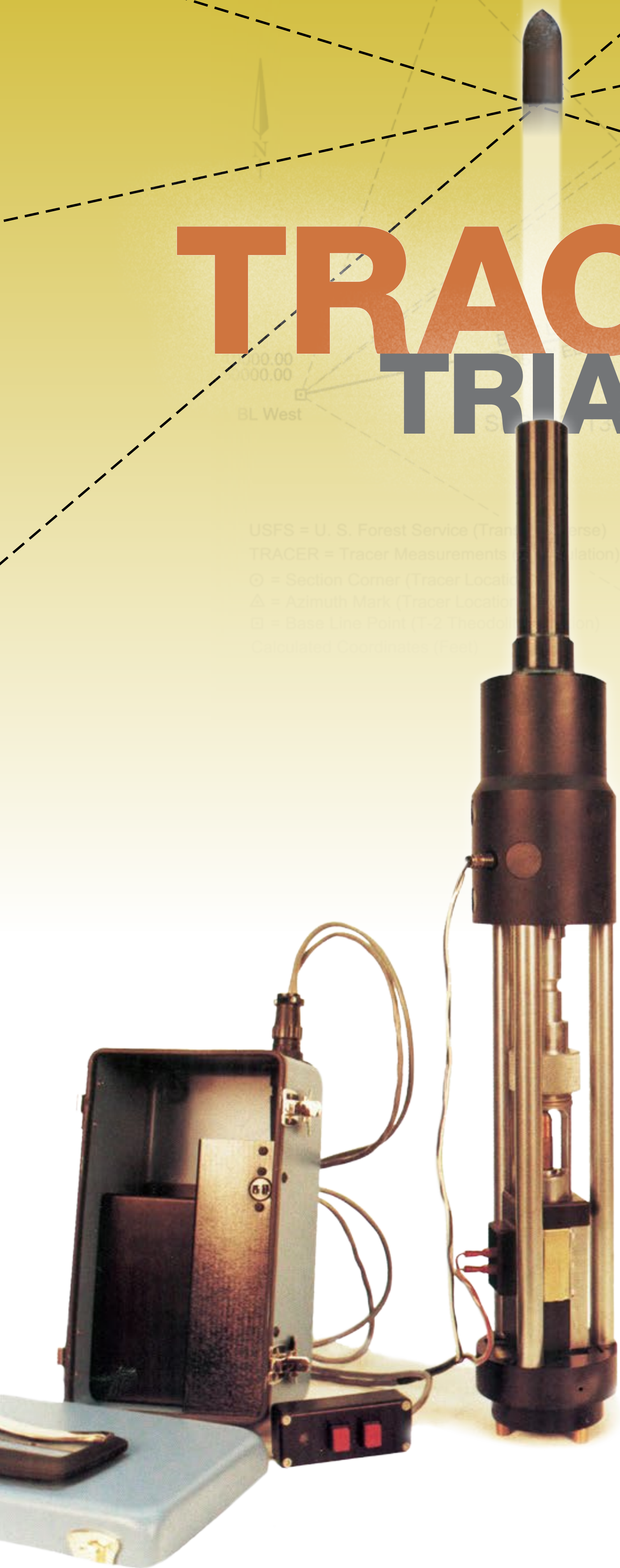
TRACER TRIANGULATION



The concept of firing tracer bullets into the air for triangulation initially drew many skeptics, but for those who put it into practice the apparatus saved both time and money. Before the advent of the modern technology of satellites, a visible line of sight was critical for traversing or triangulating between obscured points on the ground. Government agencies built tall towers to reach above the trees or to see over the tops of hills, but the average surveyor often had to traverse through many intermediate points to go over or around existing obstacles.

By the 1960s, triangulation was still rarely performed by the average surveyor due to the calculations involved and the hindrance of not being able to see a sight above a distant point. Solving this dilemma was simple in concept–extend something vertically above the point to be seen from far away. The solution to this problem, however, was frustrating. Tall connected range poles leaned. Helium filled balloons could not be trusted in the slighted breeze. Laser beams had not been perfected. Beacons on aircraft hovering above a point could not ensure the desired accuracy.

On November 7, 1967, Albert L. Whitehead of Arvada, Colorado, filed a design with the United States Patent Office for an apparatus which was to fire a rocket flare, tracer bullet, or other projectile from an appropriate launcher mounted on a tripod (3,350,783). It is unclear if Whitehead's idea ever advanced beyond the design and patent stages.

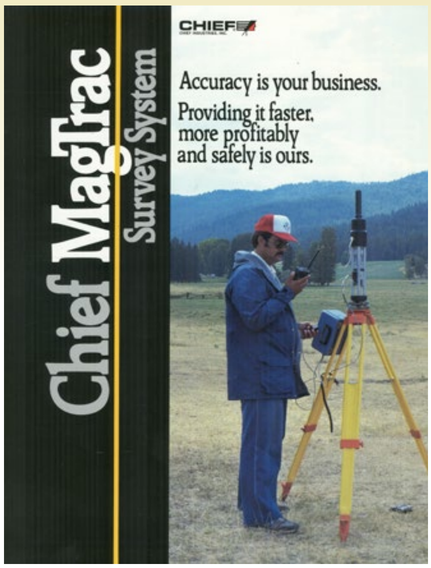
Whitehead was not alone in his vision of surveying by use of a vertical tracer. The father and son team of Norman E. and Jan Van Sickle, of Council Bluffs, Iowa, experimented with their own design for many years dating back to the late 1960's. After several years of diverting money from the family surveying business

>> By Jerry Penry, PS

Spencer Hogue of Dunaway Surveying, Inc., in Bothell, WA, inserts a Thompson/Center Contender .45 caliber pistol into the tracer apparatus. This firearm is also capable of firing the .410 bore shotshell for first clearing the tree canopy.

toward the project, the Van Sickles created their first prototype of a tracer triangulation system in 1972. The tracer bullet, however, was always their first objective of the system and was deemed the key to developing a successful patent. Initial experiments utilized shotgun tracers and then transitioned to using a .45 caliber handgun cartridge. The bullet design had to be unlike a normal military tracer since it needed to be viewed from the side and not from behind. The tracer also had to be clearly visible during daylight in order for surveyors to turn angles to its location.

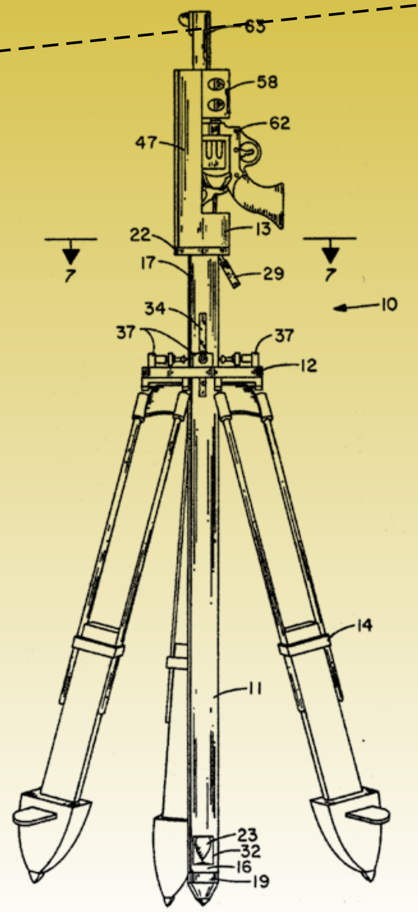
A patent for a 'Firearm Alignment and Support Apparatus' was filed by Norman E. Van Sickle with the United States Patent Office on January 23, 1978, and granted on June 24, 1980 (4,208,946). His patent for the tracer bullet was filed on June 20, 1979, and was granted on November 24, 1981 (4,301,732). The development of the apparatus closely coincided with the advent and popularity of the programmable calculator and with the introduction of Electronic Distance Measurement (EDM) instruments. With the calculator and EDM, surveyors could establish and measure long triangulation baselines with precision



Chief Industries of Grand Island, Nebraska advertised their redesigned version of the tracer apparatus known as the 'MagTrac Survey System' with a four-page color brochure in 1986.

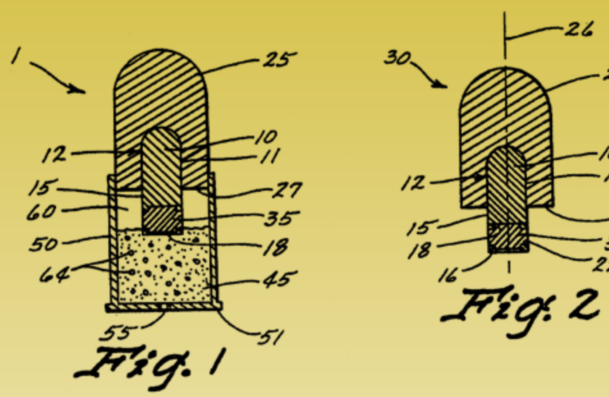
and perform the necessary computations for triangulation in the field.

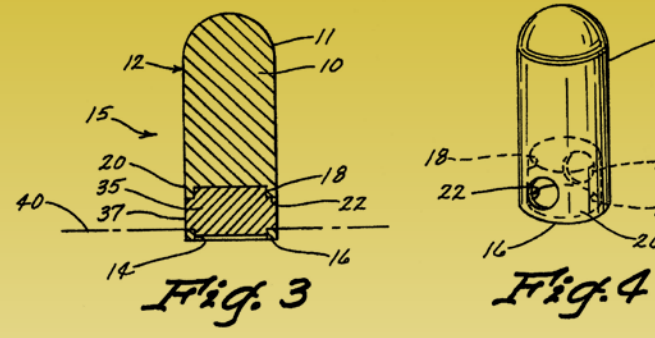
Multiple theodolites would be positioned along the measured baseline and coordinated by two-way radio to individually sight the vertical tracer extending upward from an obscured point. Repeating the process by moving the apparatus to other obscured points then created a triangulation network from the baseline. Utilizing more than one apparatus greatly sped up the process. Since more than one instrument on



The patent for a 'Firearm Alignment and Support Apparatus' was issued to Norman E. Van Sickle on June 24, 1980.

the baseline were simultaneously triangulating to the same point, multiple sets of coordinates were quickly calculated in the field upon that same point. Upon comparison of the coordinate values and evaluation of the desired precision, the position was quickly determined to be good or bad. The 500-foot-long tracer streak, which was actually a point of light to the eye or brain, could easily be viewed from several miles away during the day and for over ten miles at night. The streak of light was determined to only be visible for 0.65 of a second, but the human eye has no difficulty responding to something this brief. The theodolite operators would first have a general idea where the tracer was to appear and then select something in the background to sight after the initial firing. With each successive firing the crosshair would be slightly adjusted until it was illuminated on both sides.





The key to the successful development of the tracer apparatus was the bullet. This modified .45 caliber bullet with a magnesium element was patented by Norma E. Van Sickle on November 24, 1981.

Many potential customers remained skeptical until actually viewing demonstrations by the Van Sickles and personally witnessing the achieved accuracy. Naturally, the concerns with firing a bullet into the air ranged from hitting an airplane, striking someone upon descent, and starting fires. The fire danger from a tracer bullet, particularly in forests, was of greatest concern. The Van Sickles explained that after the tracer burned out, the bullet kept traveling upward and had sufficient time to cool by the time it returned to the ground. Due to their chemical properties, the bullets were never hot. These magnesium bullets produced light rather than fire.

When the Van Sickles began production of their surveying apparatus, they initially hand loaded the tracer rounds for their customers. As part of the design, an aluminum rod below the gun transferred the blast downward to the ground, insuring the apparatus' stability. The Van Sickles sent fliers to surveyors and held demonstrations at conventions. The price for the complete system was $4,000. Less than one dozen of these Van Sickle designs were built. Those early models do not bear any markings.

A complete and independent test of the Van Sickle survey system came on March 27, 1979, when the U. S. Geological Survey's Topographic Division, the Missouri State Surveyors Office, the U. S. Forest Service, and the University of Missouri joined forces for an evaluation near Rolla, Missouri. The tests came under the supervision of Dr. Joseph H. Senne who was chairman of the Department of Civil Engineering at the University of Missouri. For one of the tests, a baseline of just over 3000 feet was measured by EDM near the center of the project with the azimuth determined by solar observations. Four tracer systems were placed at the N ¼, NE, and SE corners of a section and upon an azimuth mark. Two T-2 theodolites were placed on the ends of the baseline. Direct and reverse angles were recorded to one second of an arc upon the tracers during wind gusting up to 20mph. The tracers being fired were 216-grain .45 caliber bullets with a muzzle velocity of 770 fps. One month later the U. S. Forest Service ran an open end traverse through the same points of the experiment for a comparison.

The results of the experiment were later published in the American Congress on Surveying and Mapping Journal of March 1981. The two separate experiments were deemed a complete success with an absolute value of differences in coordinate comparisons of 0.30 feet. None of the surveyors who participated in the experiments had any previous training with the system except for a two-hour familiarization meeting the previous evening. Robert E. Myers, State Surveyor of Missouri, observed the tests and stated: "With proper reconnaissance, careful establishment of the

One design of the tracer apparatus (with toy pistol for simulation) had recoil springs to absorb the shock. The MagTrac Signals shown above were developed by the Hornady ammunition company to use with Chief Industries version of the tracer apparatus.

base lines, care in making observations and with selection of good triangles for the computation, this instrument and its resultant techniques could be effectively used for cadastral control work."

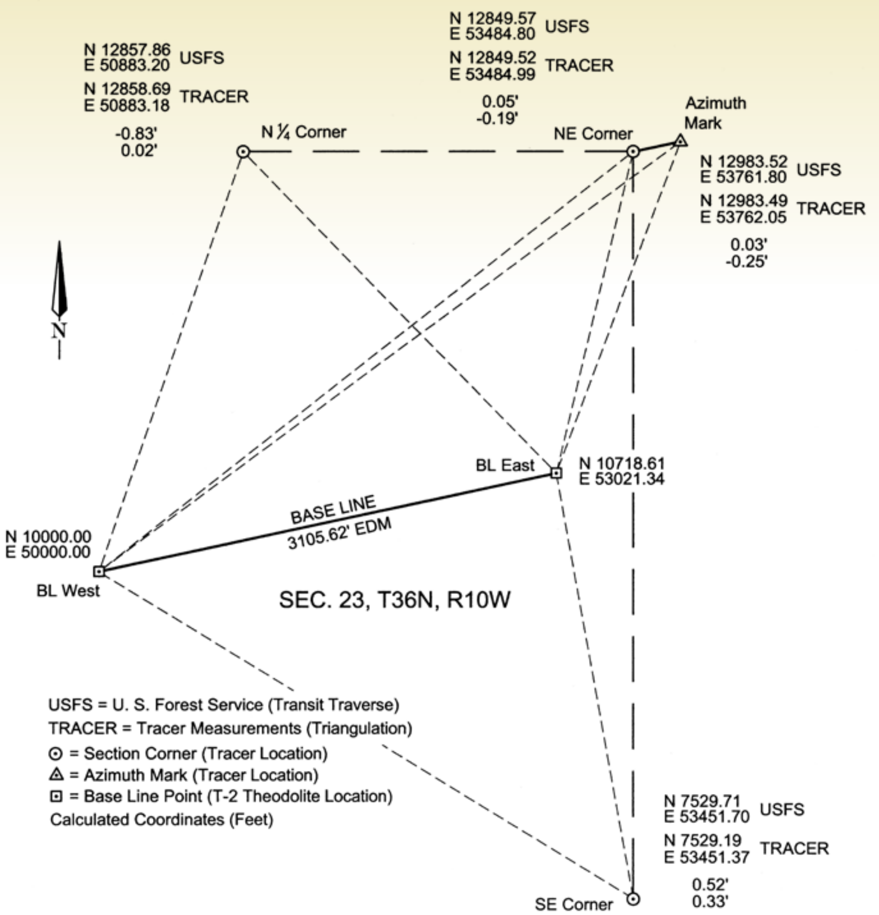
Chief Industries of Grand Island, Nebraska, later bought the patent and began changing the design. Hornady, a major ammunition manufacturer in Grand Island, began producing the tracer rounds to be fired from the apparatus. Those systems sold by Chief Industries were given the name "MagTrac Survey System" and are believed to bear the markings from that company. Initially, the main component to fire the tracer round was a Thompson Center Contender .45 caliber pistol. This gun can also fire a .410-gauge shotgun round that could be used to clear obstructing tree canopy above the point before the tracer round was fired. Eventually, the system was redesigned to an electronic firing system with a short barrel that did not require the use of a conventional firearm.

Several types of bullets were used. These included coreless types with thick hollow lead bullet jackets, a brass bullet loaded in a case, and at least three different copper bullets which differed in nose configuration. Ammunition cartons were marked "MagTrac Signals" and were packaged 20 to a box.

According to the Chief Industries 4-page brochure printed in 1986, the tracer appeared as a vertical moving orange light which extended 1,200 feet. Horizontal visibility varied with background brightness and air clarity. Pointing was expected to take from six to ten shots until the sighting was fixed in the instrument crosshair. The MagTrac launcher consisted of a cylindrical device which fit into a standard tribrach on a surveyor's tripod with centering by means of the optical plummet. The electronic firing system could only be fired while in an upright position and required a two-stage process. The firing buttons were mounted on a box with a six-foot remote cord allowing the operator to fire the system from a safe distance. The use of the tracer system was advertised to save surveyors 30% of the project cost.

Chief Industries stated that maximum efficiency was achieved with standard one-second theodolites along three baseline stations. Field tests indicated that an accuracy between 0.1 and 0.2 feet was obtainable when sighting the tracer from distances in the two to three mile range. This indicated an accuracy of 1:50,000 and 1:100,000. A specially made backpack system allowed the user to easily transport the system to remote areas. By 1986, Chief Industries was already stating their system could work in heavily forested areas where satellite systems and photogrammetry could not be used.

Despite the repeated and proven tests, many surveyors who never used the system or witnessed a demonstration remained skeptical. The Van Sickles, owners of Space Age Surveyors, Inc., became somewhat of an enigma to some surveyors who reasoned they were surveying by unconventional and unproven methods. Those writing the minimum standards for limits of closure in their state's regulations could not agree on how to handle the situation when standards had clearly been established for other methods of surveying. It became a difficult chapter for the Van Sickle family, but also something they would rather leave in the past. Norman E. Van Sickle died on March 16, 2006, at age 90. The Van Sickles were pioneers in the surveying industry and developed a system that to this day still cannot be equaled when determining the position upon a point in heavily forested areas.



TRACER RANGE POLE EXPERIMENT No. 2

Phelps County, Missouri

Two independent tests were made using the tracer apparatus on March 27, 1979, near Rolla, Missouri. The diagram above shows Experiment No. 2 which had tracers being fired from three section corners and an azimuth mark while observations were made to the tracers from a baseline using T-2 theodolites.

Note: Jan Van Sickle contributed to the historical information contained in this article.

Jerry Penry is a historical writer, public speaker and published author. He is a licensed land surveyor in the states of Nebraska and South Dakota.