The Craftsmanship of the Heller & Brightly Explorer's Transit

by David V. St. John

Photo courtesy of David V. St. John

One example of the instrument's well-thought-out design is the use of captive screws, seen here as a slotted screw and washer on the upper tangent adjustment assembly, so that the component could not be lost during transport or use.

We all know the early excitement of being called to our profession, the first years of learning, the desire to know more, to grow and be productive. Then, as we exercised new knowledge, we became acquainted with the rush of things, the repetition of duties, the mundane tasks, and even boredom. Mixed within the normal "business as usual" there would be the occasional special project that demanded all of our interest and attention. There was excitement, research, new instrument procedures, a higher order of accuracy, special fixtures, a deeper understanding of optical procedures, and a need for increased accuracy.

We can look back on our experiences and remember those special challenges that not only taxed our energy but our intellect. We are better professionals for having had our minds exercised with the new and the difficult. From this vantage point in life, I believe the *special challenge* is the driving force for progress in all fields of technology. Persistent problems demand better methods,

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In this age where data and technology are the most sought after commodities, there is a growing interest in the craftsmanship of the past. Artisans are beginning to hold a respected place in the professional sector. The conservation community has been working to create an infrastructure for its members by establishing standards for restorative work and forming organizations through which conservators with different areas of expertise can meet and form professional relationships.

As the years passed by, apprenticeship was phased out since it must have seemed futile to spend years studying the techniques of the past that were thought inferior, when the goals and dreams of the twenty-first century were the driving force for the majority of the population. However, as the work of early apprentices is being collected and is in need of restoration, knowledge of early methods is critical. It is no longer necessary to hand-tool components, to record measurements painstakingly and work through mathematical equations; computers run machines that determine the dimensions of parts and can produce many of them in a fraction of the time that it took the instrument maker and his pencil to work through mathematical formulas. Today, while it may be possible to produce hundreds of one instrument in a matter of weeks, there is no longer the same level of craftsmanship. How many people today could properly build or restore an instrument such as the Heller & Brightly Explorer's Transit? Those who enter the fields of machining, engineering, and instrument production lack the knowledge of their ancestors, for they have been specifically, rather than comprehensively, trained. It would likely take several people working as a team to restore the work that a single craftsman performed without the aid of technology. Unfortunately, the United States embraced these mass production theories, and thus lost a great part of its heritage. There is a strong need for a revival of an apprenticeship model of training in instrument making if we are to retain any sense of the history of the craft in the approaching century. ▲

Hilary Nieukirk is currently a sophomore at Smith College in Northampton, Massachusetts, where she is studying English in pursuit of a photojournalism career. This last summer she worked for David V. St. John at Benchmark Instruments, Franklin, Massachusetts, performing office work, technical photography, and writing-related tasks.

Photo courtesy of David V. St. John

From a top view of the instrument one can see the capstan adjustment screws for adjusting the reticle and stadia. The single slotted pilot screw allows relatively quick removal of the telescope assembly for repair.

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new equipment, and a higher order of accuracy, which, in turn, expand our manufacturing base and create new jobs.

At one point in my career, I began to look back at the history of instrument making in this country. I had been designing optical tooling and alignment equipment for many years. I had also rebuilt large numbers of typical surveying instruments and seen more than a few thousand by that time. Standing by the doorway to my lab one day, I watched the last European instrument maker being led from his bench by fellow workers to be taken home. He passed on a few days later. Being in the plant alone one night, I stood in the same doorway, viewed the instrument assembly area, and realized that I was the only one left who cared about the knowledge of "Old World" techniques. It was then that I changed direction and began to preserve and restore early American scientific instruments.

Part of my work has involved creating standards for the conservation of American surveying instruments, which continues to be an expanding project. Designing special tooling, building workstations, documenting procedures, and developing a training program have consumed more than 17 years. Even as this article is being written, a fully developed *apprentice program* is being approved by the Department of Labor and Industries, Commonwealth of Massachusetts (Ms. Gayann Wilkinson, director). Hopefully the program will be replicated in other states.

Although each assignment I receive is important and the work is performed to a standard, there are some operations that have long become mundane. When each assignment is completed, the instrument matches the work of the original maker and there is satisfaction. However, it is still a transit, octant, sextant, or a level of some sort—so much of the effort falls into "business as usual."

There are exceptions, though, such as the Heller & Brightly Explorer's Transit featured on the cover of this issue. According to Charles Smart in his book *American Survey Instrument Makers*, Charles S. Heller and Charles J. Brightly formed Heller & Brightly, of Philadelphia, Pennsylvania, in 1870. Brightly, originally from England, retired from the company in 1889. Heller, a native of Philadelphia who had a background in making surgical instruments before forming the company, continued the business until his death in 1912.

The five-pound instrument stands 7.125" from the footplate to the center of the telescope. Because of its size, compactness, and light weight, it is likely that the transit was used by explorers who were making maps—a service that came to be more highly demanded after the Civil War. Specifically designed for hard service, it was easy to maintain, could be repaired in the field, and certain components were reinforced to enable it to withstand rough treatment.

The horizontal circle has a reading edge of 3.687" and is equipped with double opposite verniers reading to one minute. The vertical arc is graduated to one minute with a range of ±30 degrees. One unusual feature is a totally enclosed horizontal circle with external tangent adjustments. Enclosed circles began to show up on a commercial basis in the late 1940s with resist-etched glass graduations filled with titanium dioxide. This procedure of making permanent markings on glass basically involved coating the glass with a waxlike substance (called a resist), using a diamond to etch the markings onto the glass through the resist surface, exposing the etchings to chemicals, then stripping the resist. As the process developed to a photographic resist with chrome-line deposition, where a contact print of the markings was made with a glass negative and developed like film, then made permanent and durable through a chemical process, the European theodolite appeared. With further economy of mass production, the enclosed transit came to the open market and the American Open Engineer's Transit was virtually eliminated.

The telescope features an objective that is exterior focusing and an erecting eyepiece, both of which adjust

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Photo courtesy of David V. St. John

The telescope axis features V grooves that fit precisely into matching V grooves on the A-frame standards. This set-up allows the telescope to rotate without any left or right movement.

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by rack and pinion. The unit is equipped with adjustable stadia. Another unusual feature is the assembly of the telescope to the trunnions. There is a line-fitted bore that is matched to a mounting sleeve on the telescope and once inserted the assembly is held in place with one pilot screw. The bore is so precise that an instrumentperson could simply rotate the telescope to center the reticle before collimating the instrument. In the event of field damage, a spare telescope could be installed, calibrated, and the transit returned to service within a matter of an hour. The telescope objective is an air-spaced doublet (a compound lens made of two glass elements, separated by silver shims that results in an air space between them, that were hand shaped and matched to reduce aberrations) with a clear aperture of $13/16$", which would technically provide approximately 5.5 seconds of resolution on axis. Even as an aberration-limited system, due to the inaccuracies of the hand-created surfaces, this small telescope can read $1/32$" at 100 feet.

Although the A-frame standards appear to be fragile, they are formed as a segment of a cone. They are very light, but extremely stiff and can easily withstand normal field abuse without disturbing the centerline of the telescope over the vertical axis. The A-frame standards are made more rigid by being fitted to the V-shaped axis on the telescope, similar to W. & L.E. Gurley and Buff & Buff instruments.

The lower portion of the instrument fits into a removable leveling base similar to the present-day tribrach. Supposedly, for compactness in transport, there is a place for two units in the carrying case, which gives rise to the question of surveying technique or just a spare assembly?

The maker was thoughtful in terms of captive screws and lock screws on motions so that components could not be lost during transport or use. Fine adjustments could be easily made with a simple screwdriver and a small pin wrench.

The compass features typical hand engraving and bears the serial number 4712. The unit is not equipped with a variation ring. The compass needle is 2.250" long.

Beyond the innovation in design, there is solid indication that "Heller & Brightly" had command of the casting process. Every component is free of blowholes or discontinuities. There are no rough edges, fine sand was used in the casting process, and all machined surfaces are at least 32 microinches or better. The instrument is deburred (removing the sharp, ragged burrs on edges that result from cutting, drilling, or casting) on all edges, inside and out. All holes and threads are chamfered (having an edge or corner cut flat). The knurling (notching of knobs) throughout is superior. The entire instrument is a testimony to the engineering and craftsmanship of "Heller & Brightly." ▲

David V. St. John is owner of Benchmark Instruments, Franklin, Massachusetts, an instrument repair and restoration business that he started in 1980. In 1990 he retired from Berger Instruments, Boston, Massachusetts, after 32 years of service as principal designer of optical alignment and geodetic instrumentation. His daughters, Laura Carroll and Theresa St. John, who have both learned to restore instruments, also help their father with documentation and other restoration tasks.

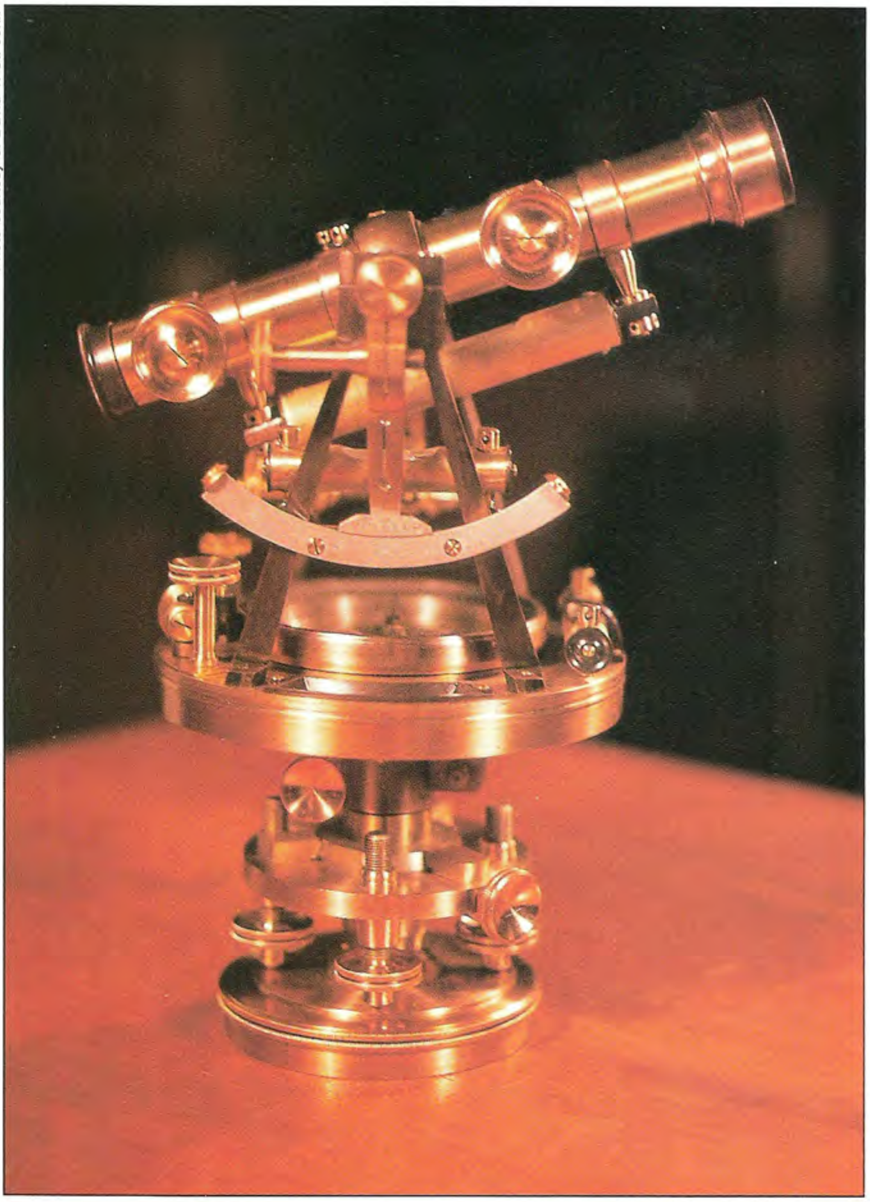


Photo courtesy of David V. St. John

Preserving History Through Conservation

by Hilary Nieukirk

"The Heller & Brightly Explorer's Transit is an especially fine piece, a tribute to its maker.**"**

The Heller & Brightly Explorer's Transit (left), as restored by David V. St. John and Hulio Henriquez, working under an apprenticeship program. Because the instrument stayed in the possession of one family, it had been well cared for (below), compared to other early American surveying instruments St. John has seen.

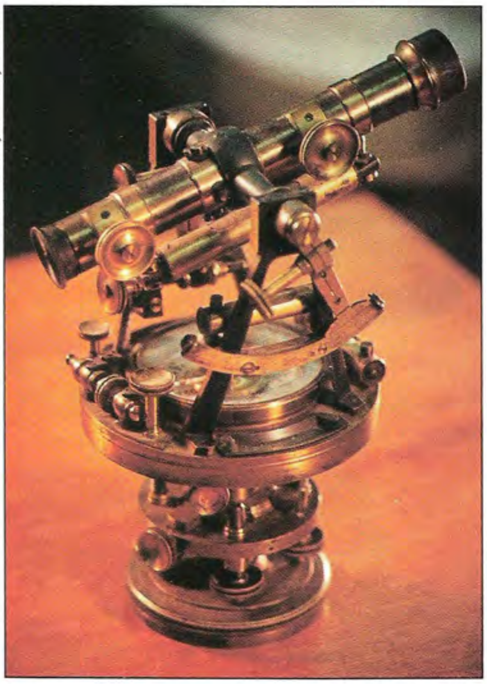
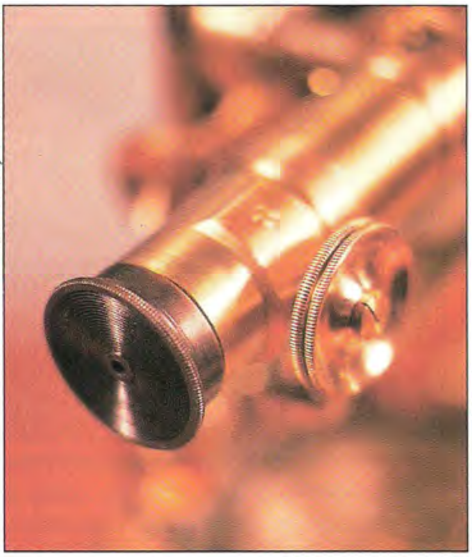


Photo courtesy of Hilary Nieukirk

Within the conservation community, there are two schools of thought concerning the treatment of artifacts. One group believes that restorative workers should preserve utilitarian pieces in their present state after stabilizing any active deterioration. The other believes that utilitarian pieces should be restored to their original state without being improved upon. One of the best-known examples of this debate is the Sistine Chapel restoration. When the work was proposed a protest arose from those who felt that the fresco should remain untouched, despite the effects of time. Each side presented a solid argument that made it difficult to determine the proper course of action. In the end, the restoration was performed, although some still claim that it ruined the integrity of the masterpiece.

The restorative community concerned with scientific instruments and surveying equipment is often faced with this type of dilemma. However, the restorers must ask themselves different questions than a museum curator or an art historian would ask. Whereas a curator would not ever suggest that new arms be crafted for the *Venus de Milo*, it is reasonable for an instrument collector to commission work that would return an instrument, such as the Heller &

Photo courtesy of David V. St. John



The superior knurling (notching of knobs) on the instrument, which can be seen on the edge of the eyepiece cap (left) and the focusing knob (right), is a unique characteristic of the instrument maker.

Photo courtesy of Hilary Nieukirk

"Knowledge of early methods of craftsmanship is imperative."

Special tools, such as this forked screwdriver that was used to remove slotted nuts on the A-frame standard assembly, are required for disassembly so as not to damage any of the precisely fitted components.

Brightly Explorer's Transit, to working condition. Both of these artifacts are examples of fine craftsmanship not often found in our modern world, yet they were crafted for very different reasons. The *Venus* is purely aesthetic, whereas an antique surveying instrument is still a functional piece, no matter how long ago it was designed. In fact, an instrument serves a greater purpose to the conservation community in working condition, because it can be compared with modern pieces and the techniques of its fabrication can be researched.

In order to restore an instrument to its original state, it is essential to have an understanding of early methods of craftsmanship and a sense of the history of the instrument maker, so his individual style and innovative work are preserved. Knowledge of early methods of craftsmanship is imperative, for a restorer by definition should not improve the original work through modern techniques. This restoration process is difficult as the restoration community of the United States is less developed than that of other nations. Standards have not been established for much of the work that restoration entails, and what technical and historical information exists is not widely circulated. This means that within the community there are people performing restorations who are unfamiliar with current conservation practices. In addition, some collectors have little knowledge of proper methods and request features such as "polished" surfaces on finished instruments. In performing this task, the untrained technician could potentially eradicate important clues, such as traces of the original finish, evidence of intermediate work that was done on the piece, and corrosion products that can be analyzed to determine patterns of use and/or storage. Any of these clues could help the educated restorer gain insight into the lives of the crafters and owners or the history of instrument making through analysis of the methods used in crafting the piece.

Another example of potential damage caused by untrained technicians concerns patina. In layman's terms, a patina is the sheen of a surface caused by age. In technical terms, it is corrosion upon copper or copper alloys caused by oxidation. A patina is highly desirable to a collector, for it is an indicator of age. However, it is not always an accurate indicator of age since patinas can be produced artifically—not an uncommon process in the antique trade, or among clever restorers. It can be a treatment requested by

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Photo courtesy of David V. St. John

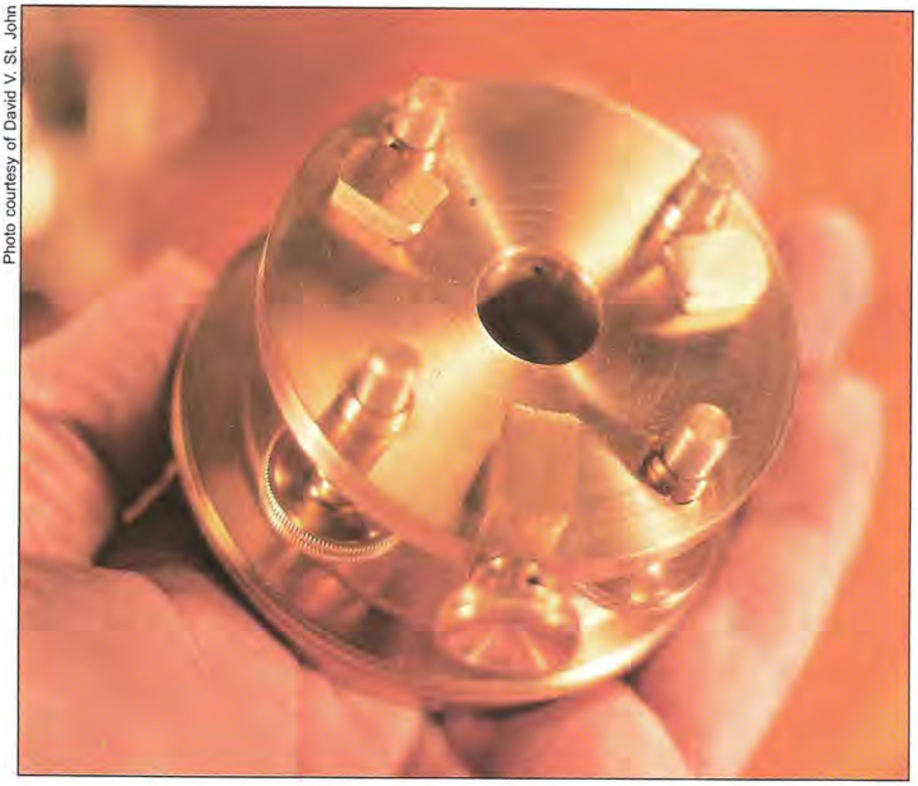

Photo courtesy of Hilary Nieukirk

The removable lower assembly of the transit, as seen after (left) and before (above) restoration, is an unusual feature for this type of instrument and appears to be a precursor of the tribrach.

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collectors so their piece looks "authentic." The corrosion of a patina is different from the corrosion caused by sea water; however, one can mask the other. When this destructive corrosion exists, neutralization is necessary. This neutralization is accomplished using the chelation process, which removes corrosion products and makes visible any damage they have caused. The clever restorer would perhaps perform the chelation process and then artifically create a patina. To this untreated surface, the educated restorer would apply only what had originally been applied—a protective transparent or colored lacquer, in most cases. An authentic patina is produced by wear and time exclusively.

Though early craftsmen did not have the technology used to produce instruments today, they were highly skilled and many of them made advances that were years ahead of their field. These crafters had few, if any, drawings from which to work—they had to create the components out of raw materials, and there were but a few machines used in instrument fabrication. Their instruments provided a solid base for generations of instrument making that developed into their modern counterparts. These men designed, crafted, and assembled each component of their work. They had a broad base of expertise—engineering, optics, mathematics—and a strong sense of aesthetics. Each of their instruments was assembled using a precise pattern to guarantee proper function. This pattern consists of a series of points and slash marks, called "telltales," that are found on an instrument's components. Telltales match identical markings on the screws, so an exact alignment is guaranteed during assembly. Without these marks (or if a restorer or repairperson is ignorant of these marks) damage or misfunction of an instrument could occur. It was discovered during disassembly of the Heller & Brightly Explorer's Transit, performed by David V. St. John, owner of Benchmark Instruments, Franklin, Massachusetts, an instrument repair and restoration business, and Hulio Henriquez, working under an apprenticeship program, that its crafter was so exacting as to make marks on the face and the underside of the compass plate.

Telltales are also an important part of the instrument for a nontechnical reason. Much like the maker's signature, they remind us that the piece is the work of a person (or people) rather than a machine. Hand-tooling is to be admired for the sheer amount of precision, knowledge, and patience it requires. However, it is also feared by the modern crafter, as the tools used to disassemble an instrument must fit perfectly or the components could retain damage, which in turn would damage the instrument. Thus, it is not uncommon for crafters to modify their tools, by filing them down, or to own tools specifically for this sort of work, such as spanner screwdrivers.

As mass production did not exist in the early years of instrument making, crafters were acquainted with their clients and they innovated their style according to the clients' needs. Each maker had characteristics that were unique to his instruments. Sometimes the work of one maker could be identified simply by looking at the lacquer, knurls (different kinds of notches on an instrument's knobs), or chamfers (flat surfaces, usually cut at 45° angles, on edges or corners of objects). These characteristics were appreciated, and often later adopted, by other craftsmen, for in earlier times craftsmen complemented each other's work rather than competing with it. During the restoration process these clues can be used to determine if another company's parts had been used to replace original components in repaired instruments.

Around the turn of the century, the demand for instruments grew and certain elements of crafting evolved into production. These machine-produced parts were designed in the style of a specific maker so they were not entirely

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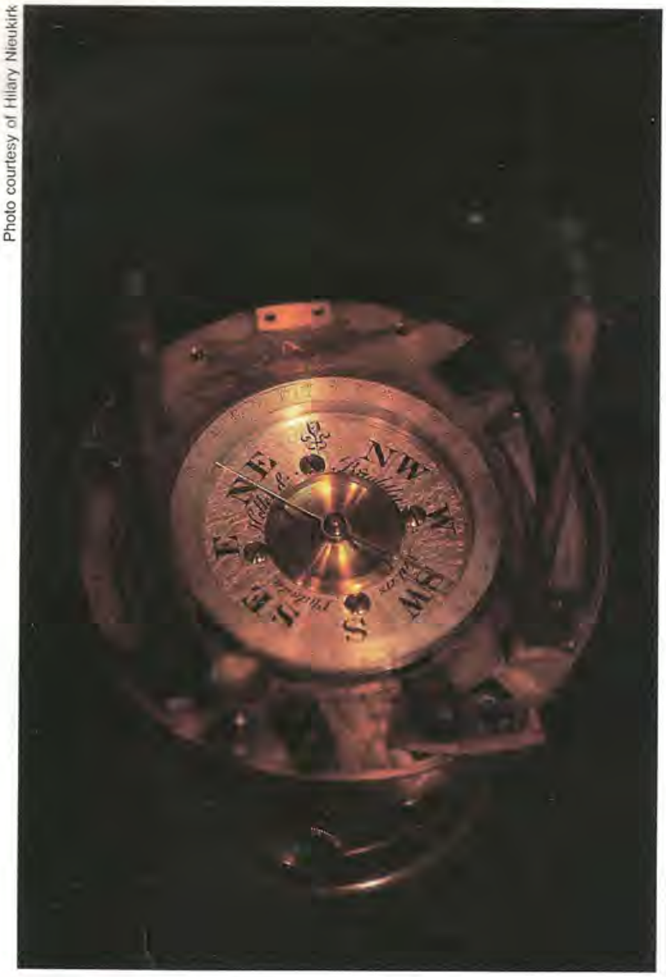
Photo courtesy of Hilary Nieukirk



The compass plate shows the fine scrollwork and engraving—ornamentation no longer found on modern surveying instruments. The totally enclosed horizontal circle, another unique feature, did not appear on a commercial basis until the 1940s.

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without the individual characteristics of hand-tooled components. This was "mass production" in terms of hundreds, rather than thousands, and cannot be equated with the machine-generated parts of the Industrial Age that bear no mark of individuality. Eventually instrument manufacturers brought over instrument makers from Europe when a large percentage of machined parts were found to require custom fitting.

The Industrial Age marked the replacement of aestheticism with utilitarianism. Early instruments used precisely tooled fine metals such as silver, brass, and bell metal. Even if an instrument had a colored lacquer, the surface of the metal beneath was free of visible defects. Around the turn of the century, in order to cut costs and speed production, instruments began to be made of lightly snagged sand castings, instead of the craftsman's perfectly finished castings, and coated with textured paints to mask the rough surface finish.

The Heller & Brightly Explorer's Transit is an especially fine piece, a tribute to its maker. According to the marks made on the underside of the compass plate, the transit was crafted by an "R. Schubert" in September of 1892. However, this date "9/92" also could be a repair date. The instrument is visually appealing with its original brass finish—a trait unique to its crafter (many instruments were colored and then hand-lacquered)—and its delicate size. At 7¼ inches, it is one-third the size of similar engineering instruments and 1½ inches smaller than the smallest instrument made by C. L. Berger & Sons, Boston, Massachusetts. However, despite its appearance, it is a rugged piece, fit to endure the rough handling of transport and surveying. Another unique feature is the removable lower assembly. Was this done to make the instrument more compact for transportation, or to make it easier to use for surveying? The latter is most likely true, as it appears to be the precursor to the tribrach of modern instruments. The disappearing stadia of the telescope was an important advancement, but was most likely copied from W. & L.E. Gurley of Troy, New York. The externally focusing telescope removes easily with the loosening of a single screw through the trunnions for maintenance and repair purposes. Though it is on a reduced scale, the vertical arc is graduated to one minute with a range of ±30°.

One loss to utilitarianism is ornamentation, which is simply not found in modern-day production. The disparity between the instruments of the past and those of today is even reflected in language: "production" rather than "crafting." Not only were early instruments works of art, so were many of the components. The transit's compass plate is one such example of this attention to detail. A pattern of fine scrollwork is seen beneath the eight directional indicators and the inscription "Heller & Brightly Makers Philada." Nowadays, background decoration is not used and engraving is the bare minimum: the company's name and four letters for the cardinal points in the simplest of fonts. Each of the transit's plate embellishments, such as the fleur-de-lis (a stylized, three-petal iris) at the north axis, is an accomplishment, for engraving required a different tool for each type of line—the same tool could not even be used to reverse direction over the same line.

Despite its innovative characteristics, the transit is not perfect; errors exist in all instruments. An early instrument maker was concerned with excellence of the craft as a whole, as well as accuracy of the individual piece. The "imperfections" of the Heller & Brightly Explorer's Transit are certainly a result of the time period during which it was made. In the early nineteenth century brass was such a precious commodity, because of restrictions on its import, that townships would often purchase it collectively to produce an instrument for common use. Discarding any piece of it was unheard of, which is evident when looking at the vertical vernier assembly casting in which there is a visible fracture. Although the piece is visually flawed, it functions properly. Another imperfection is found on the vial housings: one has a large pinhole, the other has an external line where the metals were soldered. The transit was built before the extrusion process (shaping metal by forcing it through a die) had been developed, thus the craftsman had to create the tube-shaped housing by rolling a sheet of metal using progressively smaller rollers until it was the right size, forming a disappearing soldered seam. This process cannot create a seamless piece like the extrusion process.

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