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This JOURNAL aims to increase and diffuse knowledge about scientific instruments made and/or sold in the United States. The areas covered include mathematical, optical, and philosophical instruments, early electrical apparatus, sundials and globes.

Articles concerning instruments, instrument makers, or other aspects of the instrument enterprise, as well as book reviews and bibliographies, should be sent to the editor.

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BENJAMIN STANCLIFFE AND HIS SUCCESSORS: A CENTURY OF MATHEMATICAL INSTRUMENT MAKERS IN PHILADELPHIA

Robert C. Miller

Benjamin Stancliffe, fl. 1815-1834 Stancliffe's contributions to the American instrument enterprise began at least as early as 1812-1815, when he worked for Edward Troughton in London, making instruments for the U.S. Coast Survey. F.R. Hassler, the first Director of the Survey, recalled this work in a letter written in 1834:

> In Philadelphia I ordered of Mr. Stancliffe, a mathematical instrument maker, who had already worked on the Coast Survey instruments, under Mr. Troughton, a duplicate of all the tangent and clamping screw arrangement for the main instruments...I ordered also one more plane-table alidade[1]

The *Directory of British Instrument Makers 1550-1851* has an entry for:

> STANCLIFFE Benjamin
> w 1816-1822
> Math IM
> 1816-1822 13 Bennet St., Blackfriars Rd., London
> Apprenticed to STANCLIFFE John, his Uncle, 1796
> Took over from STANCLIFFE John [2]

Gloria Clifton, the compiler of this publication, has recently explained that Benjamin Stancliffe "was apprenticed to John Stancliffe Mathematical Instrument Maker, of Little Marylebone Street, London, on 19 September 1796 for 5 years, 8 months, for a fee of £60." His addresses were taken from *Underhill's Directory of London* for 1816, 1817, and 1822. And, while the first date is probably reliable, the directories were notorious for carrying entries from one edition to the next, "so this evidence may not be incompatible with Benjamin turning up in Philadelphia in 1817." Clifton further noted that the suggestion of the relationship between Benjamin and John Stancliffe "was given by Dr. Chaldicott to Michael Crawford."[3]

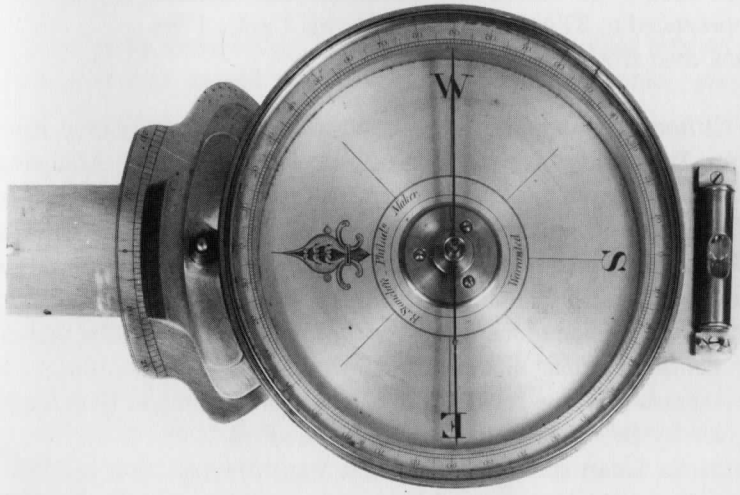
Charles Smart states that Benjamin Stancliffe was born in 1782.[4] In that case he would have started his apprenticeship when he was 14 and completed it when he was 20, and he would have been 30 to 33 years old

while working on the Coast Survey instruments. While we might like to find more links between the Benjamin Stancliffe who was apprenticed to John Stancliffe and the Philadelphia instrument maker, the evidence at hand suggests that the two men were one and the same.

Benjamin Stancliffe immigrated to the United States sometime after the end of the War of 1812, arriving in Philadelphia in time for his name to appear in the city directory for 1817.[5] Listings continued through 1833. With the exception of the first entry, all of Stancliffe's addresses were on or near the block of South Front Street between Dock and Walnut, which was the center of the mathematical instrument trade in Philadelphia from the early 1800s through the 1850s. In 1832, Stancliffe advertised as:

> Stancliffe, Mathematical Instrument Maker, 118 S. Front St. manufactures all kinds of Mathematical, Optical, and Philosophical Instruments, Surveyors Compasses, Theodolites, Sextants, Quadrants, &c.[6]

Several surviving Stancliffe instruments are known. There are two sextants, of 8-inch radius, marked "B. Stancliffe Maker Philadelphia."[7] There are also at least five surveyor's compasses and a small compass that was made to mount on a level bar, all marked "B. Stancliffe Maker Philada" and "Warranted." The larger compasses are well made instruments but of little special note. The small compass, and the documents filed to settle his estate, indicate that Stancliffe also made wye levels.



Surveyor's vernier compass marked "B. Stancliffe Philad[a] Maker" and "Warranted." NMAH.

The two Stancliffe sextants are similar in size and shape to another marked "Lukens Phila" and another marked "W. J. Young Philadelphia"[8] and yet another marked "B. Stancliffe London" which has just come to light,[9] as well as to sextants marked "Cary London,"[10] "Bate London,"[11] and "Berge London late Ramsden."[12] A review of the catalogs of the Peabody Museum,[13] and those issued by Historical Technology, The Antiquarian Scientist, and Tesseract, revealed no other sextants constructed on this same distinctive lattice frame. Despite the many similarities between these instruments, there are a few differences. The Stancliffe Philadelphia sextants, for instance, have graduated scales on inlaid silver, while the Stancliffe London sextant is divided on brass.

In terms of workmanship, the Stancliffe sextants bear little resemblance to the other instruments made by Stancliffe, or by Stancliffe and Draper, and thus I suspect that they were not made in Stancliffe's shop. Nor is it likely that they were made by Lukens, or Young, or any of the Bates' identified by Clifton, or John or William Cary, none of whom are known to have made sextants. Matthew Berge may have made the sextant bearing his name; but since he died in 1819, it is unlikely that he made the instruments that were apparently sold in Philadelphia in the 1820s and 1830s.

Benjamin Stancliffe may have made the B. Stancliffe London sextant while he was still working in John Stancliffe's shop. The four Philadelphia sextants may have been made by someone who operated John Stancliffe's shop and supplied unmarked sextants to the trade. Another possibility is that they were made by Worthington & Allan, who were listed as successors to Berge and who, as owners of Ramsden's dividing engine, were capable of manufacturing sextants. Although Worthington & Allen are reported to have sold sextants, sextants bearing their name are rarely if ever seen.[14]

There is no evidence indicating how many people Benjamin Stancliffe had in his shop. We do know, however, that Edmund Draper served an apprenticeship with Stancliffe before going into partnership with him (see below), and that Hassler's son Edward Troughton Hassler was working with Stancliffe in 1834.[15]

Stancliffe had three patents issued in his name: a valve cock in 1829 (with John Cluley), a valve cock for hydrants in 1827, and friction rollers in 1833. He became a member of the Franklin Institute in 1825; and his "improved turned compass sights" were shown at a meeting of that organization in 1833.[16]

Stancliffe died on Sept. 7, 1834. His wife Sarah settled his debts and other expenses to the sum of $858.50 and, after selling a pocket compass for $18.00, a leveling instrument for $50.00, and a second leveling instrument

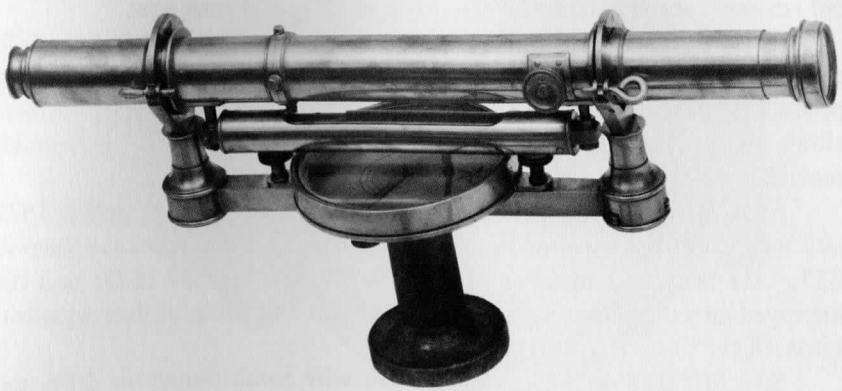
for $125.00, she retained goods valued at $665.50. The plane table alidade that Hassler had ordered in Jan. 1834 was unfinished when Stancliffe died.[17]

Stancliffe & Draper, fl. 1828-1832 The origin of this partnership between Benjamin Stancliffe and Edmund Draper is inferred from a letter from the president of the Chesapeake and Ohio Canal Company to Stancliffe and Draper, written in December 1828, and ordering "two of the best leveling instruments you can make with circumferenter attached to each & with double stands so that the level and circumferenter may be used either together or separately by different engineers at the same time."[18] An undated trade card from the partnership reads:

> Stancliffe & Draper Mathematical Instrument Makers 118 South Front St. PHILADELPHIA Manufacture and carefully repair all kinds of Mathematical, Optical, & Philosophical Instruments, Surveyors Compasses, Theodolites, Sextants, Quadrants, &c.[19]

The two men were still together in 1832, when they won a silver medal at the Exhibition of the Franklin Institute. The citation states:

> Premium No. 17--To the makers of the best Surveyor's Instrument, is awarded to Stancliffe & Draper of Philadelphia, for specimen No. 316, being an engineers level, provided with Mr. William Strickland's divided circle. This instrument is remarkable for the beauty of its workmanship, and accuracy with which it is divided, and fully entitles its ingenious makers to the silver medal.[20]



Wye level with compass below , marked "Stancliffe and Draper Philad[a]" and "Warranted." University of Delaware Archives; Hagley Museum and Library Photograph.

There are about a dozen surviving Stancliffe and Draper instruments, most of which are either levels or compasses. The compasses differ from those marked "B. Stancliffe" only in the signature, and the use of a five pointed star in place of the fleur-de-lis. Some of the levels are equipped with compasses, and some are not.

The one major surviving instrument made by Stancliffe and Draper could be described as an eccentric transit. It consists of a compass box with a 5 inch needle, mounted above a divided plate and arranged to permit the measurement of horizontal angles independent of the needle. There is a bracket attached to the side of the upper plate and centers provided so that a telescope mounted in wyes could be rotated in a vertical plane. An arc of 180 degrees permits the measurement of vertical angles. Both the vertical arc and the horizontal circle are divided in one degree steps, and have tangent screws and verniers that permit them to be read to 5 minutes of arc. The instrument had two straight levels on the upper plate and probably a four screw leveling base (now missing). It may have preceded Young's American transit of 1831, but was not very practical: it was unbalanced by the weight of the telescope hanging to one side; the telescope could not be transited; and, as the repairs indicate, the arm for the telescope, and the construction of the tangent screws and verniers (although typical of those on nautical instruments) were too fragile for use in the field.

Draper's father, John Draper, was a proprietor of Draper & Co., a firm of bank note engravers, and he left an estate valued at over $60,000 when he died in 1865. A possible explanation for the relatively large number of instruments signed "Stancliffe and Draper" is that John Draper financed a large expansion of Stancliffe's shop.

Edmund Draper, fl. 1832-1882 The origin of this business is inferred from a notice in the *American Advertising Directory* for 1832, noting that:

> Draper, Edmund, 80 S. 3d St. Manufactures and carefully repairs all kinds of Mathematical and Optical Instruments, Theodolites Engineer's Levels, Surveyor's Compasses, &c.

This address, 80 South Third, was about two block west of South Front. Draper was listed at Pear near Third (or 25 Pear) from 1839 until 1850; he then moved across the street to 22 Pear, where he remained until his death in 1882. Pear ran from South Third to Dock. When the Philadelphia streets were renumbered in 1857-8, 22 Pear became 226 Pear.

Another early Draper document is a trade label reading:

> Manufactory of THEODOLITES, ENGINEERS' Levels, SURVEYORS' COMPASSES, &c. &c. No. 80 South Third Street...As surviving partner of the late firm of Stancliffe & Draper, he also flatters himself he possesses an additional claim to a share of public patronage, on account of the high reputation universally conceded to their instruments.[21]

In order to make theodolites and transits, Draper built a dividing engine--which, it was said, "amongst those acquainted with it, has a high reputation for accuracy."[22] The one Draper theodolite that I have examined is well built and impressive, but could only be used under ideal conditions.

Draper's transits are relatively simple instruments with flat centers. Three forms have been noted. The earliest and rarest has a single exposed vernier, and the transit detaches from the leveling base as in the contemporary Young instruments. The most common form has a single vernier which can be viewed through a window in the plate, and the leveling base is permanently attached. A more accurate but less common form has pillars for standards, one of which is adjustable for height, and wyes supporting the telescope axis. These transits were attached to the tripod with either a Draper leveling base or a simple round base which was held to the tripod by two capstan head screws. While most of Draper's transits have a 4¾ inch needle, there are rumors of two instruments with 3 inch needles. The signature "Edmund Draper Philadelphia" appears on the compass face of all of these instruments, and north is marked with a seven pointed star.

Draper's surveyor's compasses are usually marked "Edmund Draper Philada" and "Warranted" and, except for a seven pointed star at the north point, are stylistically and mechanically indistinguishable from those made by Stancliffe or by Stancliffe and Draper. The small compasses are marked "E.A. Draper" or "E. Draper." The levels are marked "Edmund Draper Philadelphia" on the level bar. The early ones are mechanically indistinguishable from those made by Stancliffe; the later ones had an improved leveling base and method of attachment to the tripod.

In addition to these standard instruments, I have seen a few particularly notable Draper compasses. These include:

- Two pocket compasses with 2⅞ inch needles in fitted leather cases. These are much nicer than most other compasses of the period.
- A vernier compass with a 3⅛ inch needle, a circular level on the face, and 5 vanes (a set of regular vanes, a set of folding vanes, and a single vane 6 inches high to be used with one of the regular vanes to be used for steep sights. The compass is marked A. P. Gordon, and is provided with a fitted leather case..
- A vernier compass marked "Made for Amasa Holcomb." This has a full 360 degree circle, and brackets for a telescope (missing) presumably made by Holcomb. It was noted at a flea market in Michigan in the early 1970s.

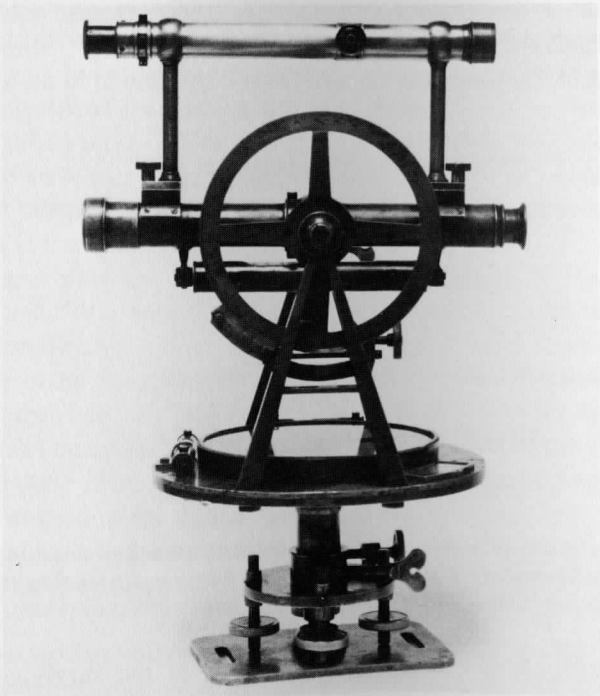
While most of Draper's instruments were sold to private individuals, some were sold to government agencies. In 1840, for instance, while surveying the Texas-Mexico border, Maj. J.D. Graham of the Topographical Engineers used a Draper transit-theodolite to obtain the true meridian; and to determine magnetic variation he used a small Draper theodolite with a 4·½ needle. In 1840, A.D. Bache ordered an instrument "combining compass & graduated circle, with transit telescope & a vertical circle" (which sounds like a complicated description of Young's American transit) for the U.S. Coast Survey. Howard Stansbury used a seven-inch theodolite made by Draper on his exploration of the Great Salt Lake. In 1860, Draper sold a small theodolite and stand for $128.90 to the Northwest Boundary Commission, to be used along the U.S.-Canada boundary from Puget Sound to the summit of the Rockies.[23]

Draper's advertisement from *Colton's Atlas of America. Philadelphia Commercial Edition* (1856). The same illustration of a theodolite equipped with a watch telescope appeared in Draper's advertisement in *Boyd's Washington and Georgetown Directory* (1858).

Serial numbers are found on about half of the surviving Draper instruments. Those numbers seen to date range from 140 to 626. An unnumbered transit with a Draper shifting head (see below) suggests that the

numbering started sometime after 1859. If we assume that Draper began numbering his instruments in 1860 with the number 1 and that all subsequent instruments were numbered, we can conclude that he produced an average of 28 instruments a year up to 1882. This level of production is confirmed by the decennial census of industry, which reported that Draper employed five male hands and produced $8000 worth of goods in 1860, and he employed but two male hands and produced but $4000 worth of goods in 1870.[24] For comparison, both Young & Sons and Heller & Brightly were producing roughly 100 instruments per year during this period.

The claim that Draper invented the surveyor's transit was advanced by Benjamin Smith Lyman in 1900, and has been repeated in recent years.[25] Lyman's claim was based on the existence of an early transit which "according to tradition was made by Draper in 1821, presumably to be used in surveying the Pennsylvania State canals and the Reading Railroad." The claim apparently was not taken seriously by Lyman since he noted that Draper was only 16 in 1821. And it was disproved by Dunbar Scott, who quoted Jay Antrim, Draper's apprentice in 1834, to the effect that "Young's transit was on the market a year before Draper became established."[26]



Edmund Draper transit instrument, serial #140. This is fitted with a full vertical circles, top auxiliary telescope, and Draper shifting head, and was intended for mine work.

Young's American transit was an instrument with which an engineer could measure angles accurately (without the aid of the needle), and run straight lines with a telescope that could be transited. It was simple and rugged and thus, unlike English theodolites, could be used in the field under the conditions that existed on the frontier in the 1830s without the need for special care. The two existing transits made by Young in 1831 are in working order and do not show any signs of any extensive repairs.

Draper introduced a shifting head in 1859.[27] This device--undoubtedly inspired by the shifting head which Young had patented (#20,915) in 1858--consisted of two rectangular horizontal plates, the lower of which attached to the tripod and the upper to the base of the transit. When the two screws holding the plates together were loosened, the transit could be shifted about an inch in any direction, and when tightened it was held firmly in place. This head was preferable to Young's head when it was necessary to place the transit exactly on a line, as was often required in mine work. Draper's shifting head was provided on his own instruments, as well as those by Young & Sons, Heller & Brightly and others on special order into the 20th century.

The often repeated claim that Draper made the first distinctive mine transit about 1850 is probably wrong. The instrument pictured in Scott's publication has a shifting base, and so was probably made after 1858; Young had produced several mining transits by this date.[28]

Draper joined the Franklin Institute in 1825, and became a life member in 1877. He regularly submitted theodolites at their fairs through the 1840s, and was elected to the board of managers in 1849, President pro. tem. in 1852, and recording secretary pro. tem. in 1853.[29] The only other mathematical instrument maker to hold office in the Institute was Charles J. Shain.

The 1837 directory lists "Draper & Knox math. ins. mr" at 60 Dock. This presumably refers to Joseph Knox--a skilled instrument maker who worked for William J. Young until 1850 when he and Charles J Shain, who had served his apprenticeship with Young, formed Knox and Shain--and either Edmund Draper or his brother George. Although George had been trained as a mathematical instrument maker, Edmund refused to recommend him for a job with the Coast Survey in 1844.[30] There are no known instruments marked Draper & Knox, and it is unlikely that this partnership produced very many instruments.

Edmund Draper died in 1882 leaving the bulk of his estate valued at $130,168.18 to his brother Robert. There were $133,346 in stocks and bonds (primarily railroad companies), $5,250 in cash, $387 in furniture at his home, $1,184 in tools and machinery in his shop, Pear and $4000 in real estate. The inventory of the shop included:

1 Vernier protractor	$10
Compasses (various)	39
1 doz. Plumb Bobs	12
7 Parallel Rules	5
1 Dumpy Level	25
9 Telescopes	25
2 Leveling Instruments	100
2 Transits Instruments (unfinished)	100
1 Milling Machine	100
1 Straight line Dividing Machine	75
1 Circular Dividing machine	150
lathes various	97
Instrument for testing Levels	5
Small tools of every description	75

Robert Wareham, fl. 1883-1892 Wareham was born in England in 1825, apprenticed with Draper, and appears as a mathematical instrument maker in the Philadelphia directories from 1851 to 1892. On Draper's death he opened a shop at 402 Locust and advertised as "late foreman for Edmund Draper deceased."[31] A few Wareham instruments are known (including a surveyor's vernier compass with a 5 inch needle and a transit) but none have been examined. Wareham died in 1892 leaving an estate valued at only $838.

Frank C. Knight, fl. 1894-19?? Knight was born in Philadelphia in 1857 and died there in 1923. He is listed in the Philadelphia directories from 1878 to 1896 as an instrument maker or engineer. In 1894 and 1895 he is listed at 402 Locust, apparently having succeeded Wareham at that address. I have found no information indicating the exact date of the end of the firm, or the disposition of its assets. In 1896 Knight issued a 66 page *Illustrated Catalogue and Price-List of Engineering and Surveying Instruments and Materials*. The preface read in part:

> The business to which we are successors, was originated in 1815 by Edmund Draper, under whose ownership and extremely successful management it was continued for over 67 years, during which time he invented many of the most valuable engineering instruments now in use. His establishment was the leading and largest plant of it's kind in the United States. His trade not only extended through the United States, but also largely in Central and South America, while his name was by no means unknown in Europe.

Much of this statement is untrue and, together with related advertisements, has been the source of much historical confusion. Knight was not, for instance, a direct successor to Draper, and the 1815 date, if correct, must refer to Stancliffe's business in England not Philadelphia.

The catalog shows two different classes of transits, both available with a wide variety of options. The Draper Improved Transits, which have little resemblance to Draper's instruments, appear to be long center instruments with two verniers to the horizontal plate, an improved telescope and standards, and a Draper shifting base. The F.C. Knight Transits are nearly identical to the contemporary Heller and Brightly instruments. The Improved Clamp & Tangent that Knight claimed to have invented appears to be identical to the arrangement used by Charles Brightly in the few transits he made after the breakup with Heller in 1891, and suggests that Knight worked with or for Brightly for a few years before taking over the remains of Draper's business. Knight also offered a large variety of levels, rods, mining plummets, and accessories, and the Ayers-Crozet protractor of which he claimed to be the sole manufacturer.

There are two known Knight transits: that with serial number 660 is a Knight pattern, and that with serial number 692 is a Draper pattern.[32] Each is marked "F. C. Knight & Co. / Makers / Philadelphia." Number 660 is also marked, on the underside of the upper plate, "Fred Quednow 1/96 9/03 11/12 7/28/13." Frederick Quednow had worked for Heller & Brightly up through 1892, and later possibly with Charles H. Brightly. His signature indicates that this instrument was made before 1896, and that Knight continued Draper's serial numbers. Like most instrument makers of the time, Knight he did a large repair business. There is a modified B&L alidade with the label in the box which states reconstructed by F. C. Knight.

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1. F.R. Hassler to R. B. Taney, Jan. 9, 1834, in *Principal Documents Relating to the Survey of the Coast of the United States, Since 1816* (New York, 1834), pp. 114-5. See also Anita McConnell, *Instrument Makers to The World A History of Cooke, Troughton & Simms* (York, 1982), p. 19.

2. Gloria Clifton, *The Directory of British Instrument Makers 1550-1851* (London, 1995), p. 262.

3. Gloria Clifton to D.J. Warner, Feb. 9, 1996.

4. Charles E. Smart, *The Makers of Surveying Instruments in America Since 1770* (Troy, N.Y.,1962), p. 157. Smart gives no reference, but he often inferred the date of birth from cemetery records.

5. Stancliffe's name does not appears in P. William Filby and Paula Byers, eds., *Passenger and Immigration Lists Index, 1991-95 Cumulated Supplements* (Detroit, 1995), in P. William Filby, ed., *Philadelphia Naturalization Records, 1789-1880* (Detroit, 1982), or in the 1820 or 1830 census.

6. *The American Advertising Directory for Manufacturers and Dealers in American Goods* (New York, 1832).

7. D.J. Warner, "American Octants and Sextants," *Rittenhouse* 3 (1989): 110.

8. Isaiah Lukens was a clockmaker in Philadelphia from 1811 to 1846; he was elected vice president of the Franklin institute in 1824, and was interested in magnetism and electromagnetism. William J. Young, a prominent mathematical instrument maker in Philadelphia, used the marking W. J. Young from 1825 to 1840. The Lukens sextant is listed in Warner (1989), p. 105. The Young sextant has only recently come to light.

9. *Tesseract* 54 (1996): item 22.

10. *Tesseract* No. 21 item 26.

11. *Tesseract* No. 24 Item 30.

12. *Tesseract* No. D Item 36. This instrument has bridgework over the mirrors, thus giving it the strength of a double frame sextant.

13. M.V. Brewington, *The Peabody Museum Collection of Navigating Instruments* (Salem, 1963).

14. Gloria Clifton, p. 305.

15. For Edward Troughton Hassler see F.R. Hassler, *Documents relating to the Weights and Measures* (New York, 1836), p. 11, quoted in Florian Cajori, *The Chequered Career of Ferdinand Rudolph Hassler* (New York, 1980), p. 179. The only evidence of the apprenticeship appears in Draper's testimony in the trial of in Bancker vs. Young (1835); see copy at the Historical Society of Pennsylvania.

16. *Journal of the Franklin Institute* 13 (1834): 92.

17. F.R. Hassler to M. Dickerson, Oct. 1, 1834: "I had already ordered one [plane table] at Stancliffe's in Philadelphia, who died before doing anything to it."

18. C.F. Mercer to Stancliffe & Draper, December 4, 1828, National Archives, RG 79, Letterbook A, pp. 53-54.

19. This printed trade card, together with a handwritten note reading "Altered & repaired by Stancliffe & Draper July 1830," appears in the box for a wye level marked "W. Davenport Maker Philadelphia" at the Henry Ford Museum in Dearborn, Michigan.

20. "Report on the Fifth Annual Exhibition," *Journal of the Franklin Institute* 2 (1828): 408.

21. One copy of this label appears in the wooden box holding a small unmarked geologist's compass, which was undoubtedly not made by Draper but only imported and sold by him. Draper also used the phrase, "surviving partner of Stancliffe & Draper" in his advertisements in *American Railroad Journal* (1847 and 1849).

22. Alfred Young,"The Invention and Introduction of the Engineer's Transit," *Engineering News* 2 (1875): 154.

23. J.D. Graham, "Observations of the Magnetic Dip, made at several positions...," *Transactions of the American Philosophical Society* 9 (1846): 328-380. A.D. Bache to E. Draper, June 1, 1946, National Archives, RG 23, U.S. Coast Survey papers. House of Representatives. 40th Congress 3d Session. EX. Doc. No. 86, p. 74.

24. U.S. Census of Industry for Philadelphia, 15th District, 5th Ward (1860 and 1870), National Archives, RG 29.

25. Dunbar D. Scott, *Evolution of Mine Surveying Instruments* (New York, 1902), pp. 267-270. Silvio A. Bedini, *Thinkers and Tinkers* (New York, 1975), p. 14.

26. Scott, pp. 298 -299.

27. Scott, p. 275.

28. Scott, pp. 24 and 157. The information was supplied by F.C. Knight.

29. *Journal of the Franklin Institute* 17 (1849): 139; 23 (1852): 212; 24 (1852): 70; 26 (1852): 141.

30. Edmund Draper to A.D. Bache, January 11, 1844, National Archives, Coast Survey papers, RG 23.

31. Smart, p. 153.

32. *Historical Technology* catalog 113 (Fall 1976), item 109; the same item is appears in 115 (Fall 1977), item 276.