins submitted the 1915 Expense Rate Report, it was agreed “for the present, not to calculate new selling rates as it is known that the existing rates are above actual cost” [M501 650.0522 HR910/6].

on methods which would reduce the cost thrown up by the system to such a level as would indicate that the 2¹/₄-inch pitch Liner Silent Chain could be made profitably, thereby enabling Hans Renold to keep faith with one of his business dictums, which he had borrowed from Mr. Sharpe of Messrs. Brown & Sharpe in the USA, "Never make anything unless it is clear that there will be a profit" [M501 650.0522 HR910/3, Head Office meeting, 5 March 1913]. Hans Renold clearly considered that the company had to make such a chain and was convinced, whatever the figures generated by the cost system, that his company should manufacture the product, and could do so profitably. If the cost appeared too high, the fault lay with the cost system, and it therefore needed to be modified. It was this experience which led to a more complex arrangement for allocating selling expenses, based on differential rates according to their specific nature, being introduced in 1914.

(2) Make-or-buy decisions. For many engineering companies, the choice between making themselves items such as components or tools for their own use, or alternatively purchasing them from external suppliers, was not always an easy one. Making such items could interrupt the flow of finished goods production where this required the use of machines which were normally engaged in such activity, or it might require the purchase of special machines which could remain idle for long periods of time. The problem of idle machine time was one that exercised the mind of many cost accountants at the beginning of the 20th century, but Church's supplementary rate concept failed to provide an adequate method of dealing with it. Bunnell [Vangermeersch, 1988, p. 35], for example, noted that by covering idle time of a big machine through increasing the rates for other machines, the loss incurred by a business through keeping a big machine for occasional jobs was effectively concealed under Church's system. It was in an attempt to overcome the problem of 'hidden' idle time that a shift to the use of actual, rather than normal, hours was made in the Renold expense rate system in July 1909 [ERR, 1915, f. 69].

The use of actual hours, however, was in itself problematic, since those machines operating only part of the time would consequently have a high machine rate and any product or job which used that machine would appear more expensive than the same job taking the same time on a less idle machine with a lower machine rate. Minutes of the Head Office meeting held on 4 December 1911 indicate a clear concern with the fact that idle time was generating high machine rates and hence high costs

[M501 650.0522 HR910/1]. To overcome the problem in relation to make-or-buy decisions it was suggested that two costs should be shown: one based on the machine rate, i.e. including charges for idle time, and the second based on the rate if the machine had been operating full time. A particular example of such a problem arising at the company, that of twist drills, is recounted by Allingham [1921-22]. Initially unable to purchase supplies of twist drills externally, Hans Renold Ltd. had acquired a machine capable of their production. Over time, however, sources of cheap twist drills emerged and, as the company began to purchase outside supplies, the twist drill machine worked less and less, with the result that its machine rate, based on actual hours worked, increased dramatically, making it appear ever more costly for the company to make its own twist drills, and thereby increasingly favoring outside purchases over internal production.

It is clear therefore that several of the changes effected to the Hans Renold expense rate system were made in the light of the fact that it was generating figures that were not helpful for decision making purposes. Nevertheless, the changes did not always provide beneficial solutions and, in many cases, only served to complicate the method of operating the system rather than to improve the quality of the information it produced. Renold [1950, p. 113] described the problem in the following manner: "In producing a cost, bits and pieces of every conceivable kind of expense had gone into the pan, and though each had contributed its flavour, the resulting omelet could not be unscrambled for examination".

Ultimately, those in charge at Hans Renold Ltd. came to realize that for the purposes of studying processes and new product designs, and making decisions in relation thereto, a system which accurately allocated as high a proportion of overheads as possible by product and processes was not necessary. All that was required was a system which enabled a comparison of costs up to producing level. Hence, Hans Renold Ltd. gradually moved to a system of 'direct' costing, that is one which merely allocated overheads to the company's overall profit and loss account, and not to individual departmental accounts [M501 650.0522 HR910/9, meeting of 25 September 1917].

FIVE PARADOXES AND A CONCLUSION

The experiment with the use of Church's 'scientific machine rate' system at Hans Renold Ltd. in the first two decades of the

20th century throws up five main paradoxes. First, although Church advocated the putting in of appropriate costing systems prior to the growth of a business, his system palpably failed the growth test. While it is possible that this may partly reflect the peculiarities of the manner in which Hans Renold Ltd. expanded between 1901 and 1918, e.g. two-stage move from Brook Street to Burnage, adoption of scientific management and the impact of the move over to munitions manufacture during the First World War, in general it appears to reflect an inability of the Church system to cope with periods of rapid business change. Such change renders the expense rates of one period totally inappropriate in the next period. Thus, while the original Church system remained operative at Renold between 1901 and 1908, subsequent developments at the company meant that changes had to be introduced at an increasing rate. The ongoing nature of change, and the unpredictability of conditions during the First World War, finally signaled the death-knell of the Church system. Although Church himself had initially indicated that his system could cope with growth, it was possibly the experience of companies like Renold which, ultimately, led him to recognize that the system could be placed under severe strain by unforeseen developments. At Renold, Church's system collapsed, in part, due to the need for almost continual re-calculation of the increasing number of components that made up the overall hourly scientific machine rate.

A second paradox relates to the fact that while the Church system was designed to generate cost figures which were as accurate as possible, the relevance of the figures which it threw up for making key decisions, especially in relation to make-or-buy decisions and the possible profitability of new products, were increasingly questioned. The changes introduced to try to make the system work more effectively, some of which went beyond the recommendations of Church, merely increased the degree of confusion and, in the circumstances of the First World War, made the system an increasingly less practicable option.

A third paradox is that while Church was concerned with administrative control through accounting [Jelinek, 1980], at Renold, the system failed to provide effective managerial control. In part, as Vangermeersch [1988, p. 28] has pointed out, this was undoubtedly due to the fact that while Church's "philosophy of accounting as a crucial part of overall management control does come through in his efforts", he failed to develop the control or decision making features of his accounting systems to the same extent [Wells, quoted in Vangermeersch, 1988,

p. 24]. At Renold, it was only when an alternative technique was introduced in the Fuse Department that those in charge of the business found a simple, and effective method of control. The way forward proved to be the use of budgetary control and standard costing, techniques which are closely associated with the development of scientific management, in connection with product-based departments [Boyns *et al*, 2000]. Given his antagonistic attitude towards standard costs, and the fact that he did not advocate the use of budgets in business until 1923, Church can hardly have been the source of these developments, though scientific management clearly was. Given the attraction of Hans and Charles Renold to Taylorism [Boyns, 2001], it is possible that if the company had never introduced Church's system, they may have begun to use standard costing somewhat earlier than they did.

There is, however, a further paradox here. A number of writers (e.g. Solomons [1952], Vangermeersch [1988]) have seen Church's system as an important precursor of the development of standard costing but, at Renold, the use of budgetary control and standard costing developed out of the failures of Church's system to cope in a simple and effective manner with the changing needs of the business. Furthermore, under the new system implemented after the First World War, the basis of the method of allocating allowable overhead expenses within the company's 'trading program by product' was that of 'cost scales' derived from special cost studies [M501/ 657.31 HR923/1]. While experience gained by the company's costing and accounting staff in operating the Church system proved beneficial in determining these scales, under them, overheads were to be "related to the wage cost of any item of product or process" [M501 920 RCG 921/1, p. 5]. Thus the experiment with the Church system, the fundamental principle of which was to provide an alternative to simple methods of allocating overheads based on a single factor, be it as a percentage of labor or prime costs, failed, only for the system to be replaced by one in which overheads were allocated in precisely such a manner.²²

²² This finding, therefore, is consistent with that of Johnson and Kaplan [1987, pp. 127-128] who discerned a retrograde move around the time of the First World War from sophisticated systems of overhead allocation aimed at determining the costs, and hence profits, of individual products, to ones which involved aggregated pools of overheads and direct-labor application thereof.

A fifth and final paradox concerns the relationship between the ideas of Church and Taylorism. Although Church's emphasis on the use of accounting to improve the efficiency of management was in line with Taylor's concept of the mental revolution, the use of both Church's method and Taylorism at Hans Renold Ltd., at least at first, does not appear to have been totally in keeping with these ideals. In reflecting on the initial experiments with scientific management some 30 years after the events, Charles Renold commented that: "It is noteworthy that a movement which began with attention focussed on speeding up individual workers ended with attention focussed on management and the means of control, coupled with great attention to the relationship between management and workers" [M501 650.05 HR938/1, f. 5].

It would appear, therefore, that senior management at Renold did not fully realize the implications of the methods they were adopting, at the time that they began to use them.²³ In this sense, Church's warning that new systems would take time to implement was correct,²⁴ but perhaps for reasons additional to those that he suggested, including the need for those adopting them to understand their full implications. Indeed, the full development of budgetary control and standard costing at Hans Renold Ltd. did not occur overnight, and the system was subjected to numerous changes over the succeeding years [Boyns *et al*, 2000; Renold, 1950].

Conclusion: This study has shown clearly the problems that can be faced by a pioneering user of new accounting systems, especially where the system adopted has not been fully thought through, particularly in respect of its practical application. Various pieces of evidence suggest that Renold may have been the

²³ It is also possible that Taylorism may not have been totally applicable at Renold. Charles Renold indicated that the company had begun to adopt Taylorist ideas such as standardization, time study, incentive payments systems c.1910 in the department producing wheels for chain driving, and this had been extended to other departments between 1911 and 1914 and then during the war to the production of munitions [M501 650.05 HR938/1, Notes on the development of scientific management at Hans Renold Ltd., 24 January 1938, ff. 1-2]. However, Charles went on to note that the method adopted differed between departments, and that the use of functional foremen had led to chaos, the company spending the period 1914 to 1921 "reconstructing the conception of management organisation" [ibid, f. 2].

²⁴ This was also the view expressed by Hans Renold himself just before the First World War [1913-14, pp. 23-27].

initial experimental proving ground of Church's scientific machine rate system and, if this is so, then the result was a negative one. At Renold, Church's system failed to live up to the claims made for it, a fact which may help to explain why its broader, long-term impact in the costing field appears to have been less than that of other systems. It has long been recognized by accountants and accounting historians that Church's system was flawed, especially in regard to the supplementary rate concept [Solomons, 1952, p. 28], but it was also the practical operation or, more correctly, increasing inoperability of Church's system at Renold which led to its replacement by standard costing and budgetary control. It was not that Renold did not give the system a chance. The system was operated for over 15 years, and attempts were continuously made from 1908 to make the system work more efficiently, but the rapidly changing circumstances of the company, exacerbated by the effects of the upheaval to production generated by the First World War, were beyond the ability of the system to cope.

Johnson and Kaplan [1987, p. 128] have suggested that if those operating the system at Hans Renold Ltd. had had available to them computers and electronic measuring equipment then the outcome might have been different. Clearly this would have eased the problem of the increased number of calculations that became necessary over time, not least to reflect changing conditions, but it is our contention that the problems went deeper than this.²⁵ Some aspects of Church's system do not seem to have been fully thought through, e.g. how to deal with selling expenses, the precise way to allocate certain production factors, the role of the supplementary rate, etc., and it was this which led to the breakdown of the system and resulted in calls within the company for a simpler and more effective costing and accounting control system. It was these demands which gave rise to the replacement of Church's system by standard costing and budgetary control. This move, like that of the development at Renold of the use of organization charts and decimal charts of accounts,²⁶ was undoubtedly influenced by the ideas of scientific management. However, these later developments were put into

²⁵ Indeed, at the heart of the problem with Church's system is the question of whether or not there is any way of effectively allocating all overheads to products in a meaningful manner.

²⁶ At no stage did Church embrace such systems and his idea of an accounting chart was a diagram illustrating the flow of information through the various ledgers and journals (see, for example, Church [1929], Fig. 145).

effect not by a 'professional business organizer' like Church,²⁷ but were developed in-house over "a number of years by men grown up and engaged in the business during its existence of 34 years" [Renold, 1913-14, p. 29]. Although the trials and tribulations of the First World War clearly played a part in the rise of standard costing and budgetary control at Renold, it was through the additional impetus that they gave to methods already being developed within the firm to overcome already existing problems and pressures, rather than through any explicit impact of the costing requirements imposed by the Ministry of Munitions.²⁸

REFERENCES

Primary Sources

Renold Collection, Local Studies Centre, Manchester Central Library (ref. M501)

(Major items used in this paper)

- | | |
|---------------------|--|
| 650.0522 HR910/1-10 | Head Office Committee meeting minutes, 1910-18. |
| 658.5 HR915/1-2 | Works ('C') Committee meeting minutes, 1915-17. |
| 650.0124 HR903/1-5 | Company minute books nos. 1-5, 1903-30. |
| 657.47 HR908/4 | Cost System, Revised January 1908. |
| 657.471 HR913/9 | 1915 Expense Rate Report. |
| 920 RCG 921/1 | Paper by Charles G. Renold entitled 'Budgetary Control in the organization of Hans Renold Limited', presented to the International Management Institute, Geneva, 1929. |

²⁷ Indeed, just before the First World War, Hans Renold [1913-14] implied a dislike for such individuals, possibly reflecting his company's experience with Church and his system.

²⁸ While the various minute books of the company's different committees contain much information of a technical nature relating to the production of war materials, there are very few references to the impact of the Ministry of Munitions on costing. One of the few is a minute of the Board, dated 7 March 1916, where it is noted that the company will need to draw up four balance sheets, one each for: the shareholders; income tax; excess profits; and the Ministry of Munitions. Three weeks later, it is clear that the company's method of valuing stocks was causing concern, it being noted that if the Government required the company to re-write its stock values, this would be done "with the Establishment Charges included at 100% of Direct Labour Cost" [M501 650.0522 HR910/7, Head Office Meeting, 28 March 1916]. A week later it was noted that the Ministry of Munitions had no desire to send an Accountant to Manchester to investigate the company's accounts and that, as long as the company had not changed its method of stock valuation during the period of assessment, it would be simpler to leave things as they were [ibid, 5 April 1916].

Secondary Sources

- Allingham, H.W. (1921-22), "Costing during a Period of Trade Depression," *The Cost Accountant*, Vol. I: 47-48.
- Bardsley, J.B. (1902), "Hints to Students in Devising Systems of Engineers' Cost Accounts," *The Accountant*, 18 October: 1053-1061; 25 October: 1087-1098.
- Berland, N. and Boyns, T. (2002), "The Development of Budgetary Control in France and Britain from the 1920s to the 1960s: A Comparison," *European Accounting Review*, Vol. 11, No. 2: 329-356.
- Boyns, T. (1998a), "Budgets and Budgetary Control in British Businesses to c.1945," *Accounting, Business & Financial History*, Vol. 8, No. 3: 261-301.
- Boyns, T. (1998b), "The Development of Costing in Britain c.1900-c.1960," *Entreprises et Histoire*, No. 20, December: 33-66.
- Boyns, T. (2001), "Hans and Charles Renold: Entrepreneurs in the Introduction of Scientific Management Techniques in Britain," *Management Decision*, Vol. 39, No. 9: 719-728.
- Boyns, T., Edwards, J.R. and Matthews, M.D. (2000), "A Study of the Interrelationship between Business, Management Organisation and Accounting Developments: Budgets and Budgetary Control in Britain between the Wars," in *Accounting and History* (Madrid, AECA): 71-90.
- Chandler, A.D. jr. (1990), *Scale and Scope: The Dynamics of Industrial Capitalism* (Cambridge, MA.: Belknap Press).
- Chatfield, M. (1977), *A History of Accounting Thought* (Huntingdon, MA: R.E. Krieger).
- Church, A.H. (1901), "The Proper Distribution of Establishment Charges," (in six parts), *The Engineering Magazine*, Vol. XXI: 508-517, 725-734 and 904-912; Vol. XXII: 31-40, 231-240 and 367-376.
- Church, A.H. (1909/10), "Organisation by Production Factors," *The Engineering Magazine*, Vol. XXXVIII: 15-26, 184-194, 361-370, 557-570, 703-715, 863-875; Vol. XXXIX: 77-88 [published in Britain under the *nom de plume*, H.C. Alexander].
- Church, A.H. (1923) *The Making of an Executive* (New York: D. Appleton & Co.).
- Church, A.H. (1929), *Manufacturing Costs and Accounts*, 2nd ed. (New York: McGraw-Hill).
- Church, A.H. (1930), *Overhead Expense* (New York: McGraw-Hill).
- Cowan, D. (1901), "Workshop Administration, with Special Reference to Tracking Work and Promptly Ascertaining Detailed Costs and Profits," *The Accountant*, 19 January: 85-92; 26 January: 114-120; 2 February: 148-155; 9 February: 188-193.
- Downie, T. Jr. (1927), *The Mechanism of Standard (or Predetermined) Cost Accounting and Efficiency Records* (London: Gee).
- Epstein, M.J. (1978), *The Effects of Scientific Management on the Development of the Standard Cost System* (New York: Arno Press).
- Fleischman, R.K. (2000), "Completing the Triangle: Taylorism and the Paradigms," *Accounting, Auditing and Accountability Journal*, Vol. 13, No. 5: 597-623.
- Jelinek, M. (1980), "Toward Systematic Management: Alexander Hamilton Church," *Business History Review*, Vol. LIV, No. 1: 63-79.
- Jenkinson, M.W. (1914), "Some Principles of Accounting Affecting Cost Accounts," *The Accountant*, 18 April: 564-582.
- Johnson, H.T. and Kaplan, R.S. (1987), *Relevance Lost: The Rise and Fall of Management Accounting* (Boston: Harvard Business School Press).

- Boyns: In Memoriam: Church's System of 'Scientific Machine Rates' 41
- Lawrence, F.C. and Humphreys, E.N. (1947), *Marginal Costing* (London: Macdonald & Evans).
- Litterer, J.A. (1961), "Alexander Hamilton Church and the Development of Modern Management," *Business History Review*, Vol. XXXV: 211-225.
- Mann, J. jr. (1891), "Notes on Cost Records: A Neglected Branch of Accountancy," *The Accountant*, 5 September: 631-637.
- Mann, J. Jr. (1903), "Oncost", in *Encyclopaedia of Accounting*, reprinted in R.P. Brief (ed.) (1978), *Selections from Encyclopaedia of Accounting, 1903* (New York: Arno Press).
- Marquette, R.P. and Fleischman, R.K. (1992), "Government/business Synergy: Early American Innovations in Budgeting and Cost Accounting," *Accounting Historians Journal*, Vol. 19, No. 2: 123-145.
- Miller, P. and Napier, C. (1993), "Genealogies of Calculation," *Accounting, Organizations and Society*, Vol. 18, Nos. 7/8: 631-647.
- Preen, H. (1907), *Reorganisation and Costings - A Book for Manufacturers* (London: Simpkin, Marshall, Hamilton, Kent & Co.).
- Preen, H. (1913), *Reorganisation and Costings - A Book for Manufacturers*, 2nd ed. (London: Simpkin, Marshall, Hamilton, Kent & Co.).
- Renold, C.G. (c.1914), "Workshop organization," *Society of Automobile Engineers Bulletin*: 222-240.
- Renold, C.G. (1950), "Management Accounts," *The Cost Accountant*, September: 108-129.
- Renold, H. (1913-14), "Engineering Workshop Organisation," *Proceedings, Manchester Association of Engineers*, Discussion Session: 21-57.
- Scorgie, M.E. (1993), "Alexander Hamilton Church: His Family and Early Life," *Abacus*, Vol. 29, No. 1: 52-74.
- Solomons, D. (1952), "The Historical Development of Costing," in D. Solomons (ed.), *Studies in Costing* (London: Sweet & Maxwell): 1-52.
- Sowell, E.M. (1973), *The Evolution of the Theories and Techniques of Standard Costs* (Alabama: University of Alabama Press).
- Tripp, B.H. (1956), *Renold Chains - A History of the Company and the Rise of the Precision Chain Industry 1879-1951* (London: George Allen & Unwin).
- Urie, J. (1902), "Oncost and its Apportionment," *The Accountant*, 11 January: 50-53.
- Urwick, L.F. (ed.) (1956), *The Golden Book of Management* (London: Newman Neame).
- Urwick, L.F. and Brech, E.F.L. (1953), *The Making of Scientific Management, Vol. II: Management in British Industry* (London: Sir Isaac Pitman & Sons).
- Vangermeersch, R. (1988), *Alexander Hamilton Church: A Man of Ideas for All Seasons* (New York and London: Garland).
- Walker, J. (1875), *Prime Cost Keeping for Engineers, Ironfounders, Boiler and Bridge Makers, et cetera, Practically Explained, With the Method of Arriving at All the General Averages Required* (Liverpool).
- Wardley, P. (1999), "The Emergence of Big Business: The Largest Corporate Employers of Labour in the United Kingdom, Germany and the United States c.1907," *Business History*, Vol. 41, No. 4: 88-116.
- Wells, M.C. (1978), *Accounting for Common Costs* (Urbana, IL: Center for International Education and Research in Accounting).
- Willmore, A.W. (1932), *Business Budgets and Budgetary Control* (London: Sir Isaac Pitman).
- Wright, W. (1962), *Direct Standard Costs for Decision Making and Control* (New York: McGraw-Hill).

APPENDIX

EXHIBIT 1

Organization Chart, Hans Renold Ltd., November 1909

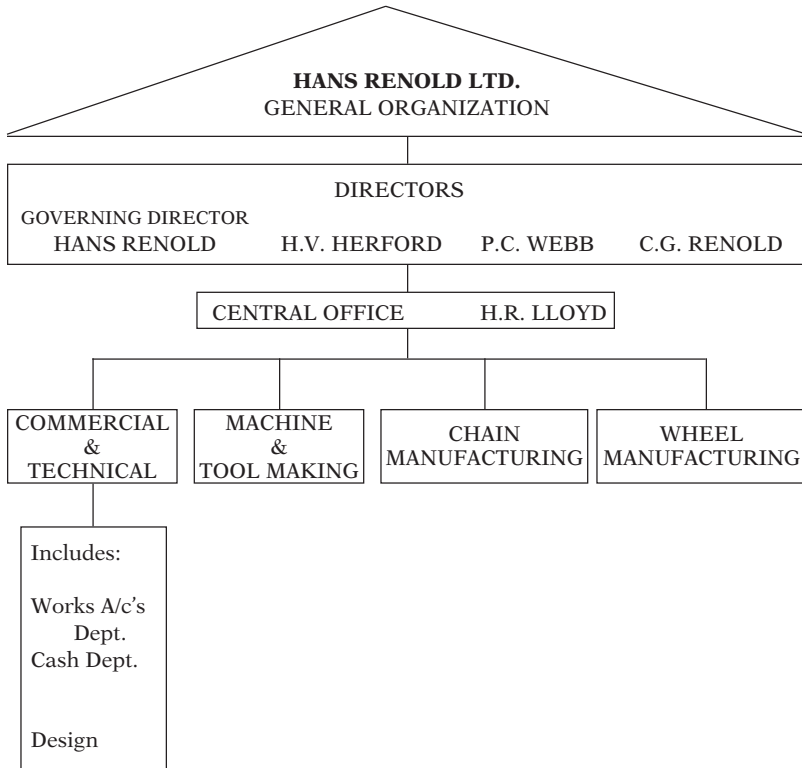


EXHIBIT 2
Organization Chart, Hans Renold Ltd., January 1917

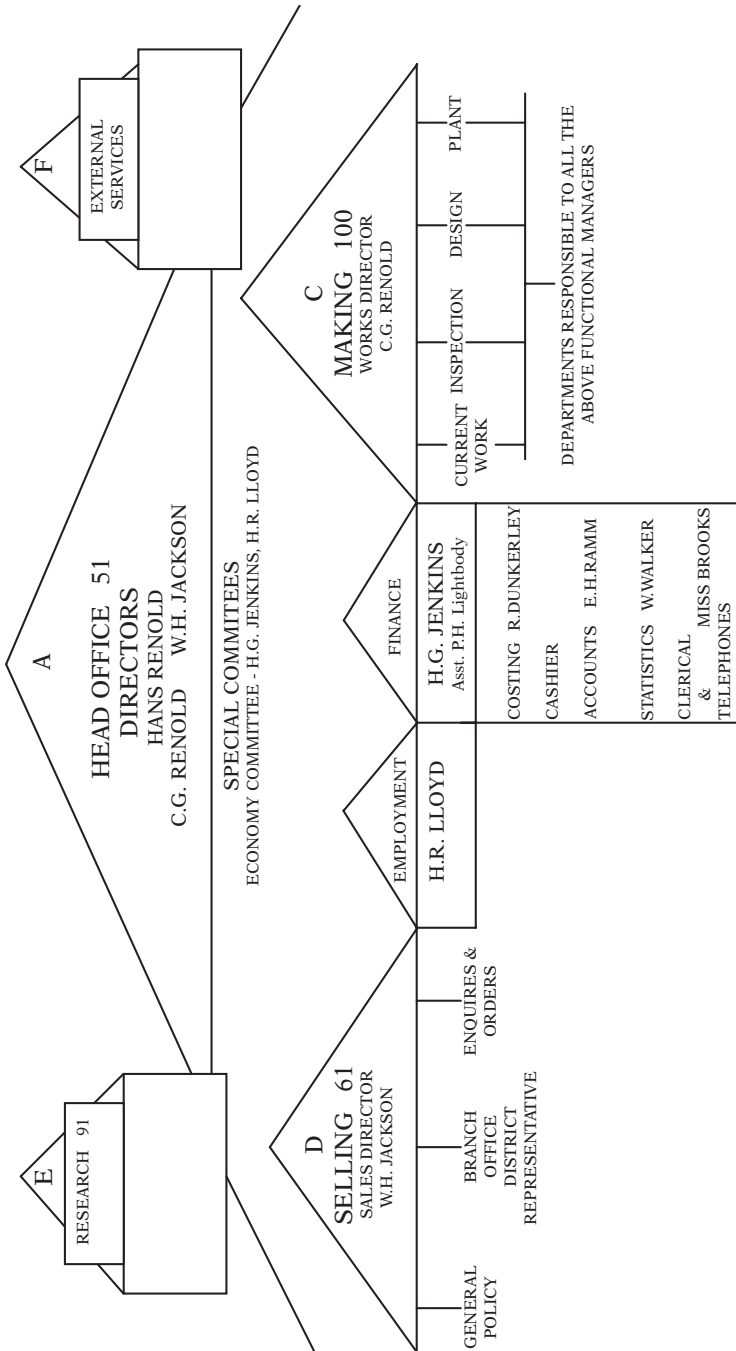


EXHIBIT 3
Organization Chart, Hans Renold Ltd., July 1920

