Chapter 6

IMPROVEMENTS TO OFF-FARM TECHNOLOGY

This chapter moves from on-farm innovative activity to the more organisational innovations once the shorn wool has left the farm but before it is processed, either in Australia or overseas. Starting the reform process was the transportation revolution of better road networks, containerised shipping which produced a real and ongoing fall in transport costs, and improvement in storage and bale handling to counter the rapidly increasing wage costs especially in the early 1970s.

1. TRANSPORT NETWORKS, AND WAREHOUSING

A report on wool handling and packaging in 1952 estimated the 1947/48 cost of marketing the entire clip at £61,000,000, of which £24,000,000 went into handling costs (about £10 per bale).[1] This represented a sizeable portion of the total costs of producing wool, but handling charges could not be reduced significantly without enormous capital investment into infrastructure. This was because the state of the transport industry in Australia during the early 1950s was still very basic. Though camel teams had disappeared before the war, the few remaining bullock and horse teams that were still around were only just being superseded by 'motor lorries'. While an improvement, the lorries were generally small, not well suited to wool cartage, and confined to short-run movements of wool. Poor safety was also a factor, as it was a regular event for lorries to overturn *en route* to the rail-depot.

For its part, the rail system of the time is best described as disorganised, inefficient and despite the long association with the wool industry incapable of catering for industry needs. Rail trucks were often extremely dirty, they were not designed to carry wool, there was little in the way of covered storage on the sidings of railway depots, all of which meant wool often arrived both wet and dirty from a rail journey.[2] Nor was the 'service' cost effective. Road transport was prevented from competing because legislation in some states required the use of rail for all long hauls. The first reform of the system came in the 1950s when rail-freight charges went from a weight basis to a per-bale charge. This not only encouraged higher bale weights, but it

---

[1] Department of National Development, *Materials Handling in the Wool Industry,* Commonwealth of Australia, 1952. The gross value of the clip that year was £158,691,000, which makes marketing costs 40% of this total and transport about 15%.
[2] ibid., p.39. No attempt was made to standardize rail truck sizes, nor was attention given to the position of the brands on bales, which made unloading disorganised when wool from more than one property was delivered on one truck.

abolished the task of weighing each bale on arrival at the rail depot and reduced administrative work and handling.

Whether it be by road, rail or sea, wool transportation required a great deal of manual labour on a seasonal basis, replete with hooks and trolleys, to do the unloading and loading between modes of transports and at destinations. There were very few mechanised handling facilities and the handful of cranes and lifting devices which did exist in the 1950s were slow. Other inefficiencies existed once the wool arrived at the main selling centre. At central city locations such as Darling Harbour in Sydney, the cross-traffic from rail to store by truck and between the small warehouses was time-consuming and costly. Growing traffic congestion in the cities as they grew also strained the facilities, especially on the links to dock facilities from stores located in and around the major centres. The paperwork accompanying these movements all added to the already costly complexity. More labour was then required to handle the bales within the wool store and auction room floor where around 50 per cent of bales were opened for display and inspection by buyers. After the sale these bales were repacked, resewn, weighed, branded with the purchaser's mark, and moved to the dump store where the bales were 'dumped' (reduce the size of the original bale). Presses had a throughput of 60-100 bales per hour. Dumping could be either single or double. Single dumping was the reduction of the size of one bale by one-third; the method of double dumping was to place two bales in the dump, reducing them to almost half and holding them together with wire ties. Dumping rates were paid for by the shipper, and were included in freight rates. Waterfront regulations required dumped bales to be no more than 700 pounds in weight (300 kgs), which also acted as a barrier to greater efficiency.[3] At every step in the handling chain the marking and countermarking of bales was necessary to avoid complete chaos. Then the loading into ships required numerous wharf labourers and cranes. Adding to the costs was that the flow of wool into wool stores was extremely uneven and unpredictable, causing work-patterns to be seasonal even in these central locations. Overall, the system fundamentally depended entirely upon the ready availability of low-cost labour from country depot to dockside for it to work effectively. For as long as labour costs remained low and the price of wool was acceptable, there was little incentive to make improvements to bale handling. What forced change was the rapidly increasing size of the clip, the fall in wool prices in the late 1960s, and increases in workers wages during the late 1960s and early 1970s.

In October, 1967, the AWB reported to the AWIC the urgent need to begin revising the entire transport and handling operation. It pointed out that a bale of wool might be handled fifty times

[3] Basically, these methods had been much the same for a hundred years. A farm-pressed bale averaged about 12 lbs per cubic foot. Whereas a single dumping is 16lbs, a double dumping is 20lbs and high density dumping is 40lbs. The opening and resewing of bales was only workable while there was low pressing-pressures.

before being loaded on a ship for export.[4] It was suggested that to reduce transit times, 'containerisation' in the countryside and the rationalisation of the existing portside facilities and wool stores was worth trialing. The report also suggested that large single central selling and storage facilities be created in a 'wool village' arrangement at each of the major outports. These recommendations largely prefigured the changes that were to take place in the years that followed.

Implementing the suggestions required substantial capital investments, but the state of the wool market in the late 1960s meant these decisions were deferred. This was probably fortunate because changes in transport systems around the world were fast providing wool-handling alternatives. It allowed time for economic evaluations to establish the actual benefits of each step in the restructuring process before the choices were made. Another consideration was the position of the woolbuying fraternity who without assurances were naturally reluctant to give ground and risk market share or profits without some guarantees. It was galling for those who knew improvements were essential to see those involved with transacting wool squabbling and jockeying to maintain a slice of the wool-transporting business, rather than being concerned about improving the efficiency of the entire system. Yet until an overall system could be put in place, the lack of efficiency in the rehandling between wool stores, dumping facilities and wharf storage would continue. Reform entailed changing the entire system, because no one innovations would be able to deliver the necessary efficiency and cost containment. For example, the more extensive use of fork-lifts in place of manual labour held much potential, but with the multi-level wool stores then in use, the benefits could not be maximised. The unions were also a factor in any attempt to reform the system and it required a determined AWB/C leadership to force the pace of change and ensure the outcomes were achieved.

2. FOUNDATIONS FOR THE SCIENTIFIC MEASUREMENT OF WOOL.[5]

The improvements in transportation, wool handling and packaging were significant but what consolidated and extended these gains was the shift to the objective specification of wool. At centre stage of reforms in this area was the introduction of sale-by-sample (SXS), which formed the basis for a standardized system of commodity specification, an integrated system of selling and distribution, and helped streamline the material handling of wool. It generated substantial cost reductions, better wool specification procedures, and improved quality control and processing performance. The introduction of SXS, was the wool industry's most important

---

[4] *Daily Commercial News and Shipping List*, 2nd August, 1968.

[5] Mr H.G. David, researcher, CSIRO Wool Division, Ryde, made available his own writings on this area in 1991, and reviewed the early draft.

post-war innovation and almost entirely the product of its own research system and the culmination of the previous twenty-five or so years of research work.

Apart from standardizing traditional classification and wool classing systems, the first improvements along more scientific lines for specifying the nature of wool came during the second world war. Wool needed to be accurately classified at this stage so that payments to growers could be made and wool could be retrieved from woolstores without the bale requiring another inspection. As a consequence, testing houses and procedures were developed to do this, but these were disbanded after the war, so re-activating the use of objective methods only came after considerable effort and perseverance from researchers at the Gordon Institute (Vic), the University of NSW, the Division of Textile Physics, CSIRO in Ryde, and later, to ensure widespread use, the efforts of the AWC and the AWTA.

Delays in forming an objective system of wool appraisal were largely caused by resistance from the buying fraternity, which was anxious to defend its commercial domain. Thus it was not until the end of the 1960s that a coming together of technical possibility with political desire put to one side buyer objections. The introduction of objective testing also required additional injections of R&D funding from the Commonwealth government and the use by the AWB/C, of their committee structures and regulative powers to ensure the system was successfully brought to the industry. Once the new specification system was introduced the AWTA became the key player for maintaining the system's effectiveness, because it became the main service organisation for creating the testing systems and providing research as required.

As a result of this work, the years 1974 to 1990 witnessed a revolution which, more than any other innovative package, gave the wool industry a solid basis on which to compete with synthetics. The effects of this entirely new system were extremely pervasive, and it represented an enormous thrust for greater efficiency and cost-containment.[6] If nothing else had been done in the wool R&D effort, the entire expenditure since 1936 was more than paid for by the productivity improvements achieved by SXS alone.

The foundation for sale-by-sample

The subjective assessment of wool outlined in Part I was what research scientists were confronted with and were looking to change. The system was ensconced in a craft tradition,

---

[6] D. David, CSIRO Ryde, personal communication, June 1, 1993. The term 'sale by sample' is actually somewhat of a misnomer because it doesn't differentiate the old and new systems. The traditional system of displaying a large portion of wool for buyer appraisal is very different from the new system in which a small selected sample is on display, accompanied by its measured details a system which might more properly be called 'sale by measurement'.

and the tight commercial relationships meant information was closely held. In seeking to improve matters, more knowledge was needed to form a solid foundation on which to suggest change. Even as early as 1931, S.G. Barker suggested the measurement of fibre diameter might be useful. Important research work was done in the interwar period to assist the wartime purchases during the second world war. However, the market highs of the early 1950s delayed the push for scientific measurement. The immediate post-war emphasis was on producing as much wool as possible, and it was this research which growers sought most keenly. Any research which agitated the buying fraternity was frowned upon, so scientists worked without much active encouragement, always mindful of the commercial sensitivities. In this instance, the relative independence of the CSIRO was crucial to any possibility of future success. In the meantime, the first changes to the traditional system came, not from the recommendations of scientists but (ironically) from the advocacy of limited scientific measurement by woolbuyers in their own commercial interests. Research continued to expand the knowledge base and over time completely altered the industry's understanding about the nature of a raw material they had traded and used for hundreds of years. In the first instance it was the exigencies of wartime experiences which began the reform process.

Technical foundations for objective measurement.

From the outset, wool research scientists working in the 1930s and 1940s realised that visual appraisals of fibre diameter based on crimp frequency were not reliable. This was confirmed by the activities of the wartime Testing Houses set up by the Central Wool Committee, but the fact had to be proven 'beyond any doubt', so that the trade would be convinced of disadvantages the traditional assessment methods entailed.[7] To do this researchers needed to fully establish which characteristics were commercially important and devise reliable equipment and procedures for measuring these. The measurement of wool at the tops stage (Hauteur & Barbe) had been in use for many years, and most wool tops were sold on that basis. Using similar techniques, data was collected to confirm that measurable attributes at the raw wool stage provided a good correlation with measured 'wool top'. The key assumption on which all the scientific work on wool measurement was predicated was that objective measurements of greasy wool could reliably predict processing outcomes.

Although the wartime Testing Houses had developed a number of measuring techniques for estimating yield, moisture regain, and vegetable content, trade reactions led to the termination

[7] Paper for the Australian Academy of Science Workshop, Canberra, August 1982, by M. Lipson. This was located at Randle St, Sydney and was staffed by M.R. Freeney who was Officer-in-Charge, and M. Lipson who later was to become Chief of the Textile Wool Division of the CSIRO, and set up the Geelong research establishment. A laboratory at Flinders Lane, Melbourne, was also established and run by R.H. Watson.

of the facility, immediately after the stockpile was sold despite representations from scientists that the laboratories remain open. Thus, it was not until the creation of the AWTA in 1957 that wool testing was reintroduced. Even then, the tests conducted at that stage were confined to levels of moisture in wool. Moisture levels would alter significantly between the showroom floor and the final overseas destination, and processors were increasingly reluctant to pay the woolbuyers for water. As overseas clients became more aware of the problem, compensation claims grew enormously. In the years 1956-57 to 1959-60, they represented around 15-20 per cent of all bales offered and the adjustment amounts averaged in excess of £1.0 million in each year.[8] This is why the first large-scale measurements made on wool were not of fibre diameter, but of moisture levels.

To advance wool testing beyond moisture testing, three lines of inquiry were followed in the research conducted in the years before 1970. The first was to see whether wool buyers really understood the manufacturer's requirements, and whether this was accurately reflected in market premiums and discounts.[9] This work confirmed that 'spinning count' (crimp definition) was the most important determiner of price and that 'character' did not influence pricing decisions appreciably. Uniformity of crimp also formed an important basis for all sheep classing at this time.[10] The second line of inquiry was led by W.R. Lang, (at the Gordon Institute, Geelong), who researched the impact from the key wool variables on final outcomes through processing trials.[11] These trials arrived at the same general conclusion: that average fibre diameter was the most crucial element in spinning performance. These conclusions were supported by the University of Leeds, when they also examined the relationship between properties of wool fibres and their subsequent processing performance on the worsted system.[12] Both centres found that very high crimp-frequency actually detracted from worsted processing performance. The research also established that crimp was neither a good indication of spinning performance, nor an accurate guide to average diameter, and more difficult to judge the finer the wool appeared to be.

Professor McMahon, at the University of NSW, contributed the third research element by considering the workings of woolclassing, and in particular the classer's ability to appraise average fibre diameter.[13] He noted that, although classing's aim was creating commercial lines

[8] *Report of the Wool Marketing Committee of Inquiry*, February, 1962, Commonwealth of Australia, p.161.

[9] Dunlop, A.A., and Young, S.S.Y., Emp. J. Exp. Agric. Vol. 28, 1960, pp. 201-10.

[10] Lang, W.R., and Shertchley, A., *Journal of the Textile Institute*, Vol. 36, 1955, pp. 433-9.

[11] Lipson, M., and Walls, J., *Journal of the Textile Institute*, Vol. 51, 1960, p.953.

[12] Whiteley, K., 'Specification in Marketing Raw Wool', in *Proceedings of the Australian Bicentenary Wool Conference*, Proceedings of an international Symposium, Hart, R.J., (ed), Sydney, 17-20 July 1988, p.115.

[13] The early commercial relationship is evident in a number of letters and news releases from the University of NSW during the 1960s. ANU Archives of Business and Labour, N92/2286.

with uniform length and yield, even the best classer could only roughly estimate fibre diameter. Shedclassing was considered useless because it was found that batching procedures by wool exporters, sorting procedures at mills, and processing mixtures for desired effects during manufacture all either reworked or counteracted the classer's first attempt at uniformity.[14] The classing system was geared towards making the buyer's job easier, but this was of little value to the processor once a mill lot had been assembled and mixed.

The research found that most of the variability in fibre diameter was actually between fibres on a single sheep, not between sheep. Moreover, it was estimated that up to 80 per cent of the 'spinnability' of wool is determined by mean fibre diameter, with length determining another 15-20 per cent, and tensile strength 0-5 per cent.[15] McMahon (in conjunction with A.A. Dunlop), estimated that the variation existing between sheep in a mob only accounted for 20 per cent of the total fibre diameter variation. About 10 per cent of the variation came from differences over the body; the remaining 70 per cent was calculated as the variation between the staple or along the length of the fibres. Therefore 80% of the variation could not be altered by the classer or sorter differentiating between whole fleeces.

These results became icons and had an important bearing on all subsequent wool testing work by establishing the order of priorities and knowledge to guide future research work.[16] McMahon's work not only confirmed the unreliability of crimp as an indicator of diameter, but also established the pointlessness of creating many lines in the woolshed. The variation in understanding these facets by woolbuyers partly explains the low price-premiums for good classing (which had been complained about for years) and why badly classed wools could be discounted more than was warranted in terms of differences in actual processing performance.[17] Processors were relying on trial and error experience gained over many years. One of McMahon's students made other important observations.[18] The first was that the colour of greasy wool could substitute for a style grading, and that well-classed wool from a super-fine clip, despite showing a comparatively wide range of crimp variation, actually registered much less variation when the fibre diameter of the lines created was measured.[19]

---

[14] McMahon, P.R., 'A new look at woolclassing', *Wool Technology and Sheep Breeding,* Vol. XVI, No. 2, 1969, pp.104-106.

[15] Ward, D.J., 'Development and utilisation of objective testing in greasy wool transactions', *Wool Technology and Sheep Breeding,* Vol. XVI, No. 2, 1969, pp.17-23.

[16] Bastawisy, A.D., Onions, W.J., and Townend, P.P., *Journal of the Textile Institute*, Vol. 52, 1961, p.1.

[17] Skinner, J.N., 'Wool handling developments in Australia', *Wool Technology and Sheep Breeding*, Vol. XVII, No.1 1970, pp.104-109.

[18] Whiteley, K., loc.cit.

[19] Skinner, J.N., 'Some Factors Affecting the Clean Price of Greasy Wool', *Australian Journal of Agricultural Economics*, Vol. 9, 1965, p.176, and Skinner, J.N., Are we giving our wool away?', *Wool Technology and Sheep Breeding*, Vol. XI, No. 1, 1964, pp.15-20.

To summarize, it became apparent that not only were buyers and woolclassers using a form of assessment to classify wools that imperfectly measured the most important variable, but research indicated a significant improvement in processing performance could be achieved were these details known. The advantage for the industry was the potential to reduce the extremely costly complexity of the traditional system, as well as to improve processing efficiency. However, industry reaction was for a long time negative. It was Professor McMahon who lead the charge in exposing the *modus operandi* of sections within the traditional system. Around 1963, other countries were applying tariffs on wool on the basis of average diameter and this exposed the growing disparity in technology availability between Australia and processing countries. It caused Professor McMahon to argue:

> *I believe I should begin by emphasizing the need for objective methods of assessment in the wool industry. As you are aware these have assumed increasing importance since the last World War and there is already a substantial amount of international trade in wool where the basis of the contract is some form of laboratory estimation rather than the result of a mill trial or the "educated guess" of a skilled buyer...The measurement of mean fibre diameter in the wool tops and bulks of wool has been reduced to a series of sampling and measuring techniques which are now reasonably repeatable... The wool trade and in particular those engaged in Wool Commerce as distinct from wool manufacture- I refer to wool brokers, wool buyers, wool dealers and the topmakers as distinct from the spinners - have in the main strenuously opposed the development of standards linking quality number with measured fibre fineness, because the existence of such standards would clearly limit their ability to "manoeuvre" in commercial transactions dealing with borderline deliveries... the opposition of certain groups of commercial wool men will need to be disposed of so that the grower and not the Merchant will obtain the additional value contained in the raw material.*[20]

Fortunately, with the setting up of the AWTA and other testing houses, post-sale bale testing expanded rapidly, and an environment was created for the extension of the necessary wool testing procedures. This was facilitated by ongoing research into the importance of wool attributes to final outcomes.

Leaving nothing to chance, other attributes were studied and in this way researchers systematically revealed the true character of the wool fibre, saving the industry from the costly mistakes that the perpetuation of myths had previously involved. Around 1961, wool 'tenderness' was investigated for its origins, frequency in the clip and the accuracy of its appraisal by wool buyers.[21] It was found that the subjective assessments of wool strength were also extremely variable, the hand test only picking wool that was grossly tender with any consistency. Around 1963 the effect of high compression on wool processing performance was investigated and found to be negligible, thereby removing any objection to high-density

---

[20] Letter to Mr. W.E.L. de Vos, General Secretary, The Graziers' Association of New South Wales, from Professor P.R. McMahon, University of New South Wales,1th July, 1963, ANU Archives of Business and Labour, N92/2286.

[21] Roberts, N.F.,James, J.F.P., and Burgman, V.D.J., *Journal of the Textile Institute*, Vol. 51, 1960, p.935.

packaging.[22] From these and similar studies, the commercial priorities were derived and they placed yield (including regain) first, then average fibre diameter, followed by fibre length, and fibre strength.

With all the information accumulating, it remained to build it into a system and reshape the existing selling arrangements. By the early 1960s, woolbuyers were still appraising wool visually, whereas a number of mills had the consignment objectively tested on arrival. This was causing buyers to lose money, with some going out of business as a result of the increasingly precarious trading environment created by the inconsistency between test and visual appraisal. To protect themselves against claims and to check the consignment earmarked for a particular client, wool exporters were avoiding claims by obtaining test certificates from testing houses on wool before shipment. Although this was costly (mainly because it required another set of handling procedures), by 1968 over 50 per cent of exported Australian wool was tested post-sale, either in Australia, or more often, overseas. Given this rate of testing, it therefore seemed logical to streamline the whole operation and reduce the handling and testing costs. It was also argued that wool producers, by not selling their product with some form of presale specification, received lower prices, because the wool was being discounted in proportion to the risk involved. However, changing this involved a transfer of information and market knowledge to growers and processors which woolbuyers were reluctant to allow. Before any new system could be devised, trialed and introduced, the instrumentation and testing procedures had to be developed further. The sampling techniques also had to have a satisfactory level of mathematical precision to minimise the range of error to commercially insignificant levels.

Sampling and testing equipment

Although techniques of wool testing were already used in research laboratories, they could only handle small-scale testing; these had to be taken from research prototypes and formed into commercially practical machines and procedures capable of handling high volumes of sampling and testing efficiently. For large-scale testing, it was also necessary to establish the size and number of samples needing to be taken from a lot, to ensure the result was representative and repeatable. Once the samples were obtained, it was laboratory testing instrumentation which needed developing so that the techniques were capable of testing large volumes. The first moves in this process occurred in relation to the technology of core sampling and regain testing.

---

[22] Roberts, N.F., and Sebestyen, E., *Journal of the Textile Institute*, Vol. 54, 1963, p.49.

Hand-core sampling.

In the early 1940s, imported bales in America were core-sampled for customs taxation purposes. The early tools used had a large diameter (75mm), requiring rotation to cut through the bale, but this was heavy going, and so various other core sizes were tried (tubes of 31mm became the standard).[23] Apart from the physical effort involved (which was partly solved by powering the device with an electric drill), the main problem with the American test was the large samples taken and the difficulty of drawing a representative subsample for other tests. The move to non-rotating pressure coring occurred around the same time in the USA and Australia.[24] In America, 3/8 inch (10mm) diameter tubes were used with a technique which was effective, if somewhat unsubtle. Bales were tested by ramming them against a battery of coring tools, mounted on a vertical pillar, using a forklift.[25] In Australia, the obtaining of a core sample was achieved by more ingenious means. Initial research revealed that the force required to penetrate the entire length kept increasing the more one entered the bale, and was well beyond the capacity of a single operator if the bale were to be tested using one long tube. In response to this, tubes of half-bale length were used to take two samples, one from each end of the bale. In 1957, the manually operated device was further improved after development work by N.F. Roberts. He optimized the geometry of the coring tool's cutting-tip, and improved the techniques for sharpening them by adapting a method similar to that used to sharpen hypodermic needles. As a result, the thrust required was further reduced so that an average person could easily hand-core a bale.[26] Having wide handles at the pushing end together with a plastic bag attached to the hollow core (which maintained the moisture content), the tool was both cheap to make and very effective. First released in 1960, these hand-coring instruments were used by woolbuyers and processors in Australia and overseas for a number of years.[27] The availability of hand-coring did much to spread wool testing and improve its credibility, because of the increasing familiarity and the other testing procedures it sustained.[28]

---

[23] These details come from H.G. David of North Ryde CSIRO, provided to the writer in 1991. Mr David says that the first description of coring as a sampling method was given by Woolner, H.J., and Tanner, L., in *Industrial Engineering and Chemistry*, Vol. 13, 1941, p.883. An account of the method, as applied to determination of moisture content (regain), and including a photograph of the American coring device, is given by McMahon, P.R., 'Core sampling in scoured wools', *Wool Technology and Sheep Breeding*, Vol.4, No.2, 1957, p.81.

[24] By 1950, the US Customs had the capacity to conduct 15,000 tests of yield and vegetable-matter content annually. The introduction in Australia followed Robert's efforts to improve the non-rotating tubes. This was published in *Journal of the Textile Institute* Vol. 52, p.416, 1961. H.G. David also makes reference to a discussion of the advantages of Roberts' device in *Wool Science Review*, Vol.55, p.2, 1978.

[25] Keller, H.R., 'Core Testing Wool Up-to-date', *Textile Industries*, Vol. 11, 1959, p.102.

[26] The cutting tip was easily replaceable being attached to the hollow tube by a standard sized screw-thread on the end of a hollow tube.

[27] The hand-coring development included a series of incremental improvements utilising existing devices, so the final successful invention could not be patented.

[28] Lunney, H.W.M., and Harley, K.A., 'The development of instruments and machines in a government research laboratory', *Mechanical Engineering Transactions*, The Institution of Engineers, Australia, 1980, p.4.

With a workable bale-sampling tool, and contained research into which qualities to test for, the next consideration was to focus work towards procedures that could handle high volume testing. For example, it was calculated that if the aim was to test all bales in the Australian clip, an unacceptable number of laboratories and technicians taking samples with hand-coring devices would be required.[29] It was soon realised the more appropriate unit of measurement would have to be a line of wool or sale lot. The clip was then around 5 million bales, so this represented about one million sale lots. Developing the subsampling principles and testing equipment became a large part of the CSIRO's wool research programme.

Laboratory equipment and procedures.

In the laboratory, much of the innovation in testing techniques involved incremental improvements in the form of mechanised handling to minimize the labour component. Similarly, data recording was streamlined by the advent of computers (especially those within the AWTA). As already mentioned, the first wool tests were those measuring moisture content. The next test was to calculate the proportion of clean wool-fibre, free of impurities and moisture (known as 'yield'). A yield-test already existed in America which involved washing the greasy sample, drying it to remove dirt and grease, and weighing the remainder. To assess the percentage of vegetable matter content, the Americans employed a caustic-soda method to dissolve the wool. The number of yield tests devised across the wool buying world meant that a new system capable of translating into all the differing yield standards across the world had to be developed. Known as 'Wool Base', this was a percentage estimate of the real quantity of wool in a sample after the grease, dirt, moisture and vegetable matter had been removed.[30]

---

[29] By Downes, J.G., of the Division of Textile Physics, CSIRO, in 1961. Lunney, H.W.M., and Andrews, M.W., 'The Background to Length and Strength in the Marketing of Wool', in Proceedings of a seminar on ***Staple Length and Staple Strength of Greasy Wool: Measurement and Effects on Worsted Processing***, Division of Textile Physics, CSIRO, December 7, 1979, p.5.

[30] LeCompte, G.C., and Coe, M.R. 'The Sodium Hydroxide Method for Vegetable Matter in Scoured Wool', *American Dyestuff Reporter*, Vol. 35, 1946, pp. 1113-52. The resulting percentage was the difference between the original greasy weight, and the oven-dry weight less the weight deductions for ash, vegetable fault and other residual impurities are made. To do this, a subsample of wool was drawn from the main sample (the rest was put aside in case of retesting). It was washed, mixed, and then dried until all moisture was removed, to arrive at an oven-dry weight. The sample was then divided and subjected to further tests to: remove residual grease and dirt, to determine the ash content (a subsample is burned and the residue weighed), to measure the unscourable residual grease content (in a solution of 95 per cent ethyl alcohol), and to determine the level of vegetable matter (by dissolving the fleece in boiling 10 per cent sodium hydroxide). At each stage, the portions were weighed and calculations made to determine the base level of wool in a sample. This basic technique has been much the same since the early 1970s, although the equipment and procedures have improved as the volumes required. From the Wool Base result are calculated the main international measures of JCSY (Japanese Clean Scoured Yield), IWTO Scoured Yield 17 per cent Regain, Australian Carbonising Yield (ACY), and the Schlumberger Dry Top and Noil Yield (SDY). To do this, an alcohol-extract test using soxlett apparatus was developed. The first of these tests was devised during the second world war, and the digestion of the fibre was done with sodium carbonate, after oxidation with hydrogen peroxide. After the testing houses were closed, a similar method, using a 10 per cent solution of sodium hydroxide held at boiling point, was developed by an American, and this became the basis for the yield test in Australia.

During the years 1951-1976 (predominantly in the 1960s), the CSIRO Division of Textile Physics developed over forty-one instruments and machines, most of which aimed at improving the accuracy of large-scale measurements of wool samples.[31] Of these instruments, seven or eight were crucial to the advance of wool testing and some were developed further and incorporated into testing systems often by the AWTA. One of these was the Direct Reading Regain Tester developed in 1961 for the rapid detection of moisture content in research trials.[32] What started out to be research equipment for the laboratory had, by 1963, developed into the CSIRO-devised Rapid Regain Tester, comprising a 'Rapid Dryer' and a 'Direct Reading Balance', which were well suited to quick tests of regain at various stages in processing in mills.[33] Testing houses used the equipment to specify the regain of the wool and calculate yield both of which were issued on certificates. After commercial release, some 400-600 of these were sold in Australia and overseas. The availability of this equipment also helped standardize procedures across the world.

Another instrument was the 'humidity probe' (1964) used to detect wet bales when they first entered the store to prevent fires. Then in 1967, small cans for use in the regain tester were developed, to test yarns, which were later modified to take core samples of greasy wool. In the same year, development began to secure an improved method of testing for percentage yield of greasy wool. Initially called the 'Yield and Fineness Tester', it was later known as the 'Wool Base Analyser'. The aim was to have a less complex method than the hot-alkali test, because it was the slowest part of the testing process.[34]

Perhaps the main piece of equipment needed was an efficient means of measuring average fibre-diameter (AFD). In the 1960s, AFD could only be reliably gauged by using a projection-microscope technique, which was too labour intensive for large-scale use.[35] In 1968, the CSIRO demonstrated that the 'airflow' method could be used by adjusting apparatus previously developed by WIRA in England (Shirley Analysers) during the 1950's for measuring the AFD of wool tops.[36] The technique involved first weighing a clean sample and measuring the resistance to air flows (in a controlled environment), the result being the product of the division of one into the other.[37] To ensure representativeness of the sample, various blenders were

---

[31] Lunney, H.W.M., and Harley, K.A., loc.cit.

[32] Ibid.

[33] Ibid., p.2.

[34] David, H.G., personal communication, 1st June, 1993.

[35] Lunney and Andrews loc.cit.

[36] This work was based on the principle that it was possible to measure the restriction of a laminar flow of air as it passed through a measured mass of clean wool fibres. The finer the fibres, the greater the restriction. Core samples were used and found to provide an acceptable sampling medium to test for fibre diameter as well as yield.

[37] Fineness can be measured by various means such as compressibility, airflow, or in more recent times, by the Optical Fibre Diameter Analyser (OFDA). Similar to the FDA instrument previously developed by CSIRO, it took advantage of

tested for mixing core samples to eliminate sample variation and an acceptable model was first installed by the AWTA in 1969. Similarly, various sample washers were trialed and modified at testing houses.

Centralised wool marketing

> *An ingenious expedient, the ultimate consequences of which are left for the future to wrestle with.* J.B. Brigden, (1935).

By the late 1950s the price of wool had fallen, renewing calls for controlled marketing. To bring the debate into some focus, the Australian Woolgrower's Council produced a report (written by G.D'A. Chislett in 1959) to canvass the issues that were to be revisited many times over the next thirty years.[38] The conclusion made in the Council report was that any departure from the free auction system was only justified as a stabilising measure for wool users, not as a way of improving grower returns.

In 1961, the Philp Inquiry into the wool industry also recommended a continuation of the auction system, but it did not rule out the possibility that marketing controls may be needed at some time in the future. After the restructuring of the AWB in 1962/3, the Board was permitted to examine options for wool marketing. As a result, in 1964 it recommended to the AWIC the establishment of a Reserve Price Plan within the existing wool auction system. The discussion between the statutory executive, wool-grower representatives and the buying fraternity continued into 1965, and in July what became known as The Great Wool Debate was held in the Canberra Science Theatre, the highlight being a verbal battle between Sir William Gunn and Mr George LeCouteur (assistant general-manager of AMLFC) which became a media event across Australia. The government pledged financial support to the tune of £50m of the £80m thought necessary to set the structure up, but the compulsory postal ballot (of growers with ten bales or more) saw the proposal defeated on the 9th December, 1965: 59,235 against; 51,388 for; and 303 informal votes. It was the most vigorous debate in the postwar period, intensifying the rift between small growers, sheep/wheat farmers and large woolgrowers. It was also a personal defeat for the then AWB chairman Bill Gunn. Despite this defeat, the Wool Marketing Committee continued to investigate the option with a view to reducing total marketing costs. In July, 1966 two 'ad hoc' committees were set up. One of these considered the question of private selling, and the other examined how to eliminate one-bale lots, and how to introduce bulk classing and improved clip preparation. The reports from these committees were considered by the AWIC in October, 1967, and in the following months

---

recent advances in image analysis hardware and software, giving it a completely different method of image acquisition and analysis.

38 Chislett, G.D'A., 'An Investigation into Wool Marketing 1959', Australian Woolgrowers' Council, 1959.

discussed formally with wool buyers, woolselling brokers and trading banks. During 1968, the AWIC met four times to consider options for wool marketing and in November, 1968, the AWIC accepted the Wool Board's proposal that a non-statutory Australian Wool Marketing Corporation Pty. Ltd. be established. At this time the AWB was authorised to enter discussions and planning for the private marketing proposal. In March, 1969, the AWB and the NCWSB formed a Joint Policy Committee to plan the details and make a final submission to the Minister for Primary Industry. The Commonwealth again offered financial assistance and in November an AWB report was submitted to the AWIC, outlining the Commonwealth offer and it was broadly agreed to 41 to 4, with 5 abstaining.[39] Just prior to the general elections of 1969, the Commonwealth accepted the AWIC proposals for marketing (with one exception - the provision relating to supply management) and provided $7.3 million to fund the new scheme in the first year.

3. IWS REFORM, WOOLMARK, AND RESEARCH LINKS

For most of the fifties, the level of funding for the IWS was considered inadequate and the promotional strategy lacked a penetrating focus. The main advantages for synthetics (which their advertising highlighted), was their easy-care ability. In quality garments where wool dominated the market, the strategy from the synthetic industry was to gain a foothold by acknowledging the attributes of wool, and advocating blends as a way of improving the performance of both fibres. Given this intrusion by synthetics by the early 1960s it was apparent a new approach, as well as more expenditure, was required. Wool did not have a clear identity, was increasingly seen as old-fashioned and could not match the easy-care properties of synthetics. A more aggressive campaign was required to replace the vague generalised slogans with careful consumer targeting based on new products to create a fresh image.

From the 1960s the IWS strategy looked to establish and protect a price premium for wool over other textiles. Wool promotion had to erase the old-fashioned image and build a quality reputation not just be seen as a cheap alternative to synthetics. This was because attempting to compete with synthetics on the basis of price would have been ruinous. Once the price of synthetics fell below the price of wool, the synthetic industry could do the job of clothing people far more cheaply and efficiently. Wool had no prospect of competing on a price only basis because the capital required to produce a kilo of wool was roughly ten times that for producing synthetics. In many respects, the premium for wool was maintained mostly by the competition narrowing of the range of products that used wool to more exclusive and formal wear, and catering for the increasingly important middle-class markets in Europe and Japan.

[39] Australian Wool Industry Conference, 'Wool Marketing Proposals - Commonwealth Government's offer', AWB Report, November 19-20, 1969.

Promotion simply consolidated this move and ensured its success. The downside of this was that wool became less of a necessity item and even more fashion-dependent, which tied it more closely to fluctuations in middle class spending power.

Leading the reorganisation of the IWS into a modern marketing structure was the new Managing Director, William. J. Vines (Appointed on 30th October, 1961). Within twelve months, a new executive organisation was created to provide clearer management-responsibilities. The reconstitution of the secretariat provided for a board of directors of fourteen and, although the board is free to appoint the Chairman, since 1961 the Chairman of the AWC always held the post. The IWS remained an unincorporated association between the AWC and the wool boards of New Zealand, South Africa, and, after the USA pulled out, Uruguay (Brazil has also been an affiliated member since 1984). A highly specialised group was installed at headquarters in London to prepare the IWS for the functional changes and large increases in funds that were to follow. Important offices such as the International Wool Fashion office in Paris were started during this period.[40] In 1963, holding structures were set up to control use of the Woolmark and other trademarks within the many countries that applied to use it. It was decided to form the IWS Nominee Company Limited (a company limited by guarantee), the members of which were the three founding members of the IWS.[41] The IWS remained a non-trading, non-profit-making organisation, and developed a separate commercial structure to allow interventions in the market when this is felt to advance the demand for wool. This was particularly important for the development of new technology from the Ilkley research centre in Yorkshire. To contend with the legal complications of operating in many different countries the Wool Development International Limited was registered in 1971 as a private U.K. company, and in 1977 it began operation by selling or licensing IWS-developed research or the extension of technology developed either in grower-countries or within the IWS research establishments. The development and extension of the technology of Sirospun was a good example of IWS-developed, extended and promoted innovation of CSIRO origin.

Woolmark - Generic advertising.

To continue the reformist momentum of the early 1960s, a competition for an advertising symbol was held during 1963. The intention of the logo competition was to develop a brand which would designate quality products made from pure new wool. Apart from maximising the outcome from limited advertising resources, the logo had the potential to release wool

---

[40] Tisdell, C.A., and McDonald, P.W., *Economics of Fibre Markets,* University of Newcastle, NSW, 1977,p.38.

[41] IWS Nominee Company Limited holds the property for the IWS in the U.K. and in other countries. It holds trademarks, including Woolmark registrations, except where local laws require the trademark to be held by a local company. In these cases the IWS established branches which were registered either as foreign companies, with shares being held by the IWS Nominee Company or by the IWS branch director, local lawyer or auditor.

products from the restrictive price-relationship with synthetics. To compete against the branding practices of the synthetic industry, required wool to also have a highly recognisable symbol. The difference was that unlike the synthetic brands which applied to particular types of synthetic, the wool logo applied to all wool.

In this form of promotion the focus was not on whose wool or what wool type, but simply the advocacy of wool. Since 1964 the bulk of the promotion expenditure has gone to this sort of generic advertising. Because wool is not homogeneous, promoting it as though it conferred the same attributes to every purchase meant quality assurance systems became an essential part of IWS strategies. To ensure the label was only attached to quality products, extensive quality-control and monitoring programmes were established to protect standards, and users of the logo were licensed and required to comply with the standards. The incentive for processors to register to use the logo was that it qualified them for access to technical assistance and promotional advice or assistance.

Chosen by a panel of designers, the winner of the logo competition was Francesci Saroglia of a Milan advertising agency, whose design was the now familiar, 'Woolmark' logo. To launch and promote Woolmark, major sponsorships were organised: for example the 1964 Miss World, Ann Sidney, became a travelling ambassador for wool, and Sir Francis Chichester, who sailed around the world single-handed, brandished Woolmarks on the bows of his Gypsy Moth IV. This helped acquaint the world with the new symbol, and once it had achieved a good level of consumer recognition, the IWS adjusted advertising campaigns to highlight the quality and style of Woolmark products.

In the IWS's promotional activity, the Woolmark concept stood out as a brilliant promotional tool because it gave the entire industry renewed confidence and direction, as well as quality assurance to the customer. In particular, it allowed progressive expenditures to build a recognition factor for wool. The goal was to maximise the market message, thereby establishing a quality image to reinforce the market premium. The IWS's predominantly European focus, was considered appropriate because most of the leading fashion houses and processing centres were in this region. This ensured Woolmark maintained an association with current fashion and a depth of continuity which was the envy of wool-competitors who operated a more fragmented and fluctuating promotional campaign. By the late 1980s the woolmark was amongst the top consumer recognised logos in the world.

Improved research links and new product development.

Another aspect of the changed approach during the 1960s was the integrating of research results with better coordinated advertising and quality assurance measures. That research needed to be better integrated with promotion and technical support was fully appreciated during the 1950's, when the introduction of SI-RO-SET suffered a series of problems. It became clear that new processes needed extensive trialing and tailoring to differing manufacturers' requirements by trained technologists.

In the early years, research and development work was done at WIRA, but by the early 1960s it was becoming clear that greater coordination and quality control was needed to bring new processes and products to the market. To facilitate the change in approach the whole IWS research structures needed reorganising. Therefore the five-year plan form 1962 to expand promotional activity, included the establishment of technical and research centres. In June, 1964, the IWS approved the establishment of an Applied Research Institute in Yorkshire to undertake research into new uses for wool and product development. Construction was expected to take two years, and the centre had 50-60 scientists. It was opened in 1968, and became the focal point for the development of wool textile innovations. The centre sought to integrate design, styling, technical and marketing services. It was also hoped this centre would halt the slide in the British textile trade. Textile plants to conduct research trials were also established in nine countries, to demonstrate new techniques. In this way, the IWS provided a vehicle for countries to share the cost of textile research which would benefit all. It also provided a framework for coordinating separate research work in the textiles area, and ensuring correct market information and priorities were given to textile research. The IWS was very much guided and assisted by the R&D programme, and it formed an important part of developing a market plan. The CSIRO involvement in textile research and the better understandings of processing wool have been a benefit to Australian manufactures as well as the international processing sector. These innovations were usually passed on to the IWS for developing and extending, taking advantage of the promotional contacts.

Since 1964 technical support constituted around twenty per cent of the annual IWS budget. Apart from extending research results in western countries, the IWS assisted developing countries, and has encouraged improvements in quality, so that Woolmark licensing and other promotional assistance could be combined with low-wage cost-advantages. The system of licensing Woolmark and the control structures were very important functions.

To help set standards and ensure correct application the IWS first analysed the market to see what levels of care consumers were requiring. They conducted consumer surveys which established that, although those who bought wool were happy with the care it required, there were certain categories of wool knitwear which needed to be robustly machine washable. These utility items were things such as school jumpers, baby blankets and general purpose knitwear. Machine washability in those categories predated Woolmark, but it was later decided to link the two by providing specifications and standards to qualify for a machine-washable endorsements under the Woolmark label. About thirteen different shrink-proofing processes, involving both hand and machine washing were tried by the AWB/IWS. The added difficulty in this work was that the treatments created a harsher feel which some processors actually utilised. Because no conclusions could be drawn about what was desirable, such issues were left as a matter for individual processor choice.[42] The key question was the shrink-resist performance.

It was also necessary to coordinate this programme across different countries. By 1970, the Germans, British, Americans and Australians all had standards linked to the IWS standards.[43] For example, washing machines in America and Japan were less severe on clothing than elsewhere and the varying capacity of washing machines to felt wool were related to a product category ranging from 0-5: from 'dry-clean only' through various levels of hand washing, gentle machine washing, through to full machine-washing, or what was called 'Superwash'. In time this lead to licensing eligible processors to use the machine washable endorsement and to bring it under the Woolmark programme where it was promoted as 'Woolmark AND machine washable'. Having gone through all this, it only remained to convince the consumer of the fact that the article could be machine washed. Later, when treatments were further refined, the branding of good machine washability was taken over by the 'Superwash Wool' label. In spite of all the efforts and integration of promotion, the proportion of wool sold that was shrink-resist treated by the late 1980s was still under ten per cent of all pure wool items.

In these ways, wool promotion came to include the full gamut of marketing related activities:

> *...including research, product development, technical service, quality control, fashion and styling innovation and service, the provision of statistical information,*

[42] An extension of the quality assurance and measurement work and flowing out of the greasy wool testing research was the development of instruments to assess fabric performance and handle. Previously a subjective judgement, Fabric Assurance by Simple Testing (FAST) is a testing package consisting of three instruments and a Dimensional Stability Test, which measured compression, bending and extension. These instruments measured the nature of the fabric surface as well as the likely shrinkage, pucker, and other elements of tailorability. Once the equipment is in place, it is up to the processor to develop a standard and interpret the results, depending on individual requirements. Essentially, the aim is to predict the performance attributes of the fabric before it is made into a garment, and help improve quality of fabrication. World-wide, the industry is estimated to lose $500 million a year because fabrics don't perform to the expectation of hand-and-eye evaluation. The method was robust and simple to use, and a 'user's group' was created so that information could be shared. The units sold for $35,000; the initial batch of thirty sold very quickly, so full-scale manufacture through the IWS was arranged.

[43] The details of the machine washable campaign are given in an AWB Feature Service issued in 1969: *MACHINE WASHABLE PURE WOOL PRODUCTS.*

merchandising jointly with textile manufacturers and retailers, cooperative projects with the world's top designers, and advertising to consumers.[44]

Scientific breakthroughs provided an important springboard for promotion to make wool more versatile and dynamic. This was also important for commercial confidence, because processors would be reluctant to purchase new capital equipment or invest in large wool stocks if the industry did not have the self-confidence to support its own research and promote wool to the world. New processing technologies and greater efficiencies were a crucial element in industry survival, and it formed the basis for technical assistance to the wool processor about machinery and the physical attributes of the greasy wool being formed into a fabric or carpet. Australian funded textile research did much to sustain the efficiency of wool processing world-wide.

4. PROCESSING IMPROVEMENTS

Raw material preparation and cleaning.

As noted above, early stage processing involves removing wool grease and suint, by washing whereas with fellmongering wool is separated from the skin by bacterial digestion. In both cases the quality of the final product was determined by the sensitivity and efficiency with which these early stage treatments were undertaken. The level of entanglement and final whiteness of the fibre determined the processing performance as well as dyeing capacity of the wool. Although scouring was always a capital intensive operation, over time it also become even more automated, more attune to reducing effluent levels, and located in producer countries. Apart from the value-adding opportunities it allowed producer nations more scope for ensuring wool top was produced efficiently, with greater quality control (free of contamination and stains).

In the worsted process, after scouring and drying, the cleaned fibres are carded to prepare the wool for combing, drawing and spinning. The traditional practice subjected wool to between 8 and 12 gilling/drawing operations followed by cap, mules or flyer spinning. The variability of wool fibre compounded by the poor state of fibre specification and measurement prior to the mid 1970s, meant machine efficiency was low and fibre breakages were high. As a consequence, producing wool yarns and textiles was substantially slower than any of the synthetic processes. The technological gap widened once the synthetic industry developed continuous manufacturing machines that could take raw material directly into either top, sliver or yarn form using cutting or stretchbreaking methods. To compete, the various stages in wool

[44] McPhee, J.R., 'IWS Promotion Strategy: Selling Wool to the World', in Hart, J., (ed), *The Australian Bicentennery Wool Conference,* Proceedings of an international synposium, Sydney, 17-20 July 1988, p.89.

processing had to be reduced and machine speeds increased. In particular, it was essential that the cost of producing wool tops be competitive because, even though synthetic yarn production was a multistage process, because production was continuous there was very little rewinding or manual handling.

The next stage in the worsted process is to prepare the fibres by removing short fibres, straightening, and laying the fibres parallel prior to spinning into a yarn. The main three combing systems used this century were the Bradford, the rectilinear comb, and the Noble comb. The Bradford System, patented in 1850 by Lister of Bradford, was well suited to longer crossbred wools, alpaca and mohair For the shorter fibres, the rectilinear comb developed by Heilmann in France (known as the 'Continental' or French method) became popular. The principles of the rectilinear comb are still used by machines for cotton and short wools. The advantage of the Continental system was that it overcame the static problem associated with faster operation of previous combs, not with oil, but by an intermittent type of combing action controlled by pins, or the pressure of aprons. Modifications over time has seen the Continental comb now used extensively for long fibres.

Fellmongering and carbonising.

Fellmongering research improved the drying of skins, tanning and the efficiency of fibre-recovery from skins.[45] For example, a rapid digestion process was developed at the CSIRO in which the natural bacterial rotting of skins was accelerated by first heating the skins to 70 degrees C for over five minutes, then immersing them in aerated tanks at body temperature. This digested the skin completely in three to four days, and the recovered wool was whiter. Other processes included a chrome recycling technique to reduce chrome in the effluent as well as the level of salinity in tanning processes (Sirochrome), an anti-felting process to contend with the felting of wool on skins (Siroskin), and a process that cleans the skins with aqueous method rather than the current dry-cleaning approach. Where both the wool and the skin are valued, the CSIRO developed an improved separation process (Sirolime), although this was mainly used to dissolve hair on cattle skins at reduced effluent loadings.[46]

---

[45] Most of the sheep skins sold from Australia end up at Mazamet in France for wool removal and treatment. Skins are classified into around 800 categories, depending on the wool quality, length, vegetable fault and soundness of the pelt, which is generally related to age. Drying of the skins before shipment occurs out of the sun (to avoid melting the fat) until a 14-25 per cent moisture content is achieved, so that they are dry but still flexible. At the fellmongery the skins are soaked, deburred, and then hung up in special chambers with high humidity to create a sweating process which will aid bacterial digestion and separate the wool from the skin. The skill is in achieving the separation without damaging the skin too much; being a natural process, it is inexpensive and clean.

[46] The process was developed by CSIRO scientist T. Pressly.

For lines of wool where the proportion of burr was high (3-7% or higher), scoured wool was steeped in dilute sulphuric acid (5% concentration for ten minutes) to penetrate the vegetable matter. The wool was then dried and baked to concentrate the acid and further degrade the contaminant. With the vegetable matter weakened by acid and charred by heat, the contaminant was then crushed to make removal during winnowing, carding and spinning easier. However, the process could also weaken the fibre chemically, and the physical damage caused by rolling resulted in further wool losses during carding. To improve the process the CSIRO in 1952 developed a protective additive for wool involving a non-ionic surface agent which protected the wool fibre, but did not prevent the absorption of acid by the vegetable matter. A few years later, an improved crushing system was developed using crimped rollers which caused less damage to the wool than flat rollers. The steeping of wool into acid was also made more rapid and with less entanglement, by ensnaring the wool between two porous conveyers and jetting the wool with acid and neutralising agents as required. Research also improved the drying of scoured or carbonised wool. For example, equipment such as the University of NSW-developed 'Unidryer', as well as a monitoring system for control of humidity, the NOCH Unitrol Humidity system, were developed to make drying more efficient. Another way to lower the energy requirements was through the use of radio-frequency drying. With carbonising it was found that allowing the wool to rest before drying assisted the dispersion of acid, which in turn, helped achieve faster drying without chemically damaging the fibre. The end result of these improvements was that carbonising of even the most highly contaminated wool could be carbonised with little damage to the fibre and then processed successfully in the demanding worsted process.

Solvent wool scouring.

Solvent scouring, as an alternative to the more common soap and water scouring process, has been around since the turn of the century. Perhaps the first commercial solvent scouring operation was the 'Maerton system' developed in 1898. It treated 2270 Kgs batches of wool with solvent aphtha and the Arlington Mill in the USA used the process for 35 years. Another firm Solvent Belge batch-processed wool with hexane, and in Sweden a wool scouring process using kerosene existed. In the 1960s, a scouring system known as the Sova process was developed which consisted of spraying wool successively with water, and a mixture of water and isopropyl alcohol, and hexane. The first commercial Sova plant started operation in 1967. The CSIRO also developed a solvent degreasing process around the same time as the Sova process, although their version involved two extractions in white spirit and two treatments in water and handled the wool less.[47] Although the process was relatively expensive (and

[47] Letter to W.E.L. de Vos, General Secretary, Graziers' Association of New South Wales from M.Lipson, Chief of Division, CSIRO Division of Textile Industry, 14th April, 1961, ANU Archives of Business and Labour N92/2296.

hazardous), one full-scale plant was built in South Australia by G.H. Michell and Sons. The advantage of such systems was that wool did not felt in organic solvents and with the use of conveyor delivery-systems, a high quality result could be achieved. However, given that the traditional aqueous systems already dominated the scouring industry, innovations involving modifications to the traditional system were more likely to be advantageous than totally new systems and it was these that dominated the research activity.

Aqueous wool scouring.

Aqueous scouring systems generally consist of a multi-bowled unit which uses a warm soap and soda-ash solution, and transports the wool between bowls (via rollers to squeeze out dirt and water) with 'harrows'. Apart from moving the wool through the scour the harrows also agitated the fibre to assist the disposition of dirt and grease but in the process this tended to entangle the fibre causing matting, and increased carding and combing losses. Tallow based soap was replaced in the 1940s by synthetic detergents, developed in Germany during the war because of shortages. By the 1960s, the use of non-ionic detergents had replaced the traditional soaps.

In the early 1950s, WIRA developed an aqueous scourer known as the 'Petri', which improved the flow of the scour liquor and the motion of the harrows or 'rakes'. In 1962 Professor Chaikin at the University of NSW developed the 'aqueous compression jet-scour' which incorporated some of the delivery features of the solvent processes.[48] The system sandwiched a continuous layer of greasy wool between a set of perforated conveyers, and passed the wool between drums, while jets of scouring-fluid squirted into the wool from above and below. The wool was then squeezed by rollers to remove excess scouring fluid. The jet scour cleaned wool faster, was more uniform, produced fewer tangles, required only one-third of the floor space of conventional scours, and was cheaper to install.[49] Unfortunately, the potential of Professor Chaikin's jet-scour was not realised. This was because by the middle 1960s, the need to reduce effluent levels from existing equipment had become urgent, and this meant that research moved away from devising completely new systems. Processors were faced with penalties for polluting and regulations were being put in place to ensure a phase-down of the level of pollution.

There was no doubt the level of pollution from a scour operation was enormous. A typical unit processed one tonne of greasy wool per hour, and used a minimum of 6 to 8 litres of water per

---

48 *Sydney Morning Herald*, 4/12/1962, '10 Countries Want New Wool Process'. ANU Archives of Business and Labour N92/2296.

49 *Country Life*, 29th September, 1962, 'Uni develops new wool scouring method'. ANU Archives of Business and Labour N92/2296. Several commercial installations were made throughout the world by Wessberg & Tulander a Sydney Company. See D.S. Taylor p.279.

kilo of wool processed and his was as much pollution each year from one scouring plant as from a city of 30,000 people.[50] Effluent levels of this order threatened to shut down the scouring industry, especially in Eastern European countries but in the meantime, pollution charges on effluent disposal seriously affected the viability of woolscouring. These factors became the main catalyst for investment in improved scouring plant and researchers were required to move quickly.

Fortunately, the scientific research into scouring since the early 1960s on the solvent and aqueous scours laid the basis for an effective response. It was already well known that, even with the same equipment, differing management practices or operator-skill could produce markedly differing levels of pollution and wool quality results. This was investigated further, leading to recommendations on how to improve the way wool was handled through the scour. This included alterations in the stages of operation, modifications to existing equipment and how they could be improved, suggestions on the best water temperature and detergents combinations for minimising water usage or waste-water output, and investigation of the best systems of pre-treating the effluent before discharge. This was a first stage for reducing the pollution impact and quick results came from reconfigurations of more standard processes based on better understandings of the scouring process rather than the more elaborate and costly treatments options.

Having reduced the volume of discharge (but not always the level of contaminant) the next phase was to develop an integrated grease recovery and effluent treatment system.[51] Numerous options were tried including biological and chemical approaches, but these were either costly, highly variable in their effectiveness, or technically very demanding.[52] They included batch acid-cracking, chemical flocculation, ultrafiltration/evaporation, solvent extraction and evaporation/incineration.[53] More reasonable options were biological lagooning, or centrifuge and evaporation. Lagooning was the lowest cost-option, but it required space which was not always available in Europe or Japan, so acid cracking, ultrafiltration and solvent extraction plants were the solutions adopted.[54] Even though the volume of discharge was reduced and dirt and grease extraction substantially improved, the best of these methods only had a 30% grease-recovery. This was because the grease and dirt components would form a stable emulsion which could not be separated.

---

[50] *Wool Textile Research,* CSIRO Research for Australia: 9, Canberra, 1986, p.36.

[51] Wool grease is used for lanolin cosmetics and rust inhibitors and other useful compounds such as cholesterol.

[52] For a good discussion of the various pros and cons see: Christoe, J.R., 'Wastewater Treatment and Disposal', in *Wool Scouring and Worsted Carding: New Approaches,* Symposium held by the CSIRO Division of Textile Industry, Geelong, November, 1986, pp 24-32.

[53] Gibson, J.D.M., Morgan, W.V., and Robinson, B., *Wool Science Review - 57,* IWS, February 1981.

[54] A number of processes were developed, including the UNSW hot acid process, the SAWTRI "Bitterns" destabilisation process (BITFLOC), the UNSW "Unisas" Superactivated Sludge Process and the Provost solvent extraction method.

The important observation for treating effluent was the observation that it was the stability of the liquor which made separation of solids and grease difficult. Researchers noted that if this balance was disturbed by overloading the level of contaminant in the scour liquor it would assist the effluent-separation and recovery-rate of grease and dirt. It was further noted that dirt recovery was slower when grease was present, and that by removing the grease first, the dirt was more easily separated from the remaining liquor in a settling tank before the final effluent was discharged. At higher concentrations of grease and dirt, extraction became easier, and by concentrating the detergent in the liquor in the early stages of the scour, the grease/dirt emulsion could be relatively easily separated by heating to 95 degrees and centrifuging in a closed-loop system. This necessitated reversing scour-water flow back through the bowls to build up the detergent concentration in the first bowl where the greatest level of dirt removal would take place. Moreover, concentrating the level of dissolved salts by recycling the effluent meant the suspended solids were more able to be centrifuged and removed as spadeable sludge. These 'self-flocculating' approaches provided the basis for the development of new aqueous systems such as the WRONZ mini-flo system, the Sover process as well as the CSIRO developed Lo-Flo process.

Carding.

Carding is the opening up, and forming of wool fibres into a soft rope called a 'sliver'. Carding laid the basis for yarn quality but it was comparatively costly part of the yarn making process because of the slow speeds the machinery needed to operate at.[55] For example, cotton cards could run at 2000 m/min. and synthetic cards at around 1000 m/min., whereas the maximum speed of a wool-card was 500-600 m/min.. Running a wool card faster reduced the quality of the top (as measured by the average fibre length) through excessive-fibre breakage. For many years, improved efficiency was achieved not by increasing the speed of the card, but rather, by building increasingly wider cards. Some were as much as 3.5 metres wide (the average was formerly around 1.5 metres wide). Alternatively, the efficiency of the card could be increased by reducing friction generated by the fibre by using improved lubricants. Vegetable oils were replaced by mineral oils and after the war, by water-soluble polymers. Mineral oils were sometimes combined with detergents to make subsequent removal from the fabric easier but

---

[55] *Wool Scouring and Worsted Carding: New Approaches,* Symposium held by the CSIRO Division of Textile Industry, Geelong, November, 1986, p.33. In one trial, the average fibre length went from 104 mm to 76 mm. Something like 39% of fibres subjected to the card were broken.

this reduced the effectiveness of the lubricant. For their part, the soluble polymers were removed easily, but they were not as effective as mineral oils.[56]

Another approach was to reduce the machine downtime involved with cleaning wool grease and embedded fibres from the card (fettling), metallic clothing (toothed wire or ribbon wound in a spiral grove) was introduced (in 1959) to replace the permanent needle system. Then as a way of decreasing the mechanical damage to the wool fibre, mechanical innovations looked to improve both the rate of delivery to the card and the action of the card itself. An automated hopper-delivery introduced wool to the card, providing a regularity of throughput. Another innovation involved the replacement of hydraulically-pressured rollers, used to crush any vegetable matter or skin pieces in the carded web with grooved rollers which were less damaging to the fibre. A sliver 'converter' was designed to help overcome fibre breakage and reduce the occurrence of small tangles, and this lead to an estimated increase of 2.5% in top yield.[57]

Combing.

To supplement the standard Bradford and Continental combing systems a third combing system devised in 1953 by James Noble of Leicester, was a horizontal circular comb that handled long, intermediate and short wools. Noble's comb became known as the 'English' method of wool processing, and was very popular. Of the three systems, the Continental system has now become dominant, although the 'New Bradford System' developed in the 1960s, with a shorter processing sequence followed by ring spinning, extended the demand for these products for some time.

Most of the early innovations involved the development of fairly simple automatic control-units for rectilinear combs. For example, Australian research on the Noble Comb showed that the rate of production fluctuated tremendously, so the CSIRO developed a control-unit which permitted the comb production-rate to be set at a predetermined volume. The capital cost of installing the innovation was low, so it met a receptive market in Australia, and overseas in Bradford mills and elsewhere .[58]

---

[56] Research found that methyl ester could improve fibre-length, and was easily removed by washing. WRDC Annual Report, 1991-92, p.44. Research continues to investigate why methyl ester works in the expectation that this might produce other options, or new compounds worth trying.

[57] Wool Research Memorandum, 27th July, 1966, p.6. ANU Archives of Business and Labour, N92/2296. The convertor replaced several carding machines, and occupied only one-tenth of the floor-space.

[58] Letter to W.E.L. de Vos, General Secretary, Graziers' Association of New South Wales from M.Lipson, Chief of Division, CSIRO Division of Textile Industry, 14th April, 1961, ANU Archives of Business and Labour N92/2296.

Finishing and treatments applied to tops, yarn and fabric.

Wool-finishing incorporates the traditional 'pure' mechanical finishing techniques such as raising and cropping, as well as chemical treatments which sought to confer easy-care attributes to wool products. In some cases such as suitings and coatings, consumer pressure for these features was minimal, but in knitwear, trouser, dress and skirt items, as well as household uses such as upholstery, it was essential. In the 1950s, the IWS nominated the research priorities requiring urgent attention as shrink resistance, permanent setting, dye fastness and wool yellowing. In 1962, the Philip Inquiry reiterated this by arguing:

> *The modern world demands textiles which will not shrink and which are easily washable, especially in a washing machine, garments which are wrinkle resistant and will take a permanent crease or pleat, light weight garments which are strong and garments which will "drip-dry". Those desiderata or some of them have been achieved, or the public has been led to believe that they have been achieved, by blending man-made fibres with wool.* [59]

However, rather than pursue fibre blending work, research efforts concentrated on achieving the same attributes as synthetics in pure wool products. The quality-setting activity of Woolmark required such a research focus because of their standard setting activity and the advocacy of pure new wool in promotional campaigns. Therefore, research which sought to ascertain the lowest proportion of man-made fibres required to achieve such qualities as shrink-resistance, washability and pleat retention was not funded, and the emphasis remained on making wool the superfibre that could do everything. In doing this the chemists looked at ways of making wool mothproof in carpets, retain permanent creases, require only minimal ironing, machine washability, flame resistant in the case of commercial woollen fabrics, and preventing ultraviolet yellowing of pastel-coloured wool. It was also important that where ever possible these chemical treatments be applied by a continuous processes.

Mothproofing.

New insects, resistance to chemical, and changes in the law about what poisons were permitted ensured that mothproofing research would be a recurring line of work. Chlorine containing compounds such Eulans (1928), Mitan (1939) and DDT (1943) were applied in the 1930s-40s. The use of dieldrin was encouraged in the early 1950s and the process was called SI-RO MOTH'D. It was cheap, effective, and remained in the wool after washing. However, the use of dieldrin had to be abandoned because of pollution concerns with mill effluent, as well as the resistance some moths were developing to the chemical. There were also quality control

---

[59] Commonwealth of Australia, *Report of the Wool Marketing Committee of Enquiry*, ('Philp Report'), Canberra, February, 1962, p.108.

problems with industrial applications being either insufficient or uneven in the coverage achieved. In the 1970s, synthetic pyrethroids became the main form of moth protection, with a permethrin solution commonly used to protect carpets. In more recent times, organophosphates were tried, but these were found to have poor durability.

Permanent creasing.

To match the permanent creasing and drip-dry capability of synthetics, a variety of techniques have been investigated. The earliest research was by Professor Speakman of Leeds University when he applied a hair-setting process to wool fabric and found that a permanent crease could be created. Australian researchers (led by Dr Farnworth) developed a permanent-crease treatment during the 1950s, known as Siroset. It put a permanent crease into wool fabric by breaking the chemical bonds holding the protein molecules together (using the chemical reagent ammonium thioglycollate), raising the temperature and moisture content of the fibres to make them plastic, and then bending the fibres into the new position. Once it had cooled the chemical bond held the item in the new position.[60] Unlike some alternatives, this method was easy to use, cheap, and effective.[61] Once the creases were made they could not be taken out and applying the solution to the whole garment improved the appearance. The process also imparted some shrink-resistance and when combined with a standard shrinkproofing treatment a 'drip-dry' fabric was created.

Siroset was released in 1957, and by 1962, some 3,500,000 to 4,000,000 pairs of trousers were treated annually.[62] However, problems were experienced in some countries with application procedures. The adoption rate in the UK by 1965 had been very slow, whereas in Holland 90% of trousers were treated with Siroset. The wet process did not suit the British industry methods and only fourteen permanent-creasing installations used SI-RO-SET. Apart from the complaint that SI-RO-SET was incompatible with existing equipment, it was argued the technique was insufficiently proven and that it had been rushed into commercial use.[63] The CSIRO was blamed for some of the failures. To improve the understanding of the technique, extension chemists were sent to various countries to re-introduce and help solve problems. For the circumstances of the British trade, the CSIRO developed an alternative method of pretreating cloth in the mill, so that when the tailor carried out the final pressing or pleating operation the crease would be permanent, without the need for special spraying. The 'dry' permanent

[60] Research by A.J. Farnworth led to the SIROSET development.

[61] 'Durable Creasing and Pleating of Wool Fabrics', *Trade Circular No. 4*, CSIRO Wool Textile Research Laboratories.

[62] Philip Inquiry, 1962, op.cit., p.122.

[63] A similar experience occurred with a process known as 'Sironized'. SIRONIZED was a Wash-No-Iron combined shrink-proofing/permanent press process based on the Si-ro-set process. It enabled wool to be machine-washed, then returned to the original smooth appearance. The process was complicated, and it was not widely accepted.

pleating process developed by CSIRO was fully trialed, then extended to the UK by the IWS.[64] The CSIRO learnt from this episode to be more circumspect, and fully test and specify a process before release, even when the need was urgent. The experience of Siroset also influenced the organisation of extension work within the revamped IWS.

Generally, the use of reductive setting techniques (such as Siroset) declined during the 1970s as high temperature steam (autoclave) setting, particularly of pleats in ladies' skirts, became more popular.[65] The latter technique was preferred because it didn't require pretreatment or spraying with reductive chemicals. A number of flat setting and garment setting processes have also been developed and tested by the IWS although autoclave setting probably remained the most widely used final finish operation for wool-containing fabric. The release in the 1980s of a process called Lintrak created another option for garment makers. This technology could be used by dry cleaners for use on men's trousers particularly in the U.K. thus returning full circle to Professor Speakman's original experiment, which involved the application of a "glue" to the inside of the required crease area and curing while holding the pleat in position.

Shrink-resist treatments.

Shrinking is a natural felting property of wool. Prevention involves restriction of fibre movement by either bonding fibres together, or stripping and then coating the scales of the fibre to reduce the ability to entangle. In the 1960s, the synthetic industry advocated the replacement of wool with synthetics to achieve fabrics that were shrink-resistant and machine-washable. The mix suggested was a 70% synthetic to 30% wool in products that previously had been all wool. The industry did all it could to match these attributes and by 1960, there were about twenty or so ways to shrink-proof wool. The objectives were to control the level of chemical damage, achieve a highly replicable outcome, and remain cost-effective. It was also important to retain the natural feel of wool after treatment. Each of the known treatments had advantages, but no one treatment delivered all these attributes. Much of the research looked to expand the points at which shrink-proofing could be applied to standardize and spread the options so that the best treatments for particular uses and needs would be known.[66]

---

64 Letter from R. B. Williams, Chief Executive Officer, AWB, to Mr. W.E.L. de Vos, General Secretary, Graziers' Association of NSW, 29th September, 1965, ANU Archives of Business and Labour, N92/2296.

65 These other processes did not fully replace Siroset. Thirty years later Siroset was still used widely, and nearly one million all-wool pairs of trousers were treated by the process in Japan in 1984/85.

66 This is why the Chlorine-Hercosett treatment was favoured, because it retained the handle in finished items and it allowed the use of a softener in the last bowl of a backwasher. In contrast, solvent treatments could not attain full machine-washability with an acceptable handle. Mechanically, the strength of the fibre was increased and pilling reduced, although the effect on wrinkle recovery was variable.

The earliest Australian developed treatments was the 'Freney-Lipson" process. It was mainly used on socks for the U.S. and Australian troops.[67] Then in 1953 the SIROFIX process was developed using a highly flammable solvent but the safety problems retarded its use. Another shrink-resist treatment was the permanganate/salt or G8 process for knitwear and woven fabric. It is still used by many processors to control pilling. To prevent the shrinking and rough laundering of woollen blankets in hospitals, and the discolouration caused by the presence of iron in water, CSIRO developed a neutral agent to shrinkproof wool blankets which meant they could be steamed without shrinkage or discolouration.[68] An couple of incidental outcomes from this research was to prove that wool blankets did not contribute to cross infection and the formulation a new detergent which permitted the boiling of shrinkproofed wool blankets. This was so successful that it was marketed for general use as 'Softly', and subsequently became a household brand in Australia.[69]

The traditional shrinkproofing method of dry-chlorination was labour intensive, requiring expensive equipment; moreover, the colour and handle of treated wool were adversely affected. The associated disadvantages for dyeing and spinning performance restricted its use to finished items such as flannels and blankets. What was known as the Kroy process was much better but it was only used for the continuous chlorination of wool tops and sliver (not in the woollen system or on fabric). During the sixties, researchers were looking to replace the so-called subtractive processes which relied on oxidation of the wool surface for their effect, with the depositing of polymeric materials on the surface of wool fibres. Although these were technically more successful, the use of subtractive processes were entrenched and being better known many would not change. This delayed the use of polymer processes although cost was also a factor. The chemical options for polymer applications were soon numerous as were the technical constraints of adhesion to the fibre. Selecting the process and application method and the point at which to apply the shrink-resistance emulsion determined which process would be employed, but options were often limited by existing equipment. By 1972 the use of polymer had yet to be realised, with only 5% of the market using them in one form or another.[70] Nevertheless this has since changed and during the 1970s overseas processes such as Dylan GRB came to be used more widely for shrink-resist treatments. These were applied to tops by continuous processing in pad-mangle, backwasher arrangements, or by batch-exhaustion methods for knitted garments or for woven and knitted piece-goods.

---

67 The patent application was not completed, so that it would be freely available for all to use. However, the U.K. company, Tootals, seized the opportunity and took out a patent on the process shortly afterwards. The Australian company, Holeproof, which was using the process, was then asked to pay royalties to Tootals. The Wool Board and Holeproof fought the patent application, and with the help of counsel R.G. Menzies, they won the case.

68 CSIRO scientist T. Pressly was the principle researcher on this hospital blanket project.

69 CSIRO, *Textile News*, No. 7, 1979. The work of T. Pressly.

70 Shaw, T., and Lewis, J., 'The Finishing of Wool Fabrics', *Textile Progress,* Vol. 4, No. 3, 1972, p.10.

The application of low-weight polymers became a possibility when it was found that a two per cent application was effective if the wool was pretreated with alcohol. The alcohol would clean the fibre and assist adhesion of the polymers. However, the process had practical problems, so an industrial application was developed using a mild aqueous chlorination as the pretreatment.[71] This lead to the development of a shrinkproofing process using an aqueous emulsion of an epoxy polyamide resin, Hercosett, which became the process for machine-washable knitwear promoted under the 'Superwash' brand. This process allowed an even treatment without damage, and it was used as a pretreatment for the Chlorine-Hercosett process.[72] Chlorine-Hercosett was developed by CSIRO as a continuous process for wool tops. To spread the polymer evenly over the fibres, required a pretreatment with chlorine to improve the application of Hercosett 57.[73] Its development was taken further by the AWC and Villawool Ltd. in Sydney, and then by the IWS, before being extended to the trade worldwide.

To expand the use of shrink-proofing also required a process whereby polymers could be applied in fabric form, using a water-dispersible compound to allow its use in continuous padding machines.[74] Application of shrink-resist polymers to garments can be done from organic solvent in modified dry-cleaning machines. Although several can be used, only the silicone-based polymers have received wide acceptance, because they maintain a soft handle in the wool fabric. However, this is relatively expensive, so the development of an aqueous solution applied by exhaustion was sought. A number of polyurethane options were available in Germany for use in dry-cleaning equipment, but none of these were water-soluble. The Sirolan BAP process overcame this difficulty by creating a water soluble polyurethane pre-polymer for fabric use. Sirolan BAP is a two-component aqueous resin formulation, applied to fabrics by a pad-dry sequence without washing-off. The amount of polymer required is low, so further treatment to restore the handle of the fabric is not necessary. After trials in Australia and New Zealand, the IWS licensed it to Bayer AG, and called the new product 'Synthappret 4694'. It was the first commercially-proven aqueous process able to make woven or knitted worsted wool fabrics shrink resistant. It was also compatible with other processing chemicals, so that jersey fabrics could be treated straight off the knitting machine without scouring. Applied to fabric, it also gets a machine washable label.

---

[71] Lipson, M., 'Some Contributions of Chemistry to the Wool Industry', *Chemistry in Australia*, June 1989, p.198.

[72] Dr. J.R. McPhee was transferred from Geelong to become Chief of the Technical Centre at Ilkley in Yorkshire, which was completed in 1968. He later became Director of Planning at the IWS in 1975, Deputy Managing Director in 1978 and Managing Director in 1984. The link with Australian science and promotion is exemplified by this.

[73] The process gave a high level of shrink-resistance, brought about by the resin-links between fibres and the cover down the individual fibres, but articles that needed milling had to be treated afterwards.

[74] CSIRO, *Textile News*, No. 2, 1976.