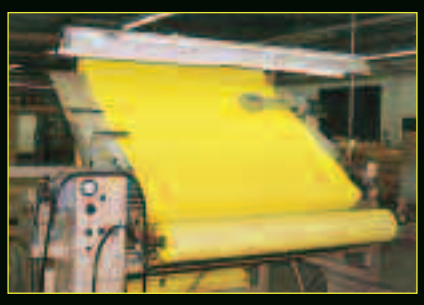
The production of tennis balls may be little changed over the years but it still takes some ingenuity to keep the ball playable, if not in play, when today's players can subject the ball to unimaginable G-forces. Although tennis has seen a decline in popularity over the last ten years, it is still a game that lights up summers around the world and represents a very competitive market for the companies which dominate the production of the balls. For the manufacturers, recent indications that the game is regaining some of its popularity, especially with the younger generation, could be good news.

"New balls, please"

"New balls, please" is that genteel reminder that still is heard coming from the umpire perched high on his or her chair at Wimbledon, south-west London, still considered the ultimate home of tennis. This year's Championship was memorable for a number of reasons: two of the top servers in the international arena completed two consecutive games in a mere 97 seconds, with no semblance of a rally to get the crowd excited. Just eight serves were enough. Then, in a final delayed by rain and played in front of a vociferous, wildly enthusiastic and partisan audience one would normally associate with soccer, Croatian Goran Ivanisevic beat Australian Pat Rafter in what must be considered as one of the most exciting games of tennis yet broadcast. The emotional final game of the 9-7 fifth set left spectators totally drained. One statistic stood out on his way to winning Wimbledon: Ivanisevic had served some 218 unplayable aces.



Yellow felt under inspection.

Photo: courtesy of Tex Tech.

The fact that the balls were able to survive such harsh treatment is as much a testament to makers Dunlop Slazenger - who next year celebrate a centenary of supplying the balls for Wimbledon, surely the longest 'sponsorship' deal in sporting history - as to the sheep grazing in New Zealand for producing the wool used on the ball. Considering that Wimbledon attracts over 600 players and some 687 matches are played during the fortnight to complete the tournament, it is also not too surprising that some 36,000-40,000* balls are needed, each one individually hand tested to ensure it meets the tournament's standards . (The balls are stored at 68°F/20°C and new balls are used after the first seven games in a match - to allow for warm-up usage, then changed after every nine games. Yellow balls were used for the first time in 1986.)

The Irish connection

What may be surprising, however, is that Ireland is one of the largest (if not the largest) exporters of tennis balls in the world. Not bad for a country that does not have any public tennis courts to speak of (private clubs only) and it takes a little research to find that the last time an Irish tennis player managed to get as far as a Wimbledon semi-final of any kind was in 1926 when a Mrs H J Feilden played in the Ladies' Doubles. To find an Irish winner, however, one has to go back to the 19th century when Frank Stoker was part of the winning Gentleman Doubles in 1890 and 1893. Actually 1890 was a vintage year for the Irish - the Gentleman Singles was won by Willoby Hamilton.

Notwithstanding these forlorn statistics, four companies closely associated with the manufacture of the balls are based within two hours drive of Dublin. Wellman International, near Kells, in County Meath, produces the fine denier nylon fibre which is used in the production of the outer felt. Wellman is probably better known for its production of polyester fibre from recycled drinks bottles but it also produces the right quality of nylon which is carefully combined, spun and woven with cross-bred wool by Tex Tech Industries, established in County Kilkenny in 1985. The company is one of the two major producers making the extremely dense woven felt needed for top quality tennis balls.

Each ball manufacturer has its own requirements for the finished felt and substantial quantities of Tex Tech production are delivered locally to Penn Racquet Sports (owned by Head), in Mullingar, County Westmeath, aiming to be the largest manufacturer (it produces some 4.2 million dozen balls a year), and Tretorn Sport, in Portlaoise, County Laois, the smallest of the big four companies which dominate the worldwide business.

The other two companies in the big four which between them control some 80% of global tennis ball production are Dunlop Slazenger (the names merged corporately in the 1960s) and Wilson Sporting Goods. Penn and Wilson seem to be



Michael MacCaughey, the man behind Tretorn.

locked in a permanent battle for the biggest share of the large US market, whereas the Dunlop brand enjoys a 44% share of the European market (in the important German market its share is 70%) and is considered the world's leading tennis ball supplier. In the UK, Slazenger is the top brand - which might be considered as the Wimbledon factor working in its favour.

Two dog bones make one ball

There are two principal parts to every tennis ball - the rubber core and the covering. Two rubber plugs are formed into the core, two dog bone or dumb-bell shaped pieces of felt cover the core. The back of the two pieces of fabric as well as the edges are coated with a special adhesive. Heat plays a major part during the formation of the ball, both when the two pellets are baked and vulcanised into the core of the ball and again when the fabric pieces are positioned and stuck. In some factories the pieces are applied by hand, in others it is an automated process. The white seams of the ball are actually felt adhesive. The finished ball is then fluffed with high pressure steam. The fluffiness of the felt is said to provide maximum ball control, allowing the racquet strings to momentarily grip the ball, so you can position it during a stroke. If the felt is too flat, the ball plays too fast and can feel out of control to the player.

The possibility of adding space age technology to this part of the game of tennis is both difficult and limited because the international authorities governing the game have laid down very stringent rules and performance requirements for the ball. Such is the concern for consistency that at Penn, for instance, 20-30 cans of balls are pulled off the production line every hour and tested for consistency, feel and bounce.



1. High-quality rubber is mixed with chemicals and milled into sheets.



2. The sheets are heated and other chemicals are added. The result is a smooth paste.



3. The paste is cut into long strips which are turned into pellets by a totally integrated process. Each pellet becomes half a tennis ball.



4. The pellets are cooled before the next production stage. Random samples are tested in the lab.



5. The pellets are moulded into halves of tennis balls.



6. The halves are checked and smoothed before moving on.



7. A special rubber adhesive is applied to the edges.



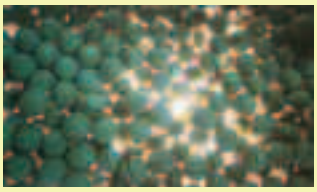
8. The halves are cemented together with a natural rubber adhesive and then vulanised. The adhesive becomes as strong as the material it holds together.



9. The balls are flex-tested.



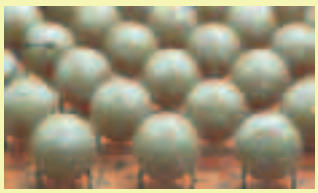
10. The balls are buffed and rubber adhesive is applied.



11. Yet another precision control is performed.



12. Pre-cemented felt blanks are punched out.



13. The balls are coated with adhesive.



14. Each felt blank is manually or automatically applied.



15. The balls are vulcanised again.



16. The final tennis ball has passed 96 quality controls.

Stages of production for the Tretorn pressureless ball.

The diameter of the ball must be more than 2.5 inches (6.35 cm) and less than two and five-eighths inches (6.67 cm) although in July 1999 the International Tennis Federation agreed an amendment to increase the maximum diameter to 2.79 inches (7.09 cm). The increased diameter is meant to generate longer rallies and provide players with more reaction time - understandable if you're facing a ball coming at you at 144 mph (240 kph**).

The idea of the larger ball has also been promoted as a means of slowing down the game, besides increasing the potential for rallies. It is even meant to help spectators see the ball a little better but tennis is only a superfast racquet sport when played on grass courts. And there are not too many of those on the tennis circuit.

Most of the technology in tennis has been seen in the production of the racquets. The new generations of these have been developed to enable players to hit the ball more accurately and faster - and the promotion of the larger ball could be akin to asking an equipment manufacturer to introduce a new racquet which would slow down a player's game. Nevertheless, Dunlop's new bigger ball was the official ball on the Delta Air Lines ATP Senior Tour of Championships last year.

Although of considerable interest to the average recreational player, it has not been met with much enthusiasm by the professional players. Christopher Gorringe, the chief executive of the All England Club which rules Wimbledon, states: "We have been aware for some time that the ITF (International Tennis Federation) has been experimenting with changes to the dimensions and properties of the tennis ball. At The Championships we will continue to use the ball which we think is in the best interests of the players and the fans, but will monitor with interest the experiments with the new larger ball over the next two years."

Besides the size, official tennis balls must have a bounce of more than 53 inches (135 cm) and less than 58 inches (147 cm) when dropped 100 inches (254 cm) on to a concrete base.

The third principal requirement is that the weight of the ball shall be more than two ounces (56.7 gms) and less than two and one-sixteenth ounces (58.5 gms). So, with volume, weight and bounce all carefully regulated, the limits of technological manoeuvre are extremely tightly drawn for the ball producer. Even the new 6% larger ball from Wilson, introduced in 2000, weighs in at two grams less than its conventional ball.

Nevertheless, there are substantial differences between the various balls available on the market and even though the rules and regulations have not been substantially changed since 1875, new concepts continue to come onto court. The move towards water resistant finishes is one, with both Penn and Dunlop offering such balls. Both Tex Tech and Milliken West of England, the other major felt producer, have been working on their respective developments. Dunlop has also introduced its Ultra Vis finish, making the yellow dyed felt that much brighter, seen as a positive advantage by players having to complete matches in the poor light of evening. It also helps the player sight the ball a fraction of a second faster, an important factor when playing on fast grass surfaces such as Wimbledon. Penn, which makes the best selling ball in the USA, has its Smart Optik felt for the same reason.

The core

The origins of tennis ball manufacture appear to be firmly linked to the development of vulcanised rubber in 1839 by Charles Goodyear and the manufacture of motor car tyres and Wellington boots. It explains why Dunlop, for instance, saw tennis balls as an offshoot of tyre manufacture; Penn was part of the US General Tire Company, while Tretorn, now owned by Puma, had developed a name for galoshes, turning out 2,250,000 pairs by the end of the 19th century. By the time the Wilson Sporting Goods company had moved into the ball business in 1978, with a production facility in Fountain Inn, South Carolina, the popularity of the game had been firmly established. The Fountain Inn facility was built solely to produce tennis balls (no links to other rubber products) as complementary to the company's range of sports equipment. Coincidentally, the same year and for the first time since 1932, the Wilson company posted a net loss ($2 million) but by the end of 1979 it had bounced back into profitability and its tennis ball had been adopted as the official ball of the US Open, considered to be the largest, if not the most famous, Grand Slam tennis tournament in the world.

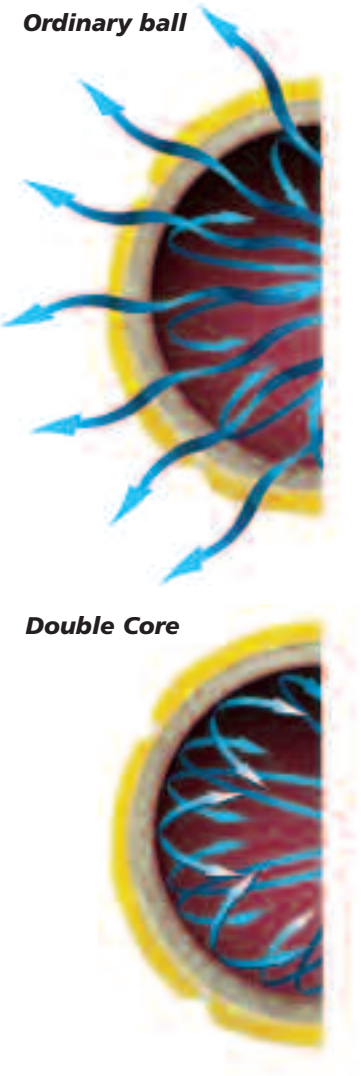
Each of the manufacturers jealously guards the formulations used in producing the rubber for the core. Essentially it is a blend of natural Malaysian rubber and synthetic rubber, although some balls use predominantly natural rubber, and it is in the chemistry that each company will lay first claim to producing a superior performance ball. This year Wilson, which produces some 4.5 million dozen balls a year, has introduced its Double Core DC1 ball, for instance, which it says will maintain the pressure inside the ball for longer, twice as long as its general competitors in the pressurised ball segment of the market. Whilst called a double core, Wilson has added a thin butyl-based barrier coating to the inner surface of the ball which slows down the escape of air through the structure of the ball. It is said that when the pressure inside the ball falls to 11 psi (pounds per square inch), players become aware that the ball is playing 'dead'. (The loss of pressure is the key factor deciding the longevity of the ball - after four weeks, most pressurised balls have lost some 20% of their air pressure. It is claimed that this can happen after just one hour of play, too.) As a counter, Dunlop has its Fort Plus ball with its core using its Duracore pressure retention technology to retain optimum pressure.

Three fibres for the felt

Two companies appear to dominate the production of the extremely tight and hard wearing felt required for quality tennis balls. Besides Tex Tech Industries, which is headquartered in Portland, Maine, Milliken West of England Cloth in Stroud, Gloucestershire, is the other major, supplying both Wilson and Dunlop Slazenger with its Playne felt. (Thomas Playne took over the original family business in 1759. Today the company claims that balls using its felt are played in more Grand Prix tournaments than any other felt.) Tex Tech is the world's largest manufacturer of both woven and needled (non woven) tennis felts. In Ireland it only produces the woven felts required for tennis balls. Besides targeting the tennis sector, Playne on the other hand is also renowned for its green melton which adorns the surface of billiard or snooker tables.

Crossbred wool from New Zealand, usually associated with top quality wool carpets, is the wool fibre of choice for both felt producers, combined with six denier nylon. The quality of the wool provides the strength, consistency and colour purity needed. A single black wool fibre shows up astonishingly quickly in a felt which is designed to be pure white or yellow!

The denier of the nylon is important. If too coarse - even nine denier - it does not combine well with the wool yarn and does not matt down properly into the surface of the felt. While tennis is not a game played in the rain (as spectators at Wimbledon 2001 discovered yet again when the men's final was delayed by twenty-four hours), Penn has introduced a water-repellent finish to its balls which means that the ball stays drier and at a more consistent weight for longer - either until the court dries, the moisture passes or the game gets rained off completely. Wool is acknowledged for its ability to regain moisture, so it is not surprising that water repellency has been launched by Dunlop Slazenger this year with its Hydroguard finish, developed for the company by its Stroud-based supplier of felt.



Wilson's Double Core technology maintains pressure and bounce for longer than ordinary tennis balls.

Wilson, in turn, has also introduced a greater wool content to the felt used on its DC1 ball. Generally the blend of the fibres in the weft is in the region of 70% wool/30% nylon. Wilson, by raising the wool content of its Playne-made felt, is claiming that it is the highest quality, longest playing felt it has yet specified and is outwearing its USA, European and Asian competitors. It claims that its new ball has a durability factor some 17% in excess of its nearest competitor after the equivalent of 360 minutes on court. It will be interesting to see whether its competitors feel that the fibre content is the reason because it is said that other felts are mixed at the same blend.

To pressurise or not to pressurise

Given that most balls are pressurised, and that the internal pressure of the ball decreases over time (it is why balls come in pressurised tins where the air pressure in the can is equal to that inside the ball so no loss occurs after manufacture and before play starts), it was only a matter of time before someone created the pressure-less ball.

With no pressure loss possible, the ball would last a lot longer, making it especially suited to practice and training sessions. Tretorn was the first to introduce such a ball to the market and has developed its reputation on its pressureless ball. Nevertheless it has recently introduced a pressurised ball to its armoury and other companies have included pressureless balls in their ranges. The first Tretorn balls at the start of the 1900s were in fact pressurised but by the end of the 1940s the company had started experimenting with pressureless balls, eventually patenting the concept in 1950. Since 1955 until now it only produced the pressureless ball. The patent was based on the use of a completely new compound of rubber and resin-like products. By modifying the compound, it was possible to vary the bounce and hardness of the ball. Tretorn's core recipe incorporates more than ten different ingredients.

The arguments about the properties and feel of different tennis balls are never ending, yet the player only has the ball touching the strings of the racquet for about three milliseconds. In that short space, the player generates subjective views about the play of the ball, whether it feels right, allows the correct amount of spin to be imparted or whatever else distinguishes one exponent of the game from another. It is said that top players can easily distinguish between the two principal types of ball. In order to maintain its position in the market, Tretorn developed a ball which would be perceived as 'lighter' (pressureless balls have a thicker core), 'softer' on the racquet, livelier in bounce, and more 'comfortable' when hit. By 1988 it had launched its Tretorn Plus which met all the subjective criteria - remembering that all balls have to meet the same objective, physical specifications. Given the quality of the felt covering and the fact that there was no air pressure leakage, the balls certainly provided the extra longevity, making it especially ideal for recreational players and coaching.

Tretorn has also developed a third type of ball: the filled pressureless ball, branded Micro X. Each ball is filled with an unbelievable 700 million balloonlike air inflated micro cells which only weigh one gram.

But, besides the questions of pressure, it is the construction of the fabric covering which must attract acclaim. In purely textile terms, the flow process may seem fairly straightforward: blending, carding and spinning the yarns, warping and weaving the cloth, and then washing, raising, milling, dyeing and drying the felt. What decides the quality and strength of the finished fabric is probably the final milling, which governs just how the fibres bind together and matt down. The testing and analysis of the finished article is more complex. In fact, testing is a crucial factor all the way through. At Tex Tech every roll of felt is individually examined and then tested to check that it has met the individual ball manufacturer's performance parameters. Every roll can be traced back to the day and time of manufacture and is colour coded on the reverse to ensure that the right roll goes to the right factory. But now consider the fact that the Micro X ball, for instance, has a spin ratio of 2,681 rpm when hit at 90 mph (145 kph) at a racquet angle of 45°. The abrasion factor is frightening - the ball suffering 1,500-G forces, going from 0 mph to over 60 mph in 0.002 seconds and hitting the ground - whether grass, clay or artificial surface of some kind - at over 140 mph. And, if the serve is returned, the ball then has to survive the variations of slam, cut and strike during a rally (which in a 1987 record-breaking match included 14,456 times across the net in 8 hours and 6 minutes).

It's enough to make any New Zealand sheep feel proud of its wool.

David Buirski



Dunlop Slazenger, the UK's leading tennis ball supplier has been supplying balls for Wimbledon for nearly 100 years.

At the end of every day at Wimbledon, the tennis balls are sold to spectators or affiliated tennis clubs for £2.50 per can of three with the proceeds going to British Schools LTA 'Wimbledon Balls for Schools' Scheme. For those interested in acquiring tennis balls which may have been slammed by an Ivanisevic, Sampras, Rusedski or Henman, the next Wimbledon Championship takes place 24 June-7 July, 2002.

The speed of service achieved by Greg Rusedski, 14 March 1998, and still acknowledged as the World Record. It was matched at Wimbledon this year by Taylor Dent.