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Research Note
Knowles' Patent Yarn Balance

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In 1883 Thomas Knowles patented a balance designed to estimate the 'counts' of a sample of yarn without the need for calculations or tables. The balance was based on a clever, but practical, idea, and it was used extensively for well over 50 years. This note explains the essence of the idea, and the background of the people who designed and made the balance.

Introduction

The story of Samuel Crompton's struggle to produce yarn suitable for weaving into muslin and other fabrics has often been told.[1] In his early years he was continually frustrated by the difficulty of spinning yarn that combined strength and fineness, and this led him to design the machine that became known as Crompton's mule. The consequent growth of the cotton industry (in Bolton, for example) resulted from the application of steam power to the mule, following Watt's invention of the separate condenser. It became possible to produce fabric that was cheaper than, and superior to, the Indian muslin then being imported in large quantities.

Thus it was that, from the late eighteenth century onwards, the spinners of yarn and the weavers who used it began to employ various pieces of technical apparatus to monitor its physical characteristics. There were ample opportunities for the leaders of the textile trade in Bolton to make technical innovations, and so improve their products. In this article we shall describe one such innovation.

The system for specifying the fineness of yarn was based on the 'counts'. It has received some attention,[2] mainly because it exemplifies how trade practices can lead to the development of metrological standards that are far from universal. In theory, the 'counts' system is simple: as the name implies, it is only necessary to count the number of hanks of yarn that weigh one pound. In practice, the problem of estimating the counts requires the weighing of a sample of known length, and some nontrivial calculations. For cotton, the usual length of a sample was a lea of 120 yards, seven of which made a hank. A lea was obtained by winding the yarn on a 'Wrap Reel', such as the one illustrated in Figure 3, below, a process that obviously required some skill to produce an accurate sample. The calculations required a different skill, but they could be avoided by the use of standard tables or, as described here, by the use of a balance that gave the answer directly. Several types of balance, with varying levels of accuracy and complexity, were used for this purpose: the one illustrated in Fig. 1 is an example of the type patented[3] by Thomas Knowles in 1883. Despite its sophistication, it was commercially successful, and remained in production until the middle of the twentieth century.

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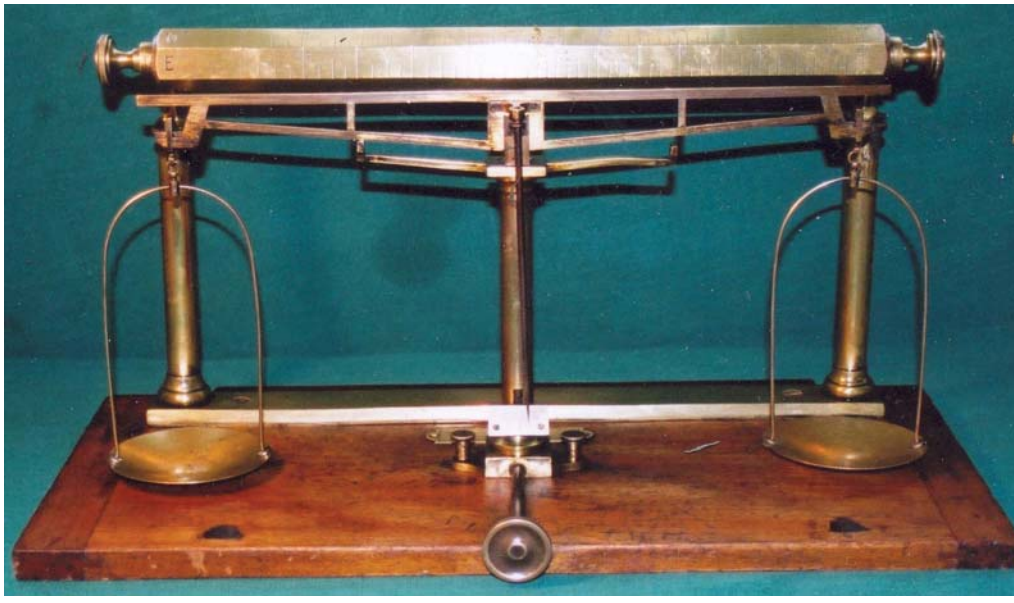

Fig. 1. Knowles' Balance.
Private collection.

The Balance

The balance itself resembles the usual type used for accurate weighing in chemical and physical laboratories. It is made of brass, with a wooden base, and was often supplied with a glass case. The prototype described in the patent specification (Fig. 2)[3] was made by Oertling, the leading London maker of accurate balances, and it is in fact a modification of one of the firm's standard models, the Model O. No examples of this version of the Knowles balance have been seen, although one is illustrated in a book[4] published in 1898.

The balance shown in Fig. 1 is a slightly later version. This version has several innovations not described in the patent, but it retains the major feature for which patent rights were asserted. That was the use of two weights in combination: a pan weight, and a 'rider' weight that slides along the scale beam. The mass of a given length of yarn determined the position of the rider weight, so that the counts (number of hanks per pound) could be read directly from a graduated scale, without recourse to calculations or tables.

In the original patent version there were four scales, each engraved on a separate plate, so that the appropriate scale must be selected and placed in position at every weighing. Also, the rider was located only on one arm of the beam. The later version has (up to) six scales, engraved on the sides of a hexagonal prism which can be rotated to the appropriate position, and the rider weight can be on either arm of the beam. This version was advertised by Oertling in catalogues[5] from 1912 to 1917, 'for the use of Spinners, Doublers, and Yarn Buyers generally'. It was also offered for export. The price

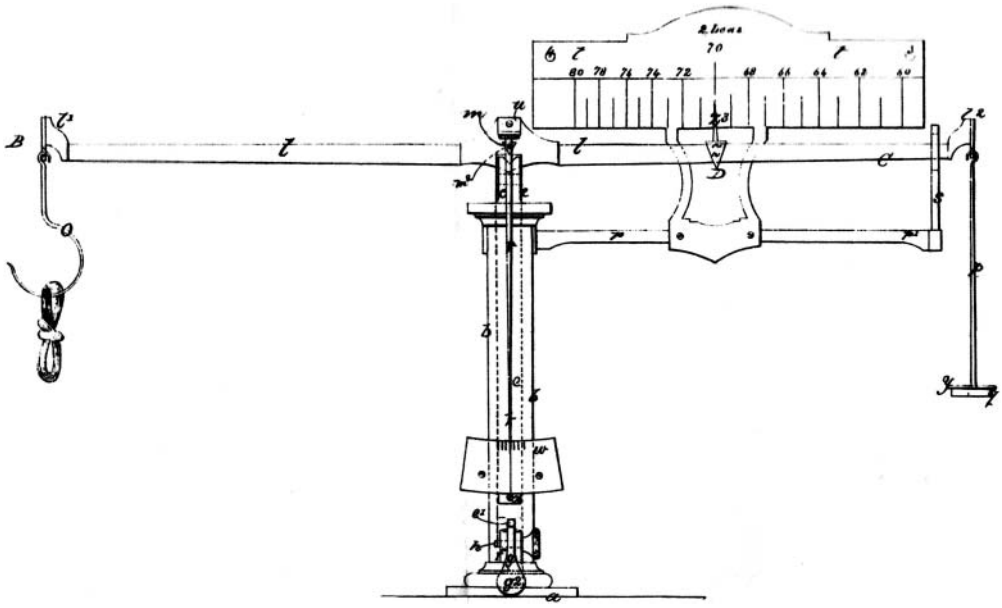

Fig. 2. Drawing of the Knowles balance, from the patent specification.

was fairly substantial: £8 10*s* for balance alone, and £11 with a polished mahogany and glass case and levelling screws.

Most surviving examples were not made by Oertling, but by Goodbrand & Co., a Manchester firm that specialized in cotton-testing machinery of all kinds. Their balance was described and illustrated in 1926 by Curtis,[6] and it was offered for sale up to at least 1947, in the catalogues issued by Goodbrands.[7] No example has been found in the major museum collections, but examples turn up regularly in the antiques trade, and the authors know of several in private collections.

Theory

The Knowles balance was originally designed for the cotton trade. A hank of cotton was 840 yards, and the 'counts' of a sample was usually determined by weighing one or more leas of 120 yards. There are 7,000 grains in a pound, so if one lea weighs N grains then the number of hanks per pound is 1,000/N. In other words, if the counts is X, one lea weighs 1,000/X grains. This calculation is automated on the Knowles' balance in the following way. One lea of yarn is placed in the right pan. For each of the ranges indicated on the hexagonal prism there is a pan-weight (placed in the left pan) and a rider-weight. The rider weight slides along the balance beam, and when equilibrium is attained its pointer indicates the counts.

The masses of the weights can be inferred from the range of counts. Suppose the pan-weight and the rider-weight have mass W and R grains respectively. When both

weights are at the left end, the lea weighs $W+R$ grains, and when they are at opposite ends the lea weighs $W-R$ grains. It follows that

$W+R=1{,}000/X$, where X is the lower bound of the range;
$W-R=1{,}000/Y$, where Y is the upper bound of the range.

For example, if the range runs from $X=10$ to $Y=25$, then $W+R=100$ and $W-R=40$, leading to the values $W=70$, $R=30$.

Because the relationship between the mass and the counts is an inverse one, the graduations on the scale are not equal in length. Presumably the procedure was to make weights according to the rule given above, and then use them to construct a master template. This would be a skilled operation and explains why, in the advertisement by Oertling, one scale only was included in the basic price; more scales (with the appropriate weights) costing 10*s* each. The Knowles balance could be used for estimating the counts of yarns other than cotton, by weighing a different length (for example, 80 yards for worsted). Additionally, the version advertised by Goodbrands in 1947 could be adapted for estimating the counts of rayon in deniers, where the system is direct rather than inverse.

Knowles and Goodbrand

In May 1820, at the age of 31, Robert Knowles was appointed manager of the 'Four Factories' in Turton Street Little Bolton.[8] These factories had been completed in 1802, and were owned by Roger Holland & Co., cotton spinners. In 1822 Holland's son-in-law George Lomas was taken into partnership. In 1835, following the death of Holland in 1828 and his son in 1832, the firm became Lomas & Knowles. This partnership was dissolved by mutual consent in 1838, when Robert Knowles & Sons came into being.

In 1852 the firm was split up. Robert Knowles continued at the Round Hill Mills, and his sons, John and George took over what became known as Peel Mill No. 1. Two more Peel Mills were built in 1855 and 1876–79, by which time Robert Knowles had died and George was running the Peel Mills, with help of his eldest son Thomas. In the 1881 Census Thomas is described as a cotton spinner aged 41, employing 175 hands, and living at 155 High Street, Turton. He is clearly the patentee of the Knowles balance.

The firm of George Knowles & Sons Ltd is described in Worrall's *Cotton Spinners and Manufacturers Directory* for 1891 as cotton spinners, reelers and warpers, at Peel Mills, Turton Street, Little Bolton. They had 133764 spindles, producing 12*s*/120*s* weft and twist and thread yarn, carded and combed. In 1904 all the surviving Knowles concerns were merged as Knowles Ltd, and the firm continued under that name into the 1950s. Two of the Peel Mills were demolished in 1959, the third was taken over by the Bolton Gate Company and was eventually demolished in the 1990s.

The firm of Goodbrand and Holland was founded by Walter Goodbrand and T. E. Holland in the 1860s. Little is known of Holland, but he may well have been related to Roger Holland, the original owner of the Four Factories. Walter Goodbrand was born in Bolton in 1839, the sixth child of John Goodbrand and Nancy Crompton. Nancy was almost certainly a relative of Samuel Crompton, but the precise relationship between them is hard to establish, because the Crompton family was so large. (Between 1762 and

1814 over five hundred Cromptons were christened in the parish church of St Peter, Bolton-le-Moors, where John Goodbrand and Nancy were married in 1827.)

John was listed as a cotton spinner in the 1841 Census, and in Pigot and Slater's 1841 *Directory of Manchester and Salford*. He was presumably the co-owner of the firm of Goodbrand, Baxter & Co. listed in the same directory. But apparently that firm failed, because in about 1847 John and his family moved from Bolton to Salford, and he is described as a Railway Book-keeper in 1851. Goodbrand and Holland appeared in Slater's *Directory of Manchester and Salford* for 1879 at 20 Market Place and the Victoria Works in Dutton Street, New Bridge Street, trading as Engineers, Machinists, and Mill Furnishers. In the 1881 Census Walter was described as an engineer and machinist, living in Barton upon Irwell. By 1895 the works had moved to Southall Street, Strangeways.

An advertisement published in 1900 gives the name of the firm as Goodbrand & Co. and the address as 19 Victoria Street (Fig. 3).[9] It shows several of the machines they produced for the textile trades, including a Wrap Reel, but not the Knowles Balance. At some point after 1909 the factory was moved to the Britannia Foundry in Stalybridge, where they remained until at least 1951. They held several patents, mainly relating to equipment for the testing of yarn, but also for improvements to steam-powered boilers.

Fig. 3. Goodbrand advertisement 1900, from Bradbury's book.

Conclusion

The material prerequisites for the growth of the cotton industry were all present in eighteenth-century Lancashire: cheap and plentiful land, soft water, and coal. Even the proverbial damp climate helped the cotton fibres to cling together, thus enabling them to withstand the stresses imposed by mechanical methods of production. The burgeoning port of Liverpool provided the means of importing the raw material and exporting the finished products. Allied to these economic factors was a supply of enterprising and resourceful men. Many of them took a broad view of their industry, including the need to exploit scientific and technical advances. In the case of Knowles and Goodbrand, we are fortunate to have an ingenious balance to remind us of their technical expertise.

References

[1] Gilbert J. French, *The Life and Times of Samuel Crompton* (London: Simpkin and Marshall, 1859).

[2] N. L. Biggs, 'A Tale Untangled: Measuring the Fineness of Yarn', *Textile History*, xxxv (2004), pp. 121–29.

[3] *Apparatus for Weighing and Ascertaining the Counts or Yarns or Threads*, Letters Patent granted to Thomas Knowles of Turton near Bolton in the County of Lancashire, 3 May 1883, No. 2254.

[4] J. Herzfeld, *The Technical Testing of Yarns and Textile Fabrics* (London: Scott Greenwood, 1898), see fig. 34 on p. 76.

[5] [L. Oertling Ltd, Catalogue 1913], p. 13 (courtesy of B. Oliver).

[6] H. P. Curtis, *The Testing of Yarns and Fabrics* (London: Pitman, 1926), pp. 53–54.

[7] [Goodbrand & Co., Catalogue 1947], p. 54 (courtesy of Tameside Archives).

[8] W. P. Crankshaw and Alfred Blackburn, *A Century and a Half of Cotton Spinning 1797–1947: The History of Knowles Ltd of Bolton* (Bolton: Tillotsons, 1948).

[9] F. Bradbury, *Calculations in Yarns and Fabrics* (Halifax, 1900).

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