ALUMINUM TRANSITS

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Since surveyors carry their instruments into the field, they want them as light as possible. One way of decreasing weight is through structural design. Another is to decrease the size. A third approach is the use of lighter material. Aluminum was the first light metal to be discovered.

Friedrich Wohler, a German chemist, extracted a small quantity of aluminum from clay in 1827. In 1845 he produced enough aluminum to demonstrate its lightness and malleability, inspiring others to try to produce aluminum in commercial quantities. Although the price of aluminum dropped somewhat, the metal remained costly, and its use confined to ornamental and luxury articles. In 1886 Charles Martin Hall (U. S.) and Paul Louis Toussaint Heroult (France) independently discovered direct electrolysis, the process which has been used ever since to produce metallic aluminum. The price of aluminum dropped markedly, and its availability surged.[1]

The first suggestion that aluminum would offer significant advantages in engineering and surveying instruments seems to have been made in 1868 by "Aluminist," a civil engineer and surveyor in Helena, Montana, in a letter to the *Scientific American*. Using Gurley's telescope compass as an example, "Aluminist" claimed that aluminum construction would reduce the weight from 12 to 3 pounds, and increase the cost by about $32 (aluminum at $1 per ounce). He felt that the benefits outweighed the costs.[2] In response, *Scientific American* reported on the manufacture of aluminum, stating that "no cheap way of producing it is yet discovered."[3]

Louis Berger, an instrument maker in Roxbury, Mass., addressed the issue the following month. He had achieved substantial weight reduction through structural design, and felt that the use of aluminum, leading to further weight reduction, would impair the stability of the instruments. He also recommended against using aluminum for screws. These, he wrote, require great strength, and should be made of German silver. Aluminum had, however, proved superior to brass in some situations. T. Cooke & Sons of York, England had used aluminum in their astronomical instruments, and were constructing the heaviest parts of transit telescopes of a compound of aluminum and copper.[4]

W. & L. E. Gurley exhibited an aluminum transit at the Centennial Exhibition held at Philadelphia in 1876. Gurley was pleased with the new material, claiming a 50% weight reduction over the brass equivalent. Bearing parts were made of bronze--the problem of different coefficients of expansion seems to have been ignored. The Gurley catalog did not mention the availability of aluminum transits until 1894 or 1895, when they claimed that they had been making them "to order only" for 20 years.[5] It is not clear why Gurley waited so long to make this announcement. The price for aluminum transits was about 50% greater than for brass.[6]

Gurley, Keuffel & Esser, Buff & Berger, and Queen all exhibited aluminum instruments at the Columbian Exposition held at Chicago in 1893. All stated that they would make aluminum transits upon request, and all, except Gurley, cautioned against their use. They offered these various reasons:[7]

1. Lightweight instruments are subject to vibration from wind, traffic, etc.

2. Divisions on aluminum are difficult to see. However, since instrument makers frequently engraved angular divisions on silver, which was either plated on or set into the brass limb of the transit, this objection is not credible.

3. Aluminum is soft, and it wears poorly. Hence transits must include brass or bronze parts. This combination of dissimilar metals with different coefficients of expansion could result in distortion under different temperature conditions.

4. The actual weight saved turns out to be relatively minor--perhaps 10% of all the weight a surveyor must carry into the field (box, tripod, chain, etc.).

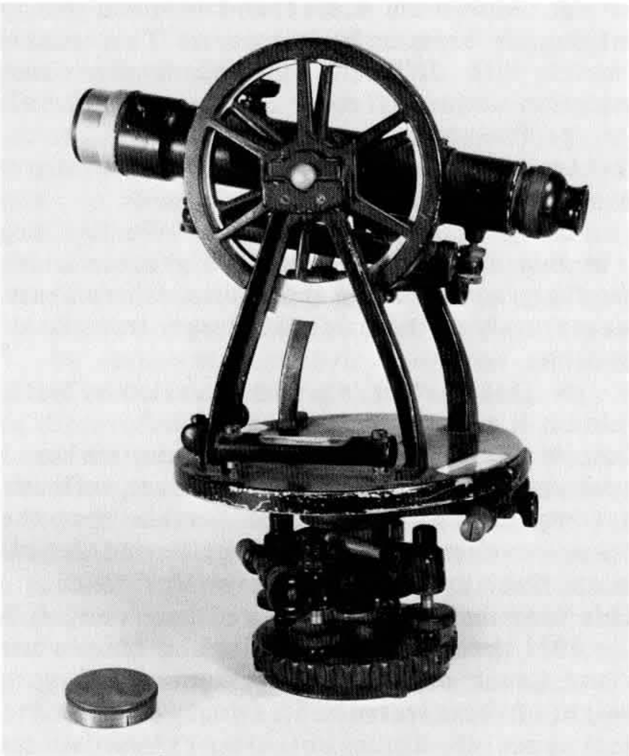
5. All the makers, except Gurley, urged their customers to buy smaller transits if lightness is imperative, claiming that the graduations on the smaller instruments could be read just as accurately as those on their larger transits. This again is hardly credible.

6. One further drawback, raised by Buff in 1907, is that aluminum is susceptible to magnetism.[8]

Despite these arguments, instrument makers regularly offered aluminum instruments such as sextants, reflecting circles and pocket compasses. They stated further that they would monitor future developments of aluminum and its alloys, and promised to use these materials whenever warranted.

This promise was first honored by Young & Sons, who announced in 1911 that they were making the "non-working parts of Transits and Levels of a patented aluminum alloy, which reduces the weight of these instruments twenty percent...." They had been skeptical about aluminum but, after exhaustive tests by the U. S. Government and others, "Young & Sons have confidence that our instruments [are] the lightest, most rigid and durable engineers instruments."[9] It is reasonable to assume that the new alloy was duralumin. An alloy of 90% aluminum, with magnesium and copper comprising the remaining 10%, duralumin had been introduced by A. Wilm of Berlin, and used in Europe for airplane engine parts.[10]

In 1925 Gurley announced that aluminum alloys such as lynite "permit improvements in manufacturing practice and result in simpler, light weight transit designs, with fewer parts, greater rigidity and more permanence of adjustment. Moreover when properly heat-treated these alloys have tensile strength and hardness near that of structural steel, certainly more than brass or bronze."[11] Lynite is 90-95% aluminum, with the remaining portion copper. Instruments of this material were said to sustain less damage from accidents than those of bronze. Gurley used lynite forgings for the vertical and horizontal limbs of their transits, and claimed that, unlike silver, they did not tarnish. After 1929 Gurley offered transits whose "design is such that the most suitable metal is used for each part."[12] In 1936 Gurley began regular production of transits of aluminum alloy.[13]



Engineers Light Transit made of lynite by W. & L. E. Gurley. The serial number, 3028, indicates this was made in 1930. Now in the Division of Physical Sciences, National Museum of American History.

At the start of World War II the military was in need of surveying instruments. Public appeals were made for privately owned instruments, and local commands were authorized to buy, borrow or lease transits from individuals.[14] In 1941 Gurley received a development contract from the Army Corps of Engineers for two transits graduated to 20-seconds of arc, and equipped with lights for night-time observations. In 1943, because of the development contract, Gurley was the only manufacturer geared up to produce the required instruments in quantity. Gurley sold the army its entire annual output of transits--more than 2500 instruments.[15] Although the army's specifications called for brass Gurley obtained a variance and delivered aluminum. Field reports indicated that the aluminum transits did not perform well. Typical failures included binding of spindles, eccentricity, binding of microscope assemblies on their tracks, and scored verniers and limbs. The Corps of Engineers procurement officer suggested that "the continuous and consistent complaints on instruments not made to specification indicate that increased efforts should be made to obtain instruments complying with specifications."[16]

Since Gurley continued to make aluminum instruments until the end of 1980, the army's experience with their instruments may well have been related to the way the army handled its transits. Now a division of Teledyne Corporation, Gurley no longer makes instruments, but sells instruments imported from Japan.

1. Joseph W. Richards, *Aluminum: Its History, Occurrence, Properties, Metallurgy and Applications, Including its Alloys* (Philadelphia, 1890).

2. *Scientific American* 18 (1868): 3.

3. *Ibid.*

4. *Ibid.*, p. 292.

5. Gurley, *A Manual of the Principal Instruments Used in American Engineering and Surveying* (Troy, N. Y., 1895; possibly 1894, but I have not been able to see this edition).

6. personal communication with A. Gutermatch of Teledyne-Gurley Corp., Oct., 1985.