STANLEY PLANES AND SCREW THREADS

by John Bates

Part Two: Stanley Plane Threads – What they are and why they were used

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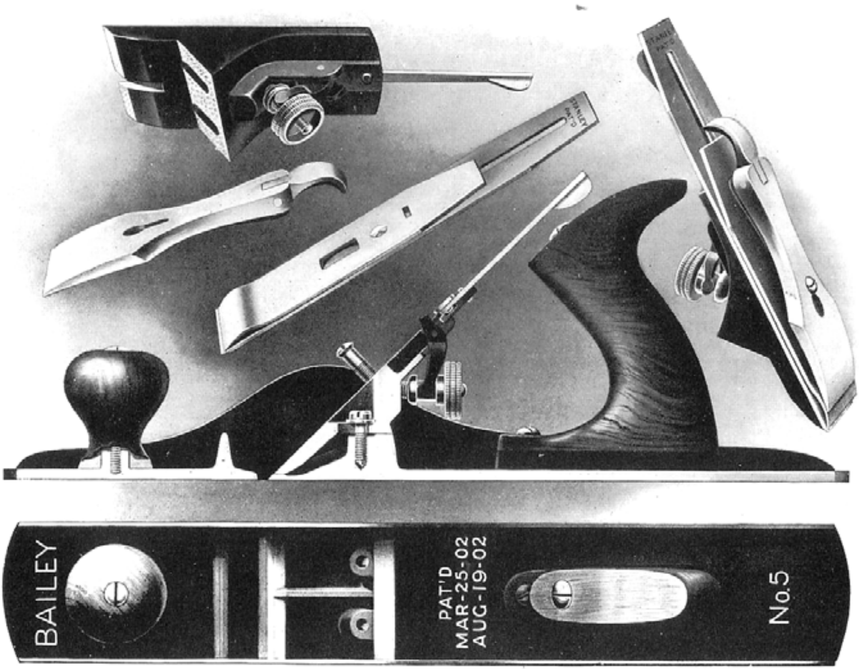

INTRODUCTION – PART II

I came to the end of the first section of this article having exhausted a ready supply of empirical data and feeling the need to better support some of the assertions made. Hence, I decided to pursue the Stanley thread debate via an historical investigation of the company and its products. This tack eventually expanded to include the practice and culture of manufacturing as well as the market demand existing in the US from around 1850 to the end of the nineteenth century.

The more I thought it through, the more it seemed essential that the products, technological progress and history of the Stanley Works must be considered in relation to a broader historical setting. Indeed, what could be called the evolution of instruments, tools and machines is more than a simple chronology of technological and scientific progress: since at least the 1600's both economic and social conditions have also affected and influenced the process (see for example DUMAS).

AMERICA IN THE LATE NINETEENTH CENTURY

Our story is played out from 1850 to 1920; a period sometimes referred to as the Second Industrial Revolution and which also marked the maturing of industrialisation (SINGER: vol 5, 822). Of particular note is the fact that it includes the years of the American Civil War of 1861 to 1865. Economic, social and cultural circumstances in the young nation not only evolved they were revolutionised. In industry too, new and evolving technology and revolutionary management ideas were set to bring about significant changes.

The major development work and production of the Bailey plane took place between 1850 and 1900. This development was set against a background of major economic, social and political change and upheaval in the US – the rise of mass production, unprecedented population growth, and the conduct of a bloody Civil War. All this changed factory production and management in America and generated demand for higher and higher output at lower labour costs. Prior to this technical innovation and knowledge had been spread by word of mouth. However, by the 1850s it was becoming available to a new breed of entrepreneur via published literature using language “intelligible to common workmen” (HAWKE: 166).

From 1850 to 1880 America witnessed the rise of railroads, steamships and the telegraph. The first American transcontinental railway was completed in 1869, the same year in which the Suez Canal was opened (DERRY: 305). This new infrastructure ultimately provided reliable all-weather transport for materials and finished goods. Industry responded by lifting production and in so doing created a large scale-up in employment and output. A revolution in the sophistication of process technology had begun as earlier constraints were overcome: coal freed production from water power and better transportation facilitated year round production and wider distribution. All this made possible the growth of mass markets for first time. Lastly, mass production technology dramatically increased the scale and complexity of manufacturing as businesses rose to meet the demands of new markets, particularly from the 1880's to the 1890's.

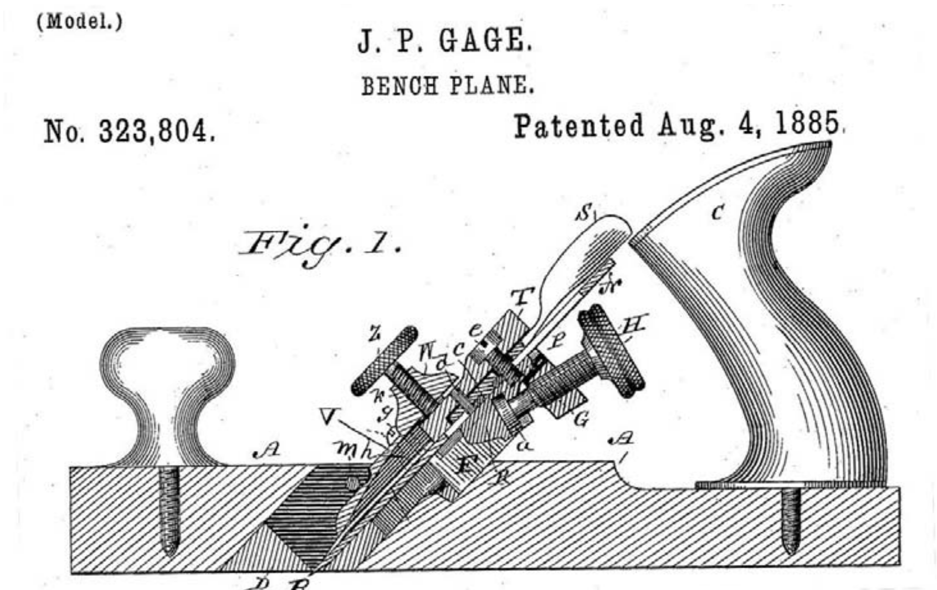

FIGURE 1: Sketch from J P Gage's design for bench plane - US Patent No. 323,804 of 4 August 1885

Perhaps America was always more disposed toward production efficiencies than other nations. Even as the 1840's drew to a close her engineering industry had already undergone rapid growth and change. A display of America's firearms and woodworking machinery at the London World Exhibition of 1851 so stunned the British in terms of its sophisticated production technology that in 1853 a panel of experts, including Joseph Whitworth, was dispatched to the US to investigate.

Whitworth was struck most of all by American's superiority in woodworking machinery; conversely, he was little impressed by the nation's capacities in the working of iron (MAYR & POST: 42). "The labouring classes are comparatively few in number", Whitworth wrote in his report, "but this is counterbalanced by, and indeed, may be regarded as one of the chief causes of, the eagerness with which they call in the aid of machinery in almost every department of industry. Wherever it can be introduced as a substitute for manual labour, it is universally and willingly resorted to …. It is this condition of the labour market, and this eager resort to machinery wherever it can be applied, to which, under the guidance of superior education and intelligence, the remarkable prosperity of the United States is mainly due" (ROLT: 155). As the 1850's ended significant levels of mechanisation was already a feature of American industrial practice.

From the end of the 1860's, American machine tools, either imported or built under licence, began to appear in European machine shops in increasing numbers (ROLT: 161-2). This was evidence of the great strides being made in the capacity and capabilities of American manufacturers. Such significant gains did not arise due to some historical accident nor were they simply fate. American knowledge of mechanical engineering, metallurgy and practical experience from day-to-day contact with machine technology provided innumerable opportunities for small improvements. Historically, the cumulative effects of these improvements proved to be very great indeed.

True to its roots, the American system of manufacture was characterised by a practical bent and possessed of a totally unsentimental approach to the productive process; one in which purely commercial considerations typically prevailed (MAYR & POST: 60). A spirit of business enterprise and daring combined with a flair for picking the best men and the best methods became the hallmark of these 'Yankee' workshops and factories. As we shall see, many of these features and qualities were evident at The Stanley Works even before its incorporation.

Across America's industries the application of mass production techniques and improvements in standardisation and interchangeability of parts was being greatly extended. By 1880 one American firm alone was producing 50,000 sewing machines per year compared with a total European production of only 15,000 units per annum (ROLT: 186).

By 1900 America was clearly leading the world in large-scale mass production and by the end of WWII she had more large scale business enterprises than the rest of the world combined. The significance of just how great and how rapid these changes were, can be gauged from steel production figures for the US and Britain as shown in the Table 1. The up-scaling of steel production in the US over that timeframe can only be described as phenomenal.

TABLE 1: Comparison of US and British steel production in 1868 and 1902

YEAR	**US steel production (tons)**	**British steel production (tons)**
1868	8,500	111,000
1902	9,138,000	1,862,000

SOURCE: see http://factory-physics.com

To really appreciate the factors which influenced or affected the choice of production method and tool design, demands of us a better understanding of culture and economic circumstances of the time. In the interest of gaining such an appreciation, let us take a closer look at factory management, consumer markets and mass production in late nineteenth century America from the establishment of The Stanley Works in 1852 (the Stanley family had been making hardware in New Britain from 1831 on; they used a series of other names before becoming The Stanley Works) up to and beyond the commencement of 'Bailey' plane production. That date seems to be May 1869 following the Stanley Rule & Level Company purchase of Bailey, Chaney & Company of Boston Massachusetts (Bailey's factory which was producing planes of various designs) and with that purchase the right to manufacture tools under Bailey's patents and using at least some machinery removed from Bailey's Boston plant (WHITBY).

FACTORY MANAGEMENT

Before 1880 in some advanced New England workshops a system of contractor-foremen operated. This system enabled owners to pass on to the contractor complicated problems of labour management. Various accounts of the time suggest this system was in use from as early as 1850 and was certainly widespread during the period of great expansion in consumer demand from the Civil War up to the onset of the depression in 1873. By the 1880 Census, Fitch observed that "the economy of large manufacturer and uniform methods is largely due to the fact that so little labor is wasted" (MAYR & POST: 10).

These early factory management practices were to become a major influence on future management structures across American manufacturers. After the Civil War leadership in manufacturing was more often provided from the top down by technologically competent, owner-investor-capitalists who made continuous efforts to develop and refine process equipment. While on the shop floor the foremen, driven by the owners for output, handled the co-ordination of integrated plants and virtually all personnel issues. In global terms this would prove to be a winning combination.

In 1968, Donald Davis, then President of The Stanley Works, gave an address to the Newcomen Society of America on the 125-year history of his company (see DAVIS). Not once did he mention the production of metal planes. That omission was probably due to the fact that the profitability of the company was initially built on the back of its builders' hardware and later its metal strapping products. I recognise that the Stanley Rule & Level Company and The Stanley Works maintained separate corporate identities from 1857 until 1920 when the former company was merged into The Stanley Works. However, the two had strong family connections, officers in common and were obviously closely interrelated commercially.

What is made clear through Davis' talk is the fact that, from the very beginning, every product the company produced was 'manufactured' rather than 'crafted'. Furthermore, his address provides some key insights into the management of manufacturing processes and human resources at The Stanley Works. I believe these insights to have a bearing on the questions surrounding the nature of the threaded fasteners used in Stanley's 'Bailey' planes.

First, and perhaps most importantly, the manufacturing practices adopted at The Stanley Works were always characterised by innovation, an eye for progress and parsimony. For instance, the little company had the first steam engine in New Britain and used it to power the machinery which turned out its bolts and house trimmings. The company's founder, Frederick T Stanley, had purchased that engine in 1830; no doubt quite a bold initiative at the time.

Second, the men who headed the company during its formative years were quite remarkable. Both Stanley and William H Hart, who served as president from 1884 to 1915, were possessed of uncommon vision and a fierce competitive spirit. They also appreciated the value of a dollar. As Davis put it (DAVIS: 10) Hart was 'frugal to the go-down' and would have the office boy recycle the envelopes from the incoming mail so that he could use the reverse side for notepaper!

Third, The Stanley Works was not always the giant global corporation it is today. In 1870 it was a small firm struggling to survive amongst fierce competition. Through pioneering innovations like the use of steel in its hinges and the development of a better process for cold rolling wrought strip iron the firm survived and ultimately prospered. Indeed, by the late 1960s the Works had become the largest cold-rolled steel producer in the North-east USA (DAVIS: 12).

Which of the three factors discussed above was the most important is debatable. However, decisive and insightful management was arguably the primary driver that carried Stanley to greatness. Davis (1968) cites many examples of this in his address. For example, Hart, in the face of strongly entrenched competition, took steps to grow the Works production. From 1866 he personally initiated and oversaw the improvement of factory facilities and production techniques. And when this was done he took charge of new marketing initiatives too. The little company weathered the storm of the 1870s depression years and by 1900 had diversified into steel strapping; again a defiant response to major competition.

The Stanley Works began in 1852 as an 'acorn' with a working capital of US$30,000. Fiscal 1854 marked its first profit; a modest $655.57 (DAVIS: 14). The tending of that seed and the maturing of the 'mighty oak' which the company is today bears testimony to the uncommon vision and management ability of its leadership.

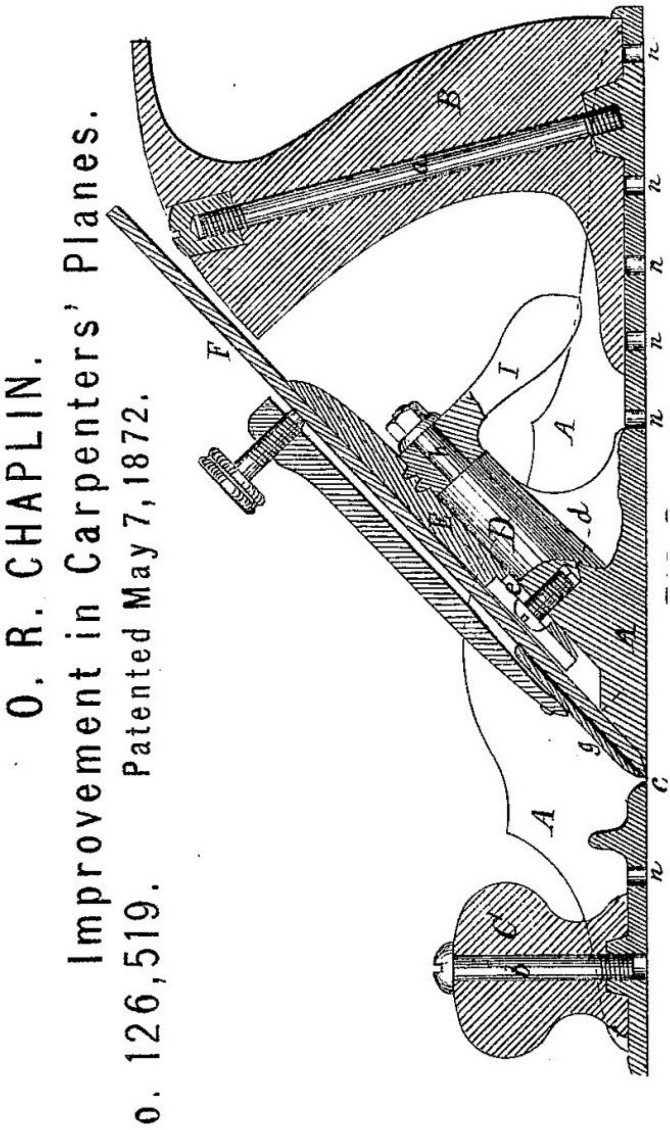

FIGURE 2: Sketch from O R Chaplin's design for improved carpenter's plane - US Patent No. 126,519 of 7 May 1872

CONSUMER MARKETS: Demand and Supply

Technological progress is highly responsive to economic forces and needs to be understood in these terms. America's early world leadership in the development of specialised woodworking machinery was a consequence of an immense abundance of forest products. An abundance of people would have a similar impact on the development of her other productive capacities and capabilities.

Every year from 1790 to 1860 America's population grew at a rate more than twice as high as that achieved in any European country (SINGER: vol.5, 822-3). This strong rate of population increase produced an equally rapid rate of growth in the US consumer market which in turn was served and supported by major improvements in land transportation and communications starting with railroad construction in the 1830s.

Better transport ultimately linked the young Nation's emerging industrial centres with previously remote, self-sufficient markets (MAYR & POST: 53). The railroads and telegraphic network facilitated production and distribution, and thus had a great impact on new production processes. For the first time in their history American producers and consumers across large sections of society were in a position to establish economically feasible market relationships. Thus in America human progress had moved well beyond simply meeting human need; it had created new wants via the application of technology (DERRY: 711).

Differences in resource endowment and demand conditions in any economy go a long way toward determining what kinds of inventions it will be profitable to develop and exploit. Nineteenth century America presented an economy in which resources and demand factors pushed her in directions quite different from those that applied in Western Europe at the time. So a defined, perhaps unique, set of American tastes and preferences emerged from what were quite propitious social and geographic conditions. These proved highly congenial to a new technology capable of producing large quantities of low-priced goods to a standard (MAYR & POST: 54).

So somewhere around 1850 the fuse was lit on an explosive mix of new industrial supply and burgeoning consumer demand that would ultimately completely transform the United States. Over the following 100 years the rise of America's economy would change the face of industry and the balance of trade across the entire industrialised world.

It was into this economic and business setting that Leonard Bailey's new steel plane would be launched. The Stanley Works may have started its life in a smallish workshop, but it would reach its apotheosis in a new economy which changed forever the nature of the traditional relations between invention, production and consumption.

The age of the artisan and the craftsman was gone; mass production was the new business imperative.

MASS PRODUCTION

How easy it is to slip into the use of the term ‘mass production’ without realising just how revolutionary a departure in manufacture it actually represents. Some scholars (for example see SINGER: vol 5, 818) believe mass production to be the single greatest contribution by America to the development of technology.

So in the circumstances why didn’t nineteenth-century American manufacturers ever achieve the accuracy of form, size and position which is now commonplace even in some home workshops?

Lack of standardisation played a large part. For example, as late as 1856 the American Watch Company used four different sizes of ‘standard’ 1/2-inch taps (MAYR & POST: 115). While steel rules and scales and the vernier calliper began to make an appearance from the early 1850’s the state of industrial metrology was fairly primitive. Just how primitive can be appreciated from the fact that in 1839 the common dimensional tolerance on parts was plus or minus 0.01 of an inch (MAYR & POST: 116 – see also HUME for a broader treatment of this subject). Furthermore, workshop machinery and tools for working metal played a part in determining the degree of accuracy possible in production work. Twist drills did not appear until about 1860, but once their presence was felt they transformed the practice of drilling and greatly improved the accuracy of drilled holes.

Yet what ultimately limited the early development of mass production into a system of practical interchangeability was the need for special-purpose gauges. The cost of these gauges meant that interchangeability of parts at the shop level, and in factories where small batch production was the rule, had probably not progressed to any great degree by the close of the Civil War in 1865 (MAYR & POST: 116). Those barriers began to be broken down once accurate, reasonably priced measuring instruments of a general-purpose nature became more widely available. It was the advent of such instruments which heralded the dawn of diffused mechanical precision in American industry. The chronology of their introduction and evolution is simply and beautifully presented in Kenneth Cope’s book on machinist tools and patents (see COPE, 1993).

Another point worthy of note here is that the introduction of the micrometer calliper by Brown & Sharpe in 1868 gave the machinist the ability of measuring to 0.001 of an inch. That instrument arguably marks a turning point in the evolution of precision measuring tools. However, the flowering of these tools and aids to precision manufacture came some 30 years later with the development of the gauge block by C

E Johansson of Sweden (for a fuller discussion see BATES). These gauges made possible production accuracies of the order of one ten-thousandth of an inch in all workshops.

The Industrial Age ushered in the rise of the corporation and the values of the “American Dream” – of achievement, status, prestige, and the tangible rewards of working hard and prospering by ones own toil and ingenuity. Henry Ford is often credited for the introduction of efficient and formal processes – including the concept of "managerial” capitalism we are familiar with today – but the wheels of standardisation and efficiency were being set into motion well beforehand. William Sellers has been evangelised for the standardisation of the screw as well as other machine parts that had previously been the “one-of-a-kind” custom handiwork of machinists. Standardization played a big part in speeding up the introduction of assembly-line and mass produced goods. Understandably he was also demonised by many ‘old school’ machinists of the day.

Mass production also created the need for new skills and knowledge of a greatly different kind to that of the artisan and the craftsman. In this ‘new order’ mental work was being separated from manual work. That is, conception and execution of design were done by separate bodies of workers in separate locations. The mental work involved in planning manufacturing processes was taken on by engineers, who decided not only what work will be done but also in minute detail how it must be done (MAYR & POST: 14). I believe that there is no doubt that The Stanley Works fully embraced this new mode of factory production. After all, the company’s metal planes involved quantity production of a relatively complex mechanism with sufficient precision that components could be stored at random and assembled without hand fitting.

Armed with this contextual rendering of society, economy and manufacturing in nineteenth century America let us now turn the discussion to the question of the threaded fasteners which The Stanley Works chose to use in these ‘new’ metal bench planes. The discussion will mainly focus on the 9/32-24 and the No.12-20 screws typically found in the frog, handles and other parts of those tools.

THE STANLEY STEEL BENCH PLANE

According to Salaman (1989) bench plane is a general term for a plane with a flat bottom and metal bench planes were first made of wrought iron, mild steel or gunmetal and later cast iron. In the US, however, from the outset metal bench planes were of cast iron without a wooden core and with the iron bedding on a metal frog.

Leonard Bailey invented three major component parts of the standard pattern of bench plane: the moveable frog (the wedge shaped iron support on which the plane blade rests), the lever cap iron securing system, and the depth adjustment wheel and yoke system. Later the improvement of the lateral adjustment lever was added. Bailey himself only manufactured planes from 1855 or 1858 through to 1869 when he sold the business and his patent rights to A Stanley & Company. The lateral adjustment for the cutter was patented by J A Traut (a Stanley employee) in 1888.

Bailey's contribution to the development of the bench plane was a quantum leap in plane technology. Those tools, which still bear his name today, are thus little changed from his prototypes of the 1860s. Hence, in an evolutionary sense, there was little more to be done but to make minor cosmetic or frivolous changes to the tool.

Indeed, Stanley metal planes have, except for certain mostly aesthetic refinements, remained unchanged since they were introduced to the market almost 140 years ago. Makers in the USA, Britain, Australia and on the Continent have also extensively copied them. Prominent among these so-called imitators is Sargent & Company of the US, and Edward Preston & Son Limited and C J Hampton Limited (Record Tools) both British firms.

Leonard Bailey was an astute and clever businessman as well as an inventive genius. This much we know from the legacy of some 77 patents and the many businesses he gave birth to during his lifetime. But for those with a fascination for hand tools and traditional methods of working wood, the Bailey plane was much more than a revolutionary design; it and the man whose name it bears have become a *cause célèbre* for collectors around the world.

On the many sites, fora and pages on the internet dealing with Stanley tools, some of the most contentious discussions centres around the type and size of thread which either The Stanley Works and/or Bailey chose to use in the comparatively few threaded parts on their planes. **However, before going further it is of great interest to note that taps and dies for both the 9/32-24 and the No.12-20 thread forms discussed below are still available in the US.**

WHY DID STANLEY USE A 9/32-24 THREAD?

Firstly, it appears most likely that the 9/32-24 screw thread was a consequence of early US adoption of the Whitworth standard; this particular screw size and pitch is part of the Whitworth Admiralty Fine series. That size was also specified as part of the BSW series (in 20 tpi) as well as the Brass and BSF series but only in 26 threads to the inch. I see nothing unusual in this, indeed to some extent it is to be expected, after all Whitworth's standard thread preceded the Seller's thread by some 23 years and achieved quite wide adoption by American industries and even in Europe.

Whitworth was by all accounts a dogged campaigner for the decimal system in measurement rather than fractions. His "New Standards of Size" for screw threads published in 1841 was further developed in an 1857 paper presented to the Institution of Mechanical Engineers entitled "On a Standard Decimal Measure of Length for Mechanical Engineers". Due in part to the immense prestige Whitworth gained from the display of his machines at the Crystal Palace Exhibition in 1851 his standard screw thread system was in general use in Great Britain by 1860 and in "almost universal use" by 1868 (NORTHCOTT: 151).

That later series starts at 0.100 inches and increases by regular 0.025 inch steps to 1.000 inch then by 0.125 inch steps to 3.000 inches. This progression contains all of the BSW sizes in his original 1841 series and which are still in use today. A comparison of these screw thread series up to 3/8 inch is shown in Table 2.

Then again, the nominal 9/32 thread size of 0.28125 inches diameter happens to coincide almost exactly with the nominal size of a No.17 machine screw. Was there a No.17-24 machine screw commonly available before 1900? Perhaps, but as screw thread standards developed in the US the numbered machine screw series was eventually abandoned for all sizes from ¼ inch and above. Today only the sizes from the No.12 down to No.2 are commonly stocked in America.

TABLE 2: Whitworth's 1841 & 1857 Screw Series (abridged)		
1841 series	1857 series	Threads per inch
—	0.100	48
1/8	0.125	40
—	0.150	32
—	0.175	24
—	0.200	24
—	0.225	24
1/4	0.250	20
—	0.275	20
5/16	0.300	18
—	0.325	18
—	0.350	18
3/8	0.375	16

SOURCE: WHITWORTH, Joseph 'A uniform system of screw threads', in Proceedings of the Institution of Civil Engineers. The Institute, London, 1841 (pp i, 157 & 159) - see also Engineering and Architecture Journal, 1857 (p 262) and 1858 (p 48)

So are we looking at an inherited Whitworth thread or a re-badged No.17 machine screw? I think enough doubt remains to allow for continuing debate about the 9/32-24 size. Others may care to pursue this line of inquiry.

There are a couple of other points that warrant closer examination. The first is related to common workshop practice. At the time the 'Bailey' planes first went into production, it was a common practice to make threads 1/64 or 1/32 oversize. One explanation for this practice is contained in an 1882 report by the Master Car Builders' Association of America which cites the "inconvenience and confusion" that existed in 1864 as a result of the diversity in screw threads used in the machinery, tool and other industries (HUME: 187). It seems that throughout US industries the understanding was that Sellers had only specified a standard number of threads per inch. Hence it was not till the Association's report of 1882 that it was confirmed to industry that, in addition to the number of threads, the thread form and the diameter must also be as specified (HUME: 183). As a result of this 'confusion' taps were routinely being made 1/32 or 1/64 inch 'oversize'.

Failure to comply with the adopted standard was not the only factor at work. Part of the problem was due to the relatively large variation from nominal size in the bars provided by the iron makers at that time. A variation of 0.01 inch on the diameter for bars of 1 inch and under was not an uncommon occurrence. Thread diameters were regularly 'adjusted' to avoid the time and waste of machining bars to size. To control this problem the now famous firm of Pratt and Whitney took unilateral action to establish standards (CALVERT: 176) and also developed limit gauges; this was the first recorded application of such gauges in America.

So could the origin of the 9/32 inch screw be attributable to a standard 1/4 inch diameter thread made 1/32 inch oversize? Perhaps, but the lack of a satisfactory measurement standard may also have contributed to the existence of this thread on Stanley planes. Issues concerning the problem of universal measurement standard are discussed in more detail when we come to consider American screw threads.

ORIGINS OF THE No.12-20 MACHINE SCREW

Now we turn to the No.12-20 screw. In the US, even in the 1890s (see SAUNDERS: 196A), machine screws were readily stocked in sizes from No.000 through to No.30 in a range of pitches. At that time the increment between sizes was noted to be 0.01316 inches, but after 1907 became simply 0.013 inches following changes adopted by the American Society of Mechanical Engineers (ASME).

By 1860 the Whitworth thread was in general use throughout Britain and the US (ATKINSON: 131). Four years later William Sellers 60-degree v-thread was proposed as a better alternative, being both demonstrably cheaper to manufacture and fundamentally more accurate than Whitworth's. When the US Navy commissioned an investigation into screw standards in 1868, it found that Sellers' screw, just 3-years old, was far more popular than the Whitworth, established 27 years before. Thus the US Government adopted the Sellers thread as its standard coarse thread and the railroads followed beginning with the Pennsylvania Railroad in 1869 (SUROWIECKI: 2002).

When Stanley began production of the Bailey plane screw threads and standards were definitely among the important production issues for manufacturers to consider; namely which thread standard to choose. Yet even within a particular series, what constituted the 'standard' was in a state of flux. Some sizes could be obtained in as many as five different pitches. The No.12-20 fastener was readily available from stock before 1900, but as the 'standard' evolved it eventually fell into disuse leaving the No.12-24 as the standard ‘coarse’ thread for machine screws of this size. Why did this happen?

The most probable explanation, in my view, is that changes in foundry practice and improvements in metallurgy had an effect on the need for these ‘ultra-coarse’ threads. Remember that for any given diameter, a fine thread has greater holding power than a coarse thread; but a coarse thread provides better tapping performance in brittle material such as cast iron.

So did developments in foundry practice and alloying of cast irons mean that the No.12-20 had simply outlived its usefulness? Well, it is clear that better, less brittle and stronger, cast irons became available from around 1900 and improvements continued to be made through to the 1950’s. These improvements in the performance characteristics of cast iron are attributable to advances in both casting and heat treatment techniques as well as metallurgy.

Similarly, development of better high-tensile steels for fasteners during the same period could, simply on economic grounds, have necessitated a move toward finer pitches that would take practical advantage of a stronger bolt.

Pursuing this line of thought I compared some of the pre-1900 machine screw pitches with those in use since the 1950s and found that for the most part the coarser pitches had been discontinued. The results are reproduced in Table 3. There has been a distinct trend to either add a finer pitch to or delete the coarsest pitch from each size thread. Similar circumstances also rendered the Whitworth thread unsuitable and led to the introduction of the BSF or British Standard Fine series. In addition, BSW was also found unsuitable for screws of less than ¼ inch diameter so a third standard thread, the British Association Small Screw Gauge or BA, was set up (HISCOX & PRICE: 247).

TABLE 3: Selected Screws and Pitches - Pre-1900 and Post-1950

SCREW SIZE	DECIMAL INCH SIZE Pre-1900	Pre-1900 PITCHES	DECIMAL INCH SIZE Post-1950	Post-1950 PITCHES
No.4	0.11048	32, 36, 40	0.1120	40, 48
No.8	0.16312	24, 30, 32	0.1640	32, 36
No.10	0.18944	24, 30, 32	0.1900	24, 32
No.12	0.21576	20, 22, 24, 28, 30	0.2160	24, 28, 32
1/4 "	0.25000	20, 28	0.2500	20, 28, 32
9/32 "	0.28125	24, 26	0.28125	26
No.17	0.28156	16, 18, 20	deleted	deleted

Source: SAUNDERS and Machinery's Handbook

AMERICAN THREADS: Standards vs. Compliance

The American fastener industry began in 1840 when a firm called Rugg and Barnes of Connecticut became the first company to manufacture and sell nuts and bolts. Their success spawned a competitive market with no standards and created a problem; screw threads varied from firm to firm. Reuleaux (1906: 51) explicitly mentions "The confusion in the use of screw threads having become very troublesome in the United States".

In such circumstances it is hardly surprising that in 1864 when William Sellers, the new President-elect of the Franklin Institute, spoke to his proposal for a new system of screw threads he drew a crowd of engineers and machinists keen to hear him; and from all reports he won the crowd over.

Sellers' speech, "On a Uniform System of Screw Threads", was given against the backdrop of the American Civil War and this added resonance to his call for a national standard. Machine tool factories and government agencies soon received word from the Institute urging their adoption of the new national thread standard. His thread form became known as the "Franklin thread," or, more commonly "Seller's thread," and later as the "United States Standard Thread" abbreviated USS. It would also form the basis of the French standard thread, and then of the Système International thread. Finally, in May 1924, it was designated the "American Standard Thread."

Within a month of Seller's speech, a committee of the Franklin Institute (then the professional body for mechanical engineers in America) had weighed the Sellers thread against that of Whitworth and recommending adoption of the former. Yet while Sellers' standard had won the approval of the members of the Institute it was quite another thing to have the standard adopted by industry to "a sufficient degree of precision for practical purposes" (BRITANNIA: 36).

At the time American screws, nuts and bolts were custom-made by machinists. Sellers' proposal seemed rational, but many machinists viewed it as a threat to their way of life. They saw themselves as 'craftsmen'. While many manufacturers adopted Seller's thread form, some did so only partially, rejecting certain key elements of his system, such as the formulas for the size of square and hexagonal nuts and bolt heads. Still others randomly chose to use a different number of threads per inch for certain sizes.

These 'compliance' difficulties are very well illustrated by the problems experienced by the Erie Railroad. The company had adopted the Sellers standard in 1874, but found that by 1876 "some nuts cut at one shop would not fit bolts cut at others" (BRITANNIA: 37). The Erie Railroad launched an investigation and found that this compliance failure was due to the fact that even the makers of commercial taps and dies were working to different standards of length! As "neither the inch nor the gage were known to be accurate measures …. bolts and nuts cut with tools made by different manufacturers were not interchangeable" (BRITANNIA: 37).

The investigators then obtained and tested the most reliable standards of measurement available. Not only did they find that no two standards would agree they also found that the same standard measured by the most reliable machines and instruments then available would not return a like reading. In short there was no standard of length anywhere in America which could be relied upon to give a satisfactory result (BRITANNIA: 38). When The Stanley Works commenced production of the Bailey steel plane around 1869 (see WHITBY), the micrometer calliper developed by Brown & Sharpe had only been on the market for two years and the famous company created by L S Starrett would not exist for fully eight more years. There were no 'international' standards of length (metric or imperial) and earlier errors surrounding the adoption of a length standard in the US would not be identified and corrected till 1896. Broadly speaking, before 1900 what constituted acceptable standards of measurement practice in machine shops and factories bore little or no similarity to those that followed in the twentieth century. The development of the micrometer in 1867 allowed the manufacture of parts to a higher standard than at any previous time. "As in the case of the vernier calliper, the introduction of the micrometer calliper into everyday shop work marked an important step in raising the standard of accuracy." (ROE: 211)

Two formulae were used to determine the pitch or threads per inch for any given screw diameter in the Sellers series. These formulae are reproduced below. The first formula is for threads of ¼ inch diameter and above, and the last (a later modification) is used for screws below ¼ inch:

$$P = 0.24 \sqrt{(D + 0.625)} - 0.175$$

and;

$$P = 0.23 \sqrt{(D + 0.625)} - 0.175$$

where P = the pitch of the thread in inches and D = the diameter of the bolt or screw in inches (see BRITANNIA: 38-40). Hence, if the manufacturer used these formulae, the Sellers standard threads are a finer pitch than standard Whitworth for diameters below 1/4 inch.

In 1907 the American Society of Mechanical Engineers (ASME) – established in 1888- defined two series that used Seller's thread, numbering the sizes by gage numbers from 0 to 30. In the series the major diameter increased by 0.013 inch with each size from No.0 to No.10, and by 0.026 inch between gages above No.10. All these ASME gauges, including the now obsolete threads, may be found by consulting the various editions of Machinery's Handbook.

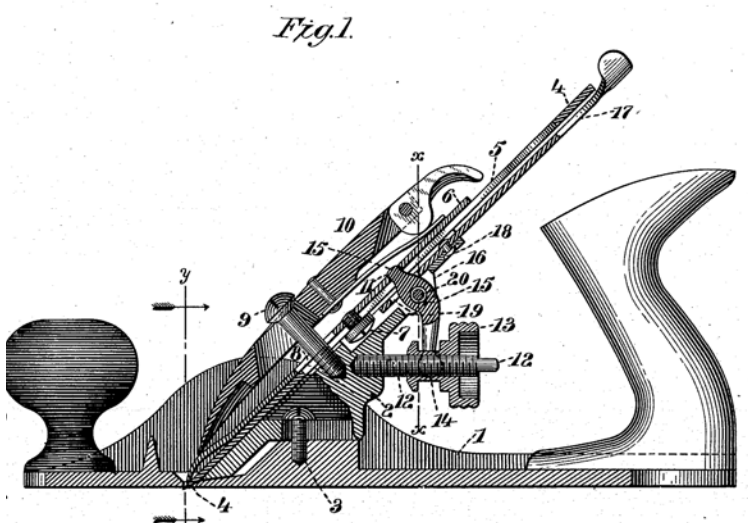

FIGURE 3: Sketch from G D Mosher's design for a plane - US Patent No. 413,300 of 22 October 1889

DISCUSSION OF 'THEORIES'

In the *TTTG Inc. Newsletter* (No.79, October 2004) Bob Crosbie posed a number of questions about the nature of screw threads used in Stanley planes, namely:

- What size threads did The Stanley Works use?
- Did The Stanley Works use standard threads?
- Did The Stanley Works use now obsolete threads?
- Are The Stanley Works threads consistent over time?
- How did The Stanley Works make its threads?

Previous to this Bob had written, "…. Stanley chose threads that were not freely available for sound marketing reasons. Stanley were also excellent production engineers. Even if they made the screws in house the tooling would have been brought in …. I still argue that Stanley used now obsolete standard threads. One thing that stands out from old photos and descriptions of The Stanley Works, and from the planes themselves, is that Stanley had a production line method of assembly. Parts seem to have been stockpiled in large numbers. It would have reduced time, and hence cost, to concentrate on quality control by machining critical parts in house and out sourcing components such as screws. Sargent and Ohio may have followed similar practices. Stanley's edge was in production volume and distribution/marketing."

How right you were Bob. Perhaps I could have saved myself a lot of effort, but the point of the foregoing discussion is really about discovery. Who is right or wrong makes no difference. Our Group is about discussing the use and history of tools; pride or prejudice should have no bearing on our endeavours. So with the foregoing survey in mind it is time to critically examine some of the various theories.

<u>1. The Economic Necessity Theory</u>

Contributors to the *TTTG Inc. Newsletter* have suggested that the explanation for Stanley's 'odd size' threads lay in the fact that some of the cheaper brands of metal plane like Carter would have used a standard Unified National or Whitworth thread for reasons of economy. Well I would have to agree 100% with that. But doesn't this also mean that The Stanley Works would have chosen the thread in its planes for exactly the same reason? The iron laws of economics rule all production and even makers of expensive planes were bound to abide by these laws if they too wanted to stay in business. With due respect to our contributors, we must acknowledge that a key distinguishing feature of a product made to a price rather than one built to a standard is the lack of overall quality in the design and build. Assuming comparable methods were employed in their production, I really fail to see any quality differential between BSW and USS (Sellers) threads.

<u>2. The Plethora of Threads Theory</u>

In the *TTTG Inc. Newsletter* (No.79, October 2004) Jim Davey, a well-know Australian plane fettler and Stanley authority, wrote that:

… I don't believe that Bailey looked up a chart when he was designing the bench plane - he was more likely to reach under the bench, grab the nearest piece of "stuff" that seemed right, …. and whipped up a thread. …I don't think it is right for us modern people to look up a modern chart and try to slot Bailey's threads into it. I think that Bailey was at the end of an era when every trade, town, city etc each had their own threads, TPI, & angles - the rule was: there was no rule..

While I respect Jim's views I find it difficult to accept that the form of a threaded part having been selected merely by happenstance would then remain unchanged for over 100 years.

3. The Brand Interchangeability Theory

Another theory is that Stanley used non-standard screw threads so their parts would not be interchangeable with the parts of other makers. I am certain that The Stanley Works would derive little or no benefit from such a strategy. Indeed, the evidence points to a much more aggressive business strategy than simple thread substitution. In any case when the Stanley 'Bailey' went into production the competition in the metal bench plane market was pretty hard to find!

The critical factor here is the year in which the metal plane first appeared in the tools offered by Bailey and Stanley and other plane-makers. The first offering of the planes appeared in the 1870 catalogue and advertisements of the time confirm that Stanley actively marketed the planes since at least 1872 (see *The Manufacturer and Builder*. New York, Vol.4, Issue 6, June 1872, p.128). Some if not all of Stanley's major competitors did not produce an iron bench plane at that time. For example, the firm of Sargent & Company did not produce a metal bench plane until 1884. So at the time Stanley had few competitors in the metal bench plane market.

Furthermore, Stanley expanded, developed and maintained its market position by aggressively competing for market share and devouring competitor firms. From the beginning, the company's aim was to dominate the market! Stanley was always playing to win and before 1900 the company had devoured several competitor firms, including:

Charles L Mead (successor to E. A. Stearns & Co), 1863;
Bailey, Cheney & Co, 1869;
R. H. Mitchell & Co, 1871;
Leonard Bailey & Co, 1878;
Bailey Wringing Machine Co, 1880; and
Upston Nut Co, 1893.

Leonard Bailey had the unfortunate distinction of being bought out twice. The evidence in support of the 'brand interchangeability' theory seems very hard to find.

4. The Design Purity Theory

Judging by the opinions expressed in the various discussion groups there is a widespread belief that The Stanley Works acquired Bailey's business and kept faithfully producing planes from those early designs.

On the face of it this may appear to be the case; but a lot depends on your definition of design. Sure the overall appearance is much the same, but there is nothing in the patents to suggest that the size of the screw thread was part of Bailey's claim or his design solution. Simple logic would rule out the idea that The Stanley Works would have hesitated for even a moments to change the size or gauge of the screws used on Bailey's bench planes. Being pure to an original 'design' rarely comes into the question of putting a product to market.

For example, I invite anyone to examine patents lodged by Darling or Brown & Sharpe or L S Starrett or any other well-known toolmaker/inventor and not see some difference (sometimes a substantial one) between the patent drawings and the final product as it appeared in the market. Those responsible for getting a tool from concept to design to production to market know that they must get that tool into the hands of the user at a reasonable price. As is pointed out in an early review of the planes; "Mr Bailey has succeeded in presenting … a plane ... at a cost consistent with every good mechanics means" (*The Manufacturer and Builder*. New York, Vol.4, Issue 6, June 1872, p.128). The price must include not just the retailer's mark-up, but the maker's production and distribution costs and a certain level of profit, after tax. Faithful reproduction of a 'design' has very little if any bearing on the outcome. This was true in 1869, and in 1969, and is remains true today.

CONCLUSIONS

The Stanley Works almost certainly used ‘standard’ but now ‘obsolete’ screw threads. Which ‘standard’ they used is difficult to say. While Sellers’ standard was first proposed in 1864 we know that industry in the US had been using Whitworth’s standard since the early 1850s but that Sellers’ threads overtook Whitworth’s becoming the dominant ‘standard’ by 1868. Either way the evidence is heavily weighed against theories running along the lines that Stanley adopted ‘oddball’ threads as a sales ploy or as some bulwark against its competitors.

Of course I am are still now unable to say whether the threads used in the various parts of the Stanley bench planes remained constant over time; this would demand further empirical study of a range of metal planes starting with those produced in 1869 and going through to at least 1920, perhaps even up to the present day.

Jim Davey may well be correct when he says that Leonard Bailey probably just used whatever came to hand as he built his prototype metal bench plane. However, it is most unlikely that he would have gone into production using expensive custom-made parts when both he and later Stanley could have substituted these for a less expensive ‘off-the-shelf’ or stock item.

What The Stanley Works bought when it purchased Bailey’s factory in 1869 could have included jigs and patterns for production of Bailey’s planes. Of course it also purchased the right to use Bailey’s registered patents. Nevertheless, based on what historical information I have found concerning Frederick Stanley and Leonard Bailey, neither man was merely a ‘parsimonious New England mechanic’. True they were careful with a dollar, but they were also astute, business-oriented people keen to exploit every possible advantage they could in order to succeed in a very competitive field of manufacture.

I confess to being amazed by the dogma, perhaps even fierce ideology, surrounding this topic despite its fundamental lack of importance to the world at large. Sure things were a bit different back in the 1860’s but, I kept reminding myself I was dealing with events which occurred during the later part of the Industrial Revolution, not during prehistory!

In part, my aim was to challenge views which were, to my way of thinking, a nostalgic portrayal of hand tools and their respective trades. This leads to a quite unrealistic, and sometimes false, interpretation and understanding of the subject. In large measure this is because it nurtures a perspective which is romantic to the point of being purely sentimental. Consequently, the harsh realities of life, business and work practices in a bygone era are too frequently glossed over, and sometimes even ignored. Such an approach risks rendering the history of tools as a kind of ‘fairytale’ rather than an interpretation of life based on logic and empirical data.

The Stanley plane is not an historic artefact but one of many products which represent a material link back to the beginning of mass production and the manufacturing and management practices of that period. There is no doubt that both Bailey and Stanley embraced mass production and actively participated in its practices. As we reflect upon their individual contribution to the world of hand tools we would do well to remember that fact.

I hope that this article will also shed new light on the subject and stimulate further study and debate; though I doubt the latter is much needed. Hopefully, along the way, it has also demolished a few old chestnuts and had a bit of fun with the mythology of The Stanley Works, and Leonard Bailey's improvements to the steel bench plane.

Encouragement, inspiration and assistance in the preparation of this article were contributed by many people. Special thanks and appreciation must go to Clynt Sheehy, Jim Davey, Henry Black and, of course, Bob Crosbie, President of The Traditional Tools Group. Any failings, omissions or errors are my own.

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NOTES:
Patent drawings and data were obtained from the US Patent Office website at www.uspo.com
US Patent No.1 was issued on 13 July 1836 - it is interesting to trace trends America's inventiveness and industry by comparing the number of patents issued each year.

The author would be pleased to receive readers' views, comments and suggestions concerning this publication. These may be sent to John Bates C/O the Secretary TTTG Inc. PO Box N240, Grosvenor Place, SYDNEY NSW 1220, AUSTRALIA or emailed direct to reproturn@bigpond.com