

## HAS THE TAPE BECOME OBSOLETE? \*

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WHEN Roy Collins asked me to speak at to-day's meeting on the subject of "Electronic Surveying" some kind fate must have prompted me to choose the subject "Has The Tape Become Obsolete?" After all, what do I know about electronic surveying? Indeed, I may well ask, what does anyone in this group know of this broad field which with each passing year becomes ever broader? Electronics, as applied to the science of land surveying, is making such giant strides that, I daresay, a paper prepared for delivery some days in advance and purporting to cover the subject in all of its many facets, would itself be out of date upon its delivery. So, lucky, if not wise, was I to have chosen as my subject just one phase of the application of this comparatively new science to that oldest of sciences, land surveying.

But before getting down to the exact subject of this discourse, I would like, if for no other reason than to impress my patient audience, to list just a few of the invasions of electronics into our ancient and honorable profession.

Perhaps the first break-through came about when two-way radio, of the light, easily portable, type found its use in surveying. I don't suppose we were by any stretch of hopeful imagination the first to employ this in Connecticut, but, more than fifteen years ago, our Connecticut Geodetic Survey crew which I then had the honor to direct, used borrowed "walkie-talkies" in our triangulation work with gratifying success. I recall the instructions which we received from our good friends, the State Police, and especially the warning that these little dandies were effective at no greater distance than five or six miles. Imagine my surprise when I learned that our conversations emanating from Bear Mountain; 'way up (about 2300 feet) in the northwesterly corner of the state, were heard plainly at Glastonbury Fire Tower, some fifty miles away! These proved so very useful, despite the bulky power supplies, that I've kicked myself ever since for not having pressed for purchase of our own equipment. For ease of communication between survey party members, whether but yards apart on a noisy construction job, or miles apart, as on triangulation, is a must. Anyone who sends survey parties out today without this dependable, inexpensive aid to communication is overlooking a very valuable tool.

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It wasn't too many years after our first experience with radio that electronic data processing, as applied to surveying computations, appeared on the scene. Now, I must confess that when I was designated to attend a class of instruction in the rudiments of this science, I felt scared and wondered if I would qualify for retirement before the boss found out how little I really knew. Now, in this day of electronic computations of virtually all breeds of surveying applications, the man who does not avail himself of this universally available service is just plain missing the boat. I've heard fellows say "No, Sir, that's not for me! I want to be sure of the quality of work that goes out over my signature!" Well, men (and ladies too, if any are present) that sort of attitude is strictly for the birds! Electronic computations, made in, say, Los Angeles, for a New Haven surveyor doing a subdivision here in Oxford, are so far superior, in every conceivable aspect, to our tried and true machine calculations, that there is truly no comparison. How many of you, for example, compute and adjust a traverse closure and then with hardly a pause, run the computation backward, using adjusted values, to check your results? Electronic data processing does this and much more in less time than a man can look up and enter upon his traverse sheet the natural trigonometric functions. So, don't be one bit afraid to send your subdivision computations out of your offices, across the country if necessary, for E. D. P. — you'll wonder why you've waited so long.

You've heard, I suppose, as I did only recently, that a cleverly devised machine called a "Coordimat" will read from punched cards coordinates of points which will then be automatically plotted upon a map. And what of soundings, either of aqueous depths or of terra firma, by electronic methods. You'll agree, I think, that I was wise to confine my talk to-day to electronic distance measurements of which I have some knowledge based upon experience most of which was gained in the hours of darkness at widely separated points in our  $50 \times 100$  state.

Edmund Gunter, the famous English mathematician, during the same year that the Pilgrims landed at Plymouth Rock, announced to the world his newly invented surveying instrument, the Gunter's chain. I don't really know what specific measuring device was rendered obsolete by Mr. Gunter's 100 link, 66-foot chain, but quite possibly it was the pole. We find in our early survey records in this country measurements noted in poles, or rods. And so we may well assume that Edmund Gunter's invention of a device whereby distances might be measured in increments of 66 feet, as compared to  $16\frac{1}{2}$  feet, enabled the surveyors of his era to take their first giant steps. Later on, the engineer's chain, 100 links of one-foot each, came into use. And then at a much later date, came the proto-

type of the steel tape as we know it today. Steel tapes of varying lengths, from twenty-five feet up to five hundred feet, have, until the coming of the electronic age, been our most commonly accepted tool in the measurement of lines on the earth's surface. Let me hasten to assure you that, as things appear to-day, the steel tape and, indeed, Gunter's chain, will continue to find acceptance and use by surveyors for many years to come.

But to the surveyor of to-day who wishes really to take giant steps, the electronic distance measuring devices present a nearly magic solution to the now age-old process of measuring distances. No longer must the surveyor gaze across a ravine, a river, a pond or lake, and wonder how the needed distance is to be determined. Sure, the ancient art of triangulation is his to employ, but the time and personnel required to accomplish it as compared to the time and personnel required for the electronic measurement are forbidding. Let me try briefly to give you a few examples of this new magic!

First, I claim no vast, or even appreciable, amount of technical knowledge of these instruments. You may obtain that, to whatever extent you may wish, from the very competent men who sell them.

Second, I am not an advocate for any particular type or make of instrument; the salesmen present their points most capably and the potential buyer or user must make his own decision. The instrument selected by my associates and me for purchase by the Connecticut Highway Department was the Geodimeter, Model 4 B. Our decision was based upon what impressed us as two very important factors. In a state the size of ours, with established control at intervals no greater than eight or ten miles, what need would there be for a machine capable of measuring up to forty or fifty miles? Whereas certain of the available types of instruments were, and still are, designed to be used in pairs, one at each end of the line to be measured, the Geodimeter requires at the point to which the measurement is to be made only a relatively inexpensive reflector or groups of reflectors. Thus, our pioneering investment was only slightly more than one-half of what would have been required for, say, the Tellurometer. Since the Geodimeter operates on the principle of the transmission of a modulated beam of light to a passive reflector and the reception of the reflected beam by the emitting instrument, lines in excess of one-half mile are measured in darkness. Succeeding models of this instrument have embodied improved lighting so that lines up to three miles in length may now be measured in bright daylight. Although the need for night operation of the Geodimeter might have seemed somewhat of a drawback, we realized that, in our Geodetic Survey traverse work, the great majority of our lines would be in the range of 1500—3000 feet. Another influencing factor was the

then tendency of the radio-wave machines to be adversely affected by the reflection of signals by paved areas and bodies of water.

Now that we all know why C. H. D. chose the Geodimeter, let's consider a few of its performances. As to accuracy, the manufacturers state it in this terse manner "1 centimeter (less than  $\frac{1}{2}$  inch in case your metric equivalents are home in your desk drawer)  $\pm$  2 millionths of the distance" or, in simpler terms, about  $\frac{5}{8}$  inch in one mile. As a matter of interesting fact, the now-stated accuracies of the three instruments, Geodimeter, Tellurometer, and Electrotape are to all practical purposes the same except with respect to short lines on which the Geodimeter appears to offer the advantage.

In our right of way survey of the Connecticut Turnpike in Waterford some difficulty was encountered in reconciling taped distances to the established control of the C. G. S. This didn't surprise us too much, for we had reason to believe that the triangulation in this area was not quite what it was supposed to be. Nevertheless, we sent our top rank precise taping crew out there to measure a couple of miles of traverse and came up with longer distances than disclosed by the right of way survey. A short time later, probably as much for the purpose of proving the ability of the Geodimeter as for any other, we remeasured these same lines with the following results:

<i>Right of Way Survey</i>	<i>Check meas't.</i>	<i>Geodimeter Meas't.</i>
4942.352	4942.692	4942.754
3100.060	3100.336	3100.342
2649.226	2649.319	2649.322

This performance by the Geodimeter completely dissipated any lingering doubts which we may have had concerning its reliability. With the passing of time our confidence in this instrument has increased to the point where we could agree with a statement made by Rex H. Fulton, who pioneered its use by the California Department of Highways. Mr. Fulton, in a paper presented at the January 1960 meeting of the Highway Research Board in Washington, D.C. said "It has never been necessary to reobserve a line because of poor results —"

Another severe test of the dependability of electronic measurements occurred while we were making a tie between existing traverse and triangulation in North Stonington. When I learned that, although the traverse passed within a mile of a second-order station, no tie had been attempted I wanted to know "Why not?" Upon looking over the situation we found a direct tie to be completely feasible and proceeded to make it. In order not to be hindered by passing traffic on Route #2 we set a point

on line between the traverse station and the triangular station, planning to measure, electronically, the longer line of about a mile, and to tape the shorter line of about sixty feet. But the traffic was so light on the evening we chose for the measurement that we made electronic measurements from both the traverse station and the point on line, as well as a tape measurement of the short line. Upon reduction, the difference between the two electronic measurements agreed with the taped distance within six one-thousandths of a foot! I myself found this so difficult to believe that I drove to Norwich and, with Frank Leonard, of the District 2 office staff, went down there and personally checked that taped distance. I was prepared for, and willing to accept, a discrepancy of four or five one-hundredths but had to see that .006 myself!

We have made traverse measurements with this new device in locations, and under conditions, which would most certainly forbid the use of conventional measurements. To those of you who are familiar with the locale, can you imagine trying to tape a line, diagonally across six lanes of the Connecticut Turnpike, from East Avenue, Norwalk, to West Avenue, same city. In case you don't know the area, this line crosses an industrial area, the city dump, the Norwalk River, and the New Haven Railroad. Yet, three of us, in just two hours' time from leaving the New Haven office, completed the job and had the stuff all packed in the car for the return trip.

Or can you picture running traverse from South Norwalk, along busy West Avenue, 'way up to the center of Norwalk on a busy Friday night, or at any other more favorable time, using your steel tape, etc. Well, the same three of us did this and even aroused the rather suspicious curiosity of the local police force. Our last station occupied was adjacent to the National Bank, and our portable generator, its raucous purring reverberating off the wall of the bank, brought the cops in a hurry. But then it *was* one-thirty A.M. on Saturday — a good time for robbing a bank.

Well, there's no point in going on with this account of what we learned and accomplished with our first electronic distance measurement device. Unlike the farmer at the circus who, upon seeing a giraffe for the first time exclaimed "There's no such dang animal!" We came around to the recognition that there are such animals as electronic line measurers and my advice to you is, you'd better believe, too.

But, you may say, where and how does this apply to me? Well, just as radar measurements of vehicular speeds are now recognized by our police courts thus obviating the need for the motor cop to fall in behind the racing motorists, these electronic distance measurements are going to gain acceptance. Perhaps every surveying office will not need this type of in-

strument but I believe a pretty good case can be made for common use of this equipment and its operating personnel by engineers and surveyors. Just as subdivision computations are now available through central agencies so, in my opinion, will be electronic distance measurements. Who among you will be the first in his area to offer these services?

But, in my opinion, such organizations as larger city engineering departments and utility companies can't afford to be without this new device. As I have pointed out by example, city surveying in this era of heavy traffic cries for some new approach. The electronic measurement of distances is the answer. I am not so sure that smaller town engineering organizations are not also ready to engage in giant steps, too. The mapping of many of our towns has lagged in the past and is now proceeding by aerial photogrammetric methods. Horizontal control for photogrammetric as well as for many other purposes must be established before significant progress in mapping, city planning, and kindred municipal works may be had. No longer are we required to bridge gaps in our control systems in mincing little steps of 100 feet!

Electric transmission lines, the last of which I am sure has not been built in our state, have a way of crossing the cussedest kind of terrain. Electronic measurements, from peak to peak, with the shorter spans conventionally measured by sub-traverse, would fit such a picture as this. Maybe they're already a part of our Connecticut scene, but, if so, I've not yet become aware of it.

By the way, you realize that these electronic measurements are made on inclined planes unless, by coincidence, the adjacent points are on the same level plane. This brings us to the point of reducing the observed distances to the horizontal or to planes representing chords on the earth's circumference. Now this is a facet of the new science which the salesmen sort of gloss over and it bothered us just a little. But we worked out a simple trigonometric reduction employing mean vertical angles and it is wholly reliable. This might prove an interesting subject for a future panel discussion — let's save it.

Well, what do *you* think? Has the tape become obsolete? My answer has to be "yes; unless we wish to continue one short step after another, the tape, for long line measurements, has been superseded by this new science of electronics." But this doesn't mean that we are to throw away our tapes and make all linear measurements in the electronic manner. One has to complement the other and this will doubtless be so for at least a few more years. So, hang on to your tapes, men, for the short hops, but look to the electronic measuring instruments to enable you to take the long strides.

And now, in closing, I'll read some lines I've been saving for this occasion and with which, I'm sure, you'll agree.

“I love a finished speaker.

Oh, yes, indeed I do.

I don't mean one who's polished,

I just mean one who's through.”

Author unknown.