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&
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My research on the technology of handweaving silk velvet led me to this story, and I pursued it like a miner follows a vein of ore. I am deeply indebted to Eugene Nicholson for bringing this fascinating tale to my attention and providing insightful information.

An excerpt from the War Diary of the Camouflage Service of Headquarters 21 Army Group, written on New Year's Day 1944, says that 'camouflage' has a double meaning. It is both "the art of concealing from the enemy the disposition of men and materials, and also of indicating false positions by means such as the use of dummy equipment."[2]

The first part of the definition immediately conjured up images of splotchy, olive green uniforms and khaki-colored tanks from a slew of 'B' movies about fictitious heroics in WW II. But it is much older. Recall Macbeth's fateful lines '*Fear not, till Birnam wood Do come to Dunsinane.'* The crux of the game is the same: to conceal, hide, to fool the eye, to throw an invisibility cloak over huge objects and colossal spaces such as airplane hangars, factories and airfields by emulating irregular natural patterns done in convincing seasonal palettes and giving the desired objects a second skin.

However, my research focused on the less familiar second part, on dummy equipment and decoys. Here the camoufleur wants the enemy to detect the display, but not to be too obvious. Surrealist artist Roland Penrose, uncle to the famous scientist Roger Penrose, lectured during the war at the Osterley Park School for the Training of the Home Guard, and outlined in his *Home Guard Manual of Camouflage*, written in 1941, the principles of matching color and texture and using false dispositions.[3] To be believable the dummies and decoys need to be full size, made from expendable materials, and relatively easy to move and deploy.

One of the first decoy images I saw was of an inflatable Sherman tank, Device 9, advancing up an idyllic Surrey lane. It was so convincing. The photograph, taken in 1943, was the property of David Medd, 1917-2009, who enlisted in the army and was posted to the Camouflage Development and Training Center (CDTC) at Farnham Castle in 1943.[4] He later became the head of its operations. The War Office had hastily set up the center in 1940, and had gathered an odd assortment of artists, architects, engineers, theater set designers, biologists, zoologists, even a magician to create military illusions. In WW I battlefields extended to include the skies and aerial reconnaissance became of paramount importance. In WW II all sides, every war theater relied on aerial views and photographs to

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[2] Goodden, Henrietta. *Camouflage and Art: Design for Deception in World War 2*. London: Unicorn Press, 2007, 123.
[3] Penrose, Roland. *The Home Guard Manual of Camouflage*. London: George Routledge and Sons, 1941, 63-66.
[4] Goodden. *Camouflage and Art*. 35.

establish targets, rank priorities and direct military action. Gathering intelligence was crucial and discerning the true from the false was vital.

But how does this relate to my velvet research? Eugene Nicholson, formerly the Senior Keeper of Industrial Technology at the Bradford Industrial Museum, knew of my keen interest in velvet weaving technology and introduced me to the work of Samuel Cunliffe Lister and the industrial empire he built on mechanizing wool, and then silk production. He was one of those larger than life magnates of the Industrial Revolution that transformed Northern England. He was an avid inventor and audacious entrepreneur. In his lifetime he registered 150 patents, more than anyone else in England. *A Fabric Huge: the Story of Listers* written by Mark Keighley is the main source for this information.

Textiles were in Lister's blood. One of his forbearers, a Cunliffe Lister was the first to spin worsted wool yarns using waterpower, at Low Mill, Addingham in 1787, and his father Ellis Cunliffe Lister built numerous new textile mills in the Bradford area over a 40-year span starting in 1815, the year of Samuel's birth.

In the mid 1800's the woolen industry, centered in Yorkshire, used local staple carded fiber. Combing the longer staple worsted had yet to be adapted to power production. There was a big demand for machinery capable of handling the softer Botany wools from Australia as well as the long-staple English fibers, mohair and camelhair. Edmund Cartwright (1743-1823), a cleric by profession, came up with a solution and registered his first patent for a wool-combing machine in August 1789. Power to run it came from a horse and it was named 'Big Ben' because the motion of the crank lasher arms resembled the relentless punching of a celebrated boxer. Others joined the race, but it was Lister and George Donisthorpe who won the prize claiming to have perfected the principles of the nip comb action. Lister now started to construct his nip wool comb for the worsted market and held patents for them during the 1850's.

From 1857 to 1865 Samuel Cunliffe Lister turned his attention to silk production. He especially wanted to convert worthless silk waste into a money fiber. Some machinery was in use, but the products were rough, coarse silk yarns. Fine silk, especially with fiber lengths up to ten inches clogged the rollers and could not be processed. Lister adapted the principles of the nip comb invention to silk; however, since silk is much tougher, he had to invent many modifications. He achieved his goal of spinning this proverbial straw into gold. Next he wanted to weave the fine silk yarns and produce velvet, the luxury fabric in high demand.

I have studied silk velvet handweaving for thirty years and deeply revere the artisans with their incredible skills and knowledge, so I first blanched at being introduced to this character as a hero. I regarded him more as one of the villains who almost completely destroyed the noble velvet handweaving tradition. But now I have come to forgive his single-mindedness and arrogance and to at least admire his ingenuity and persistence.

Let's first address how silk velvet is woven by hand. The loom has two sets of warps: the ground warp is under heavy tension and is interspersed with the pile warp held in light tension. The weaver lifts the pile warps and inserts in the shed a fine brass wire that has a miniscule longitudinal channel running down its length. Next the even ground threads are lifted and the first weft shot is gently beaten it. Then both the pile and the odd ground threads are raised and firmly beaten in, thus making the interlacement solid. Finally the even ground threads are lifted again and the third weft is secured. The process is repeated for subsequent velvet wires. After two or more commonly three wires are woven in, it is safe to insert a slim blade into the groove, draws it full length, and free the first wire. The work demands acute concentration and superb skill. Irregularities in the beat or jerky knife cuts mar the cloth. Imperfections are easy to spot. A master can weave only 8, 12, or perhaps 15 inches per day. Since the velvet wire has a propensity to twist if it is longer than two feet, the width of the cloth is relatively narrow. If the wire is not erect and the groove at the exact top, when it is cut, the pile is uneven and of inferior quality. It is a very unforgiving weave technique, and I love it.

Many attempted to increase production. One interesting strategy was to weave two pieces of velvet at the same time by superimposing, one on top of the other. This technique is described and diagramed in Alfredo Redaelli's chapter, "The Evolution of the Velvet Loom" in the book *Velvet: History, Techniques, Fashions.* It is a very clever approach where the pile warp is carried on two shafts. In the pile lift, both sets of pile warps go over the wire, but then they interlace separately, one for the upper and one for the lower cloth. The knife cuts them both simultaneously; however, since the lower pile's path is longer over the wire, the lower velvet has deeper pile. The reduction in production time was significant reducing it about 30 per cent. However, this improvement did not increase quality and eventually it was soon abandoned when a better innovation became available.

I have heard mention of a wire velvet loom, but I have not been able to find a full description of this invention. Some vague accounts describe that each velvet wire has its own cutting knife attached to it, but it is still a hand technique because the weaver slides the cutting apparatus down the track to cut the pile. My best source to date is in the web article, "The History of Moquette Supply in the UK Bus/Rail Industries 1863-1923." More research is needed before I can report how this development fits into the mechanization of velvet weaving. In the *Telegraph and Argus* newspaper, 3 June 2006 edition, the article "Remember when? Mystery fabric that helped win the war" Derek Grimshaw relates how his father, Harry, who usually wove cut and uncut moquette, was taken off the wire loom and trained on the new velvet loom at Lister & Company.

The fully mechanized velvet loom had a long birth starting with an 1824 patent. It produced two pieces of velvet woven simultaneously, but now the velvets were face-to-face, that is pile to pile. The pile warps alternately interlacing with the lower then upper cloths. A major obstacle was cutting them apart and winding them into separate bolts. Cutting them apart after they came from the loom was too laborious, so considerable energy and attention was paid to developing a cutting mechanism on the loom itself. Jacinto Barrau y Carter of Barcelona emerged as the first one to invent a fully mechanized velvet loom capable of weaving double velvets that he patented in 1857. At that time there were mechanized double-piece velvet looms in Lyon that could produce twelve times more an hour than the traditional handweaver, but this new velvet loom promised to do better.

Sadly Barrau's mounting debts forced him to sell his patent to Lister in 1867 or 1868. José Reixach, a handloom weaver came from Spain along with the patent and prototypes, and together with Lister continued to perfect the velvet power loom. In 1871 a horrendous fire destroyed the mill, the looms, the Spanish velvet loom and all the models of the inventions, but undaunted Lister rebuilt and expanded. In 1878 his double velvet power loom wove twelve times faster than the handwoven process and with its continuous cutter the cheaper velvet captured the market. Reixach earned the sobriquet, 'King Plush', and in 1906, the year of Samuel's death, he had headed the Velvet Department for 36 years working alongside the joint managing director, William Watson, who later became the firm's chairman in 1916.

In the book, *Advanced Textile Design,* there is an excellent diagram of the double-plush velvet structure. Since no velvet wires restrict it, the weaving width could be wider. Lister's super velvet was faster, wider, and much cheaper to produce, and fashion eagerly turned it into elegant display. He made a huge fortune and was even knighted assuming the title of Lord Masham in 1891.

Lister's new Manningham Mill was a magnificent brick colossus. It covered 18 acres and at its height employed 11,000 men, women and children. The chimney, nicknamed Lister's Pride, soared 250 feet high and weighed 8,000 tons. Even today this building dominates the Bradford skyline. Self-reliance was a guiding principle. It is believed that the machine shop made the looms and all the equipment. The sources of raw materials were controlled. It even had its own colliery to provide the vast quantities of coal needed to power the machines. Lister's silk, plush and velvet commanded the domestic market and gained substantial international recognition. It became the largest silk factory in Europe.

Lister velvet rose in status and public view. In June 1911 the firm supplied more than 1,000 yards of wide-width velvet to drape the interior of Westminster Abbey for the Coronation of King George V. It also reproduced a 16th century figured velvet with dark blue pile and fawn and silver ground, and the fabrics for the Coronation Chair used in Queen Elizabeth II's Coronation. It provided the Royal Opera House at Covent Garden with its crimson velvet upholstery and stage curtain, and the lush curtains in the Treaty Room of the White House were installed for the United States' Bicentennial Celebration in 1976.

Like so many British manufacturers, Lister & Company contributed to the war effort in WW II. A summary taken after the war showed that the mill had made 518 miles of duck cloth, 1,440 miles of shell cloth, 50 miles of khaki battle-dress material, 284 miles of flame-proof wool, 57 miles of lightweight rayon fabric, 1,330 miles of real silk parachute material, and 4,430 miles of parachute nylon and silk cord.

Besides this impressive list, the firm was asked to develop a new product for the war effort, a double-pile fabric called Resilitex or slab fabric. It was top secret and even now it is difficult to find information about its development, production and applications. It started with a visit by the Army's Technical Branch and with an idea to adapt the face-to-face velvet weaving technology to manufacture Resilitex or slab fabric. The specifications were daunting, instead of a 3/8-inch pile, the pile height needed to be almost two inches. Nylon thread substituted for the silk pile. Because the pile would not be cut, problems with tensioning and winding the woven slab onto some sort of cloth beam needed to be solved. Lister's entire team of engineers, chemists, machinists took up the challenge.

A draft titled "Specification for 'Slab Fabric' for Use in the Construction of Inflatable Shelters" written by the Chief Technician of the M. L. Aviation Company, Ltd consists of several pages on the details of materials and construction plus a clarifying hand-drawn diagram. Imagine a hefty sandwich with the 2" nylon pile as the middle layer. The backsides of the upper and lower woven slab are smeared with black neoprene like mayonnaise. It glues the slab to the ply or covering fabric layer and serves as a gas-holding barrier. Then comes the outermost layers, the bread, white hypalon on top and blue hypalon on the bottom. Dunlop, the giant tire factory in Biringham developed neoprene as a rubber substitute, because the Japanese had sieved control over the Malaya region and had cut off the natural rubber producing sources. The slab fabric could be glued together to make it thicker and it could be cut with an electric knife into desired shapes. It could serve many needs for shock absorbing and insulating. I believe that the white hypalon surface was the skin and the blue was inside. The color difference suggests that there were other properties to distinguish the types of hypalon, but I have no information to verify this surmise.

Two advertisements appear in *Flight,* one dated May 13, 1943 and the other, July 8, 1943 furthered my understanding. One ad had an illustration of three slabs laminated together and the other showed a skyscraper high stack of slabs next to a tiny figure.

> It eats up shock. It de-vibrates. It insulates, Petrol-proof, oil-proof, and water-resistant, 'Resilitex' weighs light and gives almost identical performance to sponge rubber. Already in wide use to official specification. Its principle is original, its future limitless. What problem could 'Resilitex' be solving for you?
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> **Untapped resources**
> 'This is a new resilient on which the government contractor can draw freely. It gives the same compression-recovery ratio as sponge rubber, and is already is wide use to official specifications. Resilitex is non-soluble in oil and petrol. The standard sheets are 1/3" thick. They can be supplied cut, curved or bonded together to make almost any shape. Have you some component that could be made up in Resilitex for you to try out on the job?[5]

In the Lister & Co. in-house magazine, published between the end of the war in Europe and Japan's surrender, there is a description of how the FF building, Furnishing Fabric, was converted into the Resilitex Department: it had ample space and was close to the weaving sheds and the packing bays. The staff was small, made up of over age or unfit for military service men and dedicated women workers. A Lister employee recalled:

> There was always an air of mystery about this particular fabric…We were not told what it was for, but we did find out that it was being dealt with by the Balloon Section of the Ministry of Aircraft Production and that the Dunlop Rubber Company had a hand in it. We got the idea that it had something to do with camouflage, and it was, in fact, always referred to in our records as the camouflage cloth.
>
> …we in the RX Department will move out and make way for the Furnishing Fabric Department, and our workers will go back to their old jobs all over the mill. No doubt many of the ladies will be released to return home and look after their families; but perhaps the smell of Bostic, Crown, and the other dopes we used will come back to them sometimes, and they will recall the buzz of the cutting machines which went on all day long. I hope they remember, too, the part they played in helping our lads achieve victory, which I can assure them was no small effort.[6]

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[5] *Flight* 13 May 1943, advertisement 27 and Flight 8 July 1943, advertisement 26.
[6] Nicholson, Eugene. "A Short History of Manningham Mil and Its Unique Contribution to Textile Inventiveness."

The military had developed Resilitex for particular purposes. It needed large, flexible surfaces that could be fashioned into inflatable dummy tanks, lorries, and artillery guns. Resilitex became the raw material for making decoys or 'spoofs' as they affectionately called them. It replaced the conventional materials of lumber and canvas. It was water-resistant and tough, able to withstand inclement weather and a rainy climate. David Medd's estate has a copy of the *Technical Handbook on Camouflage Display*. In it are illustrations, diagrams and instructions for constructing inflatable Churchill and Cromwell tanks. They are described as pneumatic low-pressure types. In fact they were more or less, sophisticated balloons.

In the same *Telegraph and Argus* newspaper article that reminisces about Lister's role in the war effort appears:

> The articles were blown up with an ordinary pump and when deflated could easily be carried in a bag by two men. Apparently one proper army lorry was capable of carrying 30 of these very realistic decoys, which were used to fox the enemy into believing that the country was much better equipped than it was.[7]

The website "Decoy Army Fooled Nazi Masterminds", has this quote: "As you can imagine, these tanks were easy to store and maneuver, their only disadvantage being that they deflated quickly once hit with artillery."[8]

One spectacular use of this new camouflage was Operation Fortitude, the code name for Allied Forces master plan to deceive the Nazi's. The strategy was to conceal in the north of England and to display in the south. The deception plan for D-Day was called Operation Quicksilver and here Resilitex decoys planned a major role. Seymour Reit, who might be better known as the creator of Casper the Friendly Ghost, wrote a detailed book, *Masquerade: The Amazing Camouflage Deceptions of World War II* in which he describes the strategy and deployments. They created an elaborate decoy army for General George Patton and installed it at Pas de Calais, to divert prying eyes from the true site, Normandy, some 150 miles away. In fact the British Fourth Army did not exist.

Lister's velvet loom was the cutting-edge technology of his day and its contribution in fabricating Resilitex was top secret and played an important role in Britain's National Defense. I am sure that there are many unsung Home Front heroes yet to be honored. So too in velvet's long history, it has been the quiet skilled hands, the agile brains, the enduring commitment and courage to imagine something more wonderful that drives the spirit to attempt and achieve.

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[7] Priestley, Mike. "Remember When? Mystery Fabric That Helped Win the War." *Telegraph and Argus*, 3 June 2006. (Bradford, England's newspaper)

[8] "Decoy Army Fooled Nazi Master Minds." www.popsci.com/technolodgy;gallery, 2011 6 August 2012 3:28 PM

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